Atlanta Conference

On Science and Innovation Policy

2023 Abstracts book

This PDF contains all the abstracts of the Atlanta Conference on Science and Innovation Policy, 2023. They are in some order that only makes sense to EasyChair. Find a talk by searching for authors or titles. Also, the first few pages list all the talk authors, titles and EasyChair paper number alphabetized by first author last name. Abstracts can also be found by searching for the EasyChair paper number.

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[s2] *Insights from the experience of TIP South Africa: networking capabilities in building a community of practice*

Erika Kraemer Mbula (University of Johannesburg).

Abstract

Based on the experience from the Community of Practice in Transformative Innovation Policy in South Africa (TIP-SA), this presentation highlights the importance of networking capabilities by key actors in TIP-SA. Networking capabilities have been essential in promoting knowledge exchange, collaboration, learning, influence and contextualisation of TIP ideas in South Africa. It is argued that dedicated efforts to building networking capabilities can help span the boundaries between academia and policymakers, as a way of supporting an ecosystem that encourages transformative innovation and accelerates positive policy impact on society.

[1564] *Innovation for start-ups: the sooner the better?*

Ming Gao (Nanyang Technological University) and Jue Wang (Nanyang Technological University).

Abstract

Background and rationale Innovation plays a critical role in firms' survival and market growth but is also associated with risks. In a high-tech industry, the density of technology innovation is high. According to grounding theories of organizations and organizational ecology, the legitimation process has been dominated by the competitive process in this high-density range. Whether these individual firms could survive in an environment with fierce competition for technological innovation presumably depends on the dynamic capabilities of a firm and the "properties" of technological innovation, such as the timing of initiating innovation and the degree of diligence for innovating. While prematurely innovating may threaten the survival of new ventures due to the inadequate preparation and uncertain payback of the new technologies, unnecessarily delaying innovation may result in the firms falling behind their competitors. Therefore, the timing of innovation is important for business survival.

Innovation activities come with risks, especially for SMEs with liabilities of smallness and newness. The liabilities of newness refer to the creation of organizational new roles and routines, and can be attributed to both organizational internal matters and external effects of the environment. Internally, new firms need to learn new roles as social actors and the members of new firms also have to learn new organizational routines. The process of inventing new roles and routines would not only request a large amount of time and effort but also has high risks of conflict and inefficiency when the individual actors coordinate their new roles and socialize within the organization. Externally, new organizations are vulnerable due to the development of networks among strangers and the competition with established organizations.

The liabilities of smallness refer to the constraints in size and resources. Innovation in the over-early stage will exert much pressure on new firms because they need to simultaneously secure resources and develop new capabilities, which is not conducive to firms' survival. The resources required by innovation may overstrain their possibilities if they devote too much effort to new projects with an uncertain payback. They also face high opportunity costs. Unlike large incumbent firms which can tolerate or absorb failures with their capabilities and adequate resource base, the failure of innovation in small firms would evoke existential risks and can be catastrophic to its survival. Lastly, small organizations have major disadvantages in recruiting and retaining skilled employees as they cannot offer "long-term stability and internal labor markets". Failure to attract talents constrains the development of business.

To summarize, technology innovation and its timing affect the chance of firm survival in a competitive environment. While innovation could be a powerful vehicle for firm success, it does not guarantee survival for new firms in the very early stage because the overall risk profile and the liabilities of smallness and newness may outweigh the benefits brought by innovation. Therefore, we hypothesized that having innovation too soon in the start-up process will negatively affect firms' survival probability.

Methods This study investigated the relationship between the timing of innovation and SMEs' survival by using a dataset consisting of 229 innovative SMEs from the nanotechnology industry in the US. The nanotechnology industry is a highly technology-intensive industry. Technology innovation is a necessary capacity for nanotechnology firms, where the competition for technology innovation intensifies much in this industry. Around 79% of firms in our sample have been granted patents by 2019. Therefore, the nanotechnology industry provides a good context for studying the relationship between innovation and survival.

Patents granted by USPTO are used as an indicator of innovation as patents function as the output of knowledge production and signal a firm's innovation activities. The application date is recorded for each granted patent to better reflect the time of innovation activities. We use both period indicators (innovation in the first three years and the second three years) and yearly indicators (innovation in each year) to measure the timing of innovation.

The data was collected from several sources including D&B Hoovers, the USPTO, the Web of Science Core Collection, the SBIR-STTR America's Seed Fund website, and commercial databases such as Crunchbase and PrivCo. To ensure the accuracy of the information, each firm's survival status was then verified by manually checking other sources such as news and firm websites.

We use the Cox Proportional Hazards Model to test the relationship, and use Logit regression to confirm the results.

Results The study found that firms with innovation have a higher survival rate than those without innovation. On average, firms with innovation survive 19 years while those without innovation survive 15 years. On the other hand, we also found that the later firms start innovation in their early stage, the higher chances of survival. That is, older firms are more likely to benefit from innovation in terms of their survival possibility. In order to find out how older firms should be, we further examine the three-year as well as the yearly effect of innovation timing. By looking at the innovation in the first and second three-year periods, we found that the innovation activities in the first three years exert a negative and significant influence on firms' survival while those in the fourth year to the sixth year exert a positive and significant influence. The contrast effect shows that the influence of innovation in the early stage is different from that in a later stage.

The results support our hypothesis. The sooner of innovation is not always the better for firms in their start-up process, especially in the first few years, as innovation in the early stage of a start-up is associated with risks of exiting. By contrast, conducting innovation in the later stage will significantly increase the chance of surviving. Having innovation in the first year appears to be most risky, while postponing by each additional year in the next three years leads to a higher

chance of survival. This study suggested that the longer pre-entry period of innovation will enhance the SMEs' subsequent survival performance.

Significance This study contributes to the research in the domain of the influence of innovation on firms' survival by deeply revealing its timing factor on firms' subsequent survival in the early stage of their lifespan. Addressing this question is important to uncover the importance of the timing of innovation to SMEs' survival, which not only provides additional insights to the business managers for determining their innovation strategies but also enlightens the policymakers for drafting the supportive schemes to provide the necessary aid to the SMEs.

[5143] *Are Federal Contractors Less Innovative?*

Anne Marie Knott (Washington University in St Louis), Brett Josephson (George Mason University) and Ju-Yeon Lee (Iowa State).

Abstract

One of the roles of federally-funded R&D, beyond its primary goal of advancing technologies critical to US security, is to fuel economic growth and US competitiveness. Thus, a recent cause for alarm (e.g., Arora, Belenzon and Patacconi 2018, Gruber and Johnson 2019) is the 67% decline in federal R&D. Not surprisingly, this decline corresponds to declines in US R&D productivity and nominal GDP growth. One policy response is the Chips and Science Act of 2022, which authorizes approximately $174 billion through FY 2027 to support the nation's science and technology base, 75% of which is for Research (R). Thus the Act responds to a common misperception that the decline in federal R&D has come from R. In fact, federally-funded R has maintained a constant share of GDP. Essentially the entire 67% decline in federal R&D has come from development (D). Because R goes principally to universities, while D goes principally to firms, universities' share of federal R&D has grown sevenfold (from 5% to 35%), while firms' share has declined 70% (from 71% to 22%). This shift is curious, since at least one study found that federal R&D contracted to industry stimulated more private R&D investment than other federal R&D (Levy and Terleckyj 1983). Moreover, the same study found that federal R&D contracted to industry increased labor productivity, while other federal R&D decreased labor productivity. Such dramatic shifts and their coincidence with declining R&D productivity suggest the former may be responsible for the latter. If so, a likely explanation for declining R&D productivity is that federal R&D enhances firm R&D productivity. Such a finding might come as a surprise, since a common conception of federal contractors is that they are less innovative than commercial firms (Gansler 2013, Srinivasta 2019, Fischetti 2020). One reason federal contractors might be less innovative is that they evolve to thrive in the highly idiosyncratic and bureaucratic federal procurement system (e.g., Josephson et al. 2019). A second reason is that they may substitute lobbying and influence expertise (necessary to secure government contracts), for innovative expertise (necessary to succeed in the market). While it is obvious that government contracting is cumbersome, it is less obvious the impact this has on innovation. As a shining counter-example, Operation Warp Speed (OWS) represents federally-funded innovation at its best. In nine short months, beginning late March 2020, the government put out a call for vaccines, evaluated 100 responses, funded development and manufacturing expansion for six candidates, and administered the first vaccine December 13. Nor is OWS an isolated example. It is well known, for example, that the Internet originated with ARPAnet, but federal R&D also led to other important general-purpose technologies such as lasers, MRI and GPS (Singer 2014). Accordingly, the net impact of federal R&D contracting on firm innovation is an empirical question. While prior research has examined this question, and concluded that the productivity of federal R&D was a small fraction of that for firms own internal R&D (Griliches 1986), the data was cross-sectional, and pre-dated the decline in federal R&D funding. Accordingly, it may have captured a period when the federal government was overinvesting in development. We re-examine the question of federal R&D contracts on innovation by comparing federal contractors with commercial firms. Our measure of innovation is firms' Research Quotient (RQ), defined as the firm-specific output elasticity of R&D. Accordingly, RQ captures the percentage increase in firm revenues associated with a 1% increase in R&D. In aggregate, RQ captures the contribution of industrial R&D to economic growth (one of the goals of federal R&D). To conduct our test, we first characterize RQ separately for firms with and without federal R&D contracts. While the RQs of both type firms have been decreasing, those with federal R&D contracts have higher RQ throughout. This is true after adjusting firms' financials to treat R&D contract dollars as an R&D input, rather than as revenues. We next examine whether the higher RQ of federal R&D contractors reflects a selection effect or a treatment effect through a difference in differences (DiD) estimation relative to the time of first federal R&D contract. Our results reveal that the higher RQ of federal R&D contractors reflects both treatment and selection. Federal R&D contractors have significantly higher RQ prior to first contract, and RQ increases significantly following the first contract. The question then turns to why federal R&D contracts increase firms' RQ. One plausible explanation is that the government issues R&D contracts to firms from whom it expects to procure the ultimate good/service. If so, then RQ is mechanically higher for these firms—increases in R&D precede planned increases in revenue from procurement. We test this by exploiting a shock to federal funding—the Budget Control Act of 2011 (BCA), also known as sequestration, which dramatically decreased federal spending. Using dynamic DiD estimation, we find that while the RQ of federal R&D contractors decreases following sequestration, the decrease is not-significant. Thus, the higher RQ of federal contractors is not

merely an artifact of the R&D being an early stage of a longer-run contract. We therefore explore whether federal contracts change the character of firms' R&D in ways that enhance its productivity. We look at two dimensions of R&D character, its expansiveness and its impact. Both measures are based on patents, thus we can't test the 50% of firms who choose not to patent their innovations. Nevertheless, for the subset of firms who do file patents, we find that the R&D of federal contractors is more expansive and impactful than that of commercial firms. Taken together our results indicate that federal R&D contractors are at least as innovative as their commercial counterparts. Thus, the benefits of federal R&D contracting appear to outweigh the bureaucratic costs they impose. These benefits reflect both selection and treatment effects: government contractors have higher RQ prior to their first federal R&D contract, but in addition their RQ increases after receiving these contracts. The higher RQ of federal contractors cannot be explained by the fact these contracts are pre-cursors to subsequent procurement contracts. Rather it appears that federal R&D contracts enhance the character of firms' R&D—making it more expansive and impactful. One reason this may be true is that the funding agencies provide a conduit from research at universities and government labs to firms who commercialize those innovations. In doing so, these contracts help solve the "valley of death" problem that few university and lab inventions are commercialized. Our results have implications for policy. First, we find no evidence that greater use of commercial firms would increase the impact of federal R&D. In fact, we find that federal R&D contractors are at least as innovative as their commercial counterparts. More importantly, our results suggest the decline in federally-funded R&D to companies likely contributed to the decline in US R&D productivity. By extension, the rise in funding to universities appears not to have generated any benefit. Perhaps this is because the shift in from D at firms to R at universities has produced an imbalance, such that research generated by universities now exceeds industrial capacity to commercialize it.

[9895] *Problematising the role of STI policy in agricultural innovation in developing countries: The case of South Africa*

Yasser Buchana (Human Sciences Research Council).

Abstract

Background and rationale

Agricultural innovation policies are defined as those policies that are designed to improve a country's agricultural innovation capabilities. In most countries, agricultural innovation is usually managed by several government agencies, but principally by those in charge of agriculture or science, technology and innovation. While Science Technology and Innovation (STI) policies at the national level may primarily focus on the establishment of an enabling environment for innovation in the country, sectoral agricultural policies on the other hand may focus on encouraging and helping farmers to enhance their outputs.

From a developing countries point of view, agriculture has been recognised as a sector that may contribute to economic growth by creating jobs, food security, and promoting the preservation of bio-diversity and scarce natural resources. While agriculture plays a significant role in the socio-economic developments of these countries, the sector's contribution to the economic growth in Sub-Saharan Africa has largely stagnated and in some cases, significantly decreased in recent years due to a myriad of factors and challenges including, high and rising input costs, lack of support, droughts caused by climate change, water scarcity, crop or livestock diseases, and global competition. For example, in South Africa, agriculture's contribution to the GDP has decreased from a total share of 7.7% of gross domestic product (GDP) in 1969, to approximately 3% every year in the last ten years (DAS, 2012). According to the OECD, South Africa's agriculture sector is among the least supported in the world. Moreover, the OECD estimates that South Africa's Producer Support Estimate is currently 3,2%, versus 4,6% for Brazil, 7,1% for the US (OECD, 2021). A recent FAO report, maintains that agriculture and aquaculture sectors will need to innovate not just to enhance the efficiency with which inputs are converted into outputs, but also to conserve precious natural resources and minimize waste in order to adapt to future global issues (FAO, 2017).

Realising these problems, many sub-Saharan developing countries including South Africa, have moved swiftly to make a number of policy adjustments, notably in the areas of agriculture and innovation. For example, one of the key objectives and justification of South Africa's innovation policy has been the boosting of declining economic growth through innovation and the increase of productivity as well as competitiveness. More specifically, the new government white paper on Science, Technology and Innovation (DSI, 2019) as well as the decadal plan both outline important innovation policy priorities which puts innovation at the centre of seeking solutions to South Africa's main pressing challenges of poverty, rising inequality, unemployment and economic growth.

Spielman and Birner argue that innovation policies are typically classified into three types, namely: (a) policies aimed at establishing and strengthening the formal structures and institutions required to collect and apply new and existing knowledge; (b) policies that encourage and enable the development of new innovations among farmers and other stakeholders; and (c) policies that incorporate and coordinate governmental, private businesses, and other stakeholders that are involved in innovation processes. Given that agricultural innovation has grown more intertwined with national

innovation priorities in recent years, it has naturally become vital to integrate it into national innovation programs. Improved national and sectoral policy coordination between agricultural and innovation policy priorities can help policymakers close gaps and focus on sectoral challenges that are usually overlooked in both national STI and agriculture policy circles.

Objectives

The objective of this study was to investigate how policy problems in national STI policies and sectoral agricultural policies have been defined in order to stimulate innovation in the agricultural sector, to enable agricultural businesses to participate in the innovation process. In addition, the study examined the assumptions behind the policy measures offered in the STI policies in order to identify asymmetries in agricultural and STI policy coordination. An efficiently coordinated agricultural innovation policy would ensure that policy makers avoid making inaccurate assumptions about important agricultural policy priorities which may prove to be costly, and may inadvertently result in inefficient policy instruments that do not address the fundamental needs of agricultural sector stakeholders. As a result, the purpose of this study is to try to bridge this knowledge gap.

Methods This study used the critical discourse problematization framework (CDPF), an approach which merges two complimentary techniques to policy analysis, namely: (a) the critical discourse analysis and (b) policy problematization approach to problematise agricultural innovation in existing innovation policies. Policy problematization can be defined as the process of breaking down specific policy issues into problems that need to be solved. This approach recognizes that all policies have inherent problems and suggests that these problems have implications for how citizens are treated by governments and how they are conditioned to understand the social world and their roles as citizens. The main goal of studying problematizations, therefore according to Bacchi, (2012, p. 2) "... is to dismantle taken-for-granted fixed essences and show how they have come to be". While traditional policy analysis techniques use quantitative methods to seek for causal explanations for why policies succeed or fail, on the contrary, qualitative discourse approaches look to analyse policy in terms of how dominant narratives emerge and come to define as well as shape policy practices. As such, to investigate the research problem, the study took a qualitative research approach, while using secondary data sources including key copies of the national innovation policy documents, national development plans and agricultural policies. This method was commensurate with other policy analysis research studies that employed secondary data (see Bacchi, 2015; Makoza 2013; Midgley, 2013). The documents were sourced from the South African Government departments of Science and Innovation as well as the department of agricultural land reform and rural development (DLDR). The researchers purposefully selected materials that were (a) related to the national STI policy and national development (b) produced as part of policy development process. Additionally, the set of documents used for the analysis enabled to examine the discourses, practices, and contextual settings that shaped the development of the problems that the national innovation and agriculture policies aimed to solve (Bacchi, 2009; 2011; 2015).

Contributions and implications

This study contributes to the debates on agricultural innovation policy by shedding light on the importance of policy coordination between national STI policies and sectoral agricultural policies in developing countries. It uses the case of South Africa's experiences with problematization of the role of STI policy in agricultural innovation to further show how problematization may be used to identify asymmetries in priorities and policy coordination issues that hinder agricultural innovation. These coordination issues may hinder the development of appropriate agricultural innovation policy instruments intended to stimulate innovation and address challenges faced by the agricultural sector.

[8706] *The commercialization of DoD-SBIR patents*

Gaétan de Rassenfosse (Ecole Polytechnique Fédérale de Lausanne), Carlo Bottai (University of Milano-Bicocca) and Emilio Raiteri (Eindhoven University of Technology).

Abstract

The paper proposes a novel, web-based approach to innovation policy evaluation. The approach overcomes one major limitation affecting current evaluation methods, namely the tracking of invention commercialization. We implement it to study the impact of the U.S. DoD-SBIR program on technology commercialization. We start by identifying the universe of USPTO patents that acknowledge support by the program, and construct a set of control patents as benchmark. We then track whether these patents are mentioned in relation to commercial products in virtual patent marking web pages. We interpret the latter event as signal of commercialization. Finally, we compare the commercialization probability of SBIR-funded and control inventions. The results support the view that the SBIR program is quite effective at stimulating the commercialization of federally-funded scientific discoveries. The effect is particularly strong for grants covering development expenditures and Phase II awards.

[5440] *Is this grant scarce and desirable? The perception of competition in public research funding*

Marco Cavallaro (Università della Svizzera Italiana), Peter Edlund (Uppsala University) and Benedetto Lepori (Università della Svizzera Italiana).

Abstract

Background and rationale

Since the 1980s, competition has become a widespread mechanism for the allocation of public research funding in most advanced countries (Geuna 2001; Musselin 2018). Competition has been implemented at the organizational level through the introduction of performance-based funding (Hicks 2012; Krücken 2019; Teixeira, Biscaia and Rocha 2021), as well as at the individual level through various types of competitive grants managed by research funding organizations (Lepori and Reale 2019). This implementation has occurred in public sector contexts within which new policy rationales have supported the adoption of private sector practices, such as quasi-markets and efficiency-focused management models (Teixeira et al. 2004; Lepori 2011).

Whereas we know much about how competition is implemented in research systems, we know little about how it subsequently unfolds. The sociological literature suggests that competition should be understood as a socially constructed phenomenon (Arora-Jonsson, Brunsson and Hasse 2020), which is enacted in (strategic action) fields (Fligstein and McAdam 2011) and is largely dependent on social hierarchies (Krücken 2019) and networks (White 2001) in these fields. This means competition in research systems will unfold differently depending on how it is organized, as well as on how it relates to specific historical contingencies (Arora-Jonsson, Brunsson and Edlund 2023). The ways in which these processes unfold are likely to affect core dimensions in competition for research funding: self-selection among applicants (Viner, Powell and Green 2004), narratives to request resources (Velarde 2018), and strategies deployed by scientists to acquire funding (Laudel 2006). Such dimensions are, ultimately, likely to have an important impact on the outcomes of competition, including the novelty of funded applications (Boudreau, et al 2016), and, thus, the ability to support research with the potential to engender scientific breakthroughs (Laudel and Gläser 2014).

Set against this backdrop, the aim of our paper is to generate new knowledge about two elements that are central to constructing competition for funding: the extent to which grants are perceived as scarce and desirable (Arora-Jonsson, Brunsson and Hasse 2020). From previous research funding literature, we know that perceptions of scarcity and desirability vary depending on the type of grants and the position of scientists (Laudel 2006). There has, however, not been any systematic investigation of how grants are perceived by the actors involved in the competition, and, specifically, on the ways in which this may be affected by rules and discourses disseminated by funding agencies.

Methods

To address this aim, we build on theory from the sociology of quality markets literature (White 2001; Krücken 2019), as well as from the commodity and consumer behavior literature (Lynn 1991; Wu, et al 2012), which provides us with extensive insights into how scarcity perceptions are generated, how they affect perceptions of quality and desirability, and how they, in turn, impact the behavior of actors (Aggarwal, Jun and Huh 2011; Nichols 2012).

Empirically, we provide a case study consisting of two schemes housed under the European Union's Framework Programs (EU-FP) for research and innovation: the European Research Council's (ERC; Laudel and Gläser 2014) bottom-up individual grants and the European Commission's (EC) top-down collaborative actions (Ulnicane 2015). These two schemes represent contrastive cases in terms of their goals, narratives, and implementation approaches.

Using a mixed methods approach involving official documents, a survey, and a series of interviews, we thus contrast perceptions of scarcity and desirability among applicants to ERC grants and collaborative projects, seeking to grasp how these perceptions are affected by the goals, narratives, and implementation approaches from public authorities and funding agencies. To avoid disciplinary bias, we focus on potential applicants in the area of immunology.

Scarcity and desirability of ERC and collaborative grants

The ERC's budgets are, as with any other economic resource, limited, and this, by default, creates certain scarcity. Scarcity is, however, intertwined with desirability in constructing competition for the ERC's project grants, because resources that are scarce and difficult to access typically become desirable and attractive to access as well (Zuckerman, 1977). The desirability of ERC grants has been reinforced through bottom-up applications – implying that scientists do not require any nominations from universities or research councils – and beneficial funding conditions – including large monetary amounts that scientists have at their autonomous disposal for lengthy duration periods at European host organizations (Schreck, 2007; Wolinsky, 2010). The desirability of these grants has, finally, been further constructed through Europe-level allocations, which are adjudicated by prominent panellists that are seen as elites and experts in their respective disciplines. This serves to envelop the ERC's grants in a meritocratic aura that is reminiscent of Merton's (1942) scientist norms.

Scarcity in collaborative calls varies according to the budget allocated and the broadness of the calls. For example, we can expect lower success rates in broad calls supporting the application of digital technologies in the health area than in calls targeting the development of a specific treatment for a particular disease. We can denote overall increasing levels of desirability and thus competition throughout the years, notably due to the shift from an EU-FP relying on the juste retour principle to today's predominant excellence narrative. The juste retour principle implied that EU Member States could expect to receive EU-FP funding in proportion to their financial contributions to the EU budget. From the 2000s and onwards, notably with the Lisbon Strategy targets and the inception of the European Research Area, the policy narrative underlying EU-FPs saw increasing importance of New Public Management elements, with past results as a key criterion for the allocation of funding, and of the concept of excellence that encompasses all EU-FP funding instruments (Young, 2015; Hoenig, 2018). Further, collaborative schemes in EU-FPs provide resources to strengthen and expand collaboration and thus stimulate knowledge exchange. They provide networking opportunities and generate new collaborations that can result in co-publications, patents and new projects.

The foreseen survey and interviews can help us explore more in-depth how researchers perceive both grant schemes, notably in terms of career opportunities, but also identify mechanisms of self-selection or the potential influence of institutional settings on the desirability of such grants. At the moment of writing, we drafted a questionnaire that will be sent to hundreds of potential applicants to EU-FP grants in November/December 2022. We expect to be able to share advanced results by the time of the conference.

Significance

Our paper offers contributions to the research policy literature and the sociology of markets literature, by advancing new theoretical and empirical understandings of scarcity and desire as core elements in the construction of competition in public research funding.

From a policy perspective, and as suggested by the sociology of law literature (Edelman, Uggen and Erlanger 1999; Lascoumes and Le Galès 2007), we highlight how, beyond setting rules for competition, the design of grant schemes also sets norms and values that might deeply affect the perceptions of applicants concerning the desirability and scarcity of grants. And the perceptions of applicants can, in turn, impact their behavior because, as we have known for some time, "if (wo)men define situations as real, they are real in their consequences" (Thomas and Thomas 1928: 571-572). Taking this into account may help tailor policy measures to better connect the outcomes of competition to the achievement of policy goals.

[2048] *Purpose, progress and significance of innovative and challenging project in South Korea*

Jonghwa Park (KISTEP) and Minki Kim (KISTEP).

Abstract

Since its establishment in 1999 according to the Framework Act on Science and Technology, the Korea Institute of Science and Technology Evaluation and Planning (KISTEP) has devoted itself to improving the quality of life of the people through the development of science and technology, innovative growth, and resolution of social problems. From science and technology policy planning and future forecasting, Research & Development (R&D) budget allocation and adjustment, national R&D project research, analysis, evaluation, and performance diffusion, preliminary feasibility study in the R&D sector, and international cooperation in science and technology, it provides in-depth research results. Today, in the face of domestic and international challenges such as competition for technological supremacy, new infectious disease, and digital transformation, the role and mission of science and technology are becoming more important. As a think-tank of science and technology innovation policy, KISTEP is providing detailed support for science and technology-oriented government operation based on data.

The innovative and challenging project is being promoted from 2020 to lay the foundation for creating innovative results by shifting away from the past "Fast Follower" method to a bold and challenging "First Mover" research project. In order to preemptively solve the challenges of science and technology related to people's happiness, quality of life, and creation of future innovation-leading industries, we are discovering and promoting innovative and challenging cross-ministerial R&D projects centered on clear missions. It covers social issues directly related to people's happiness and quality of life, such as environment, safety (disaster, accident, public safety, security), aging, health care, and food, and the creation of future innovation-leading industries. Themes that can be achieved through step-by-step improvement of existing technologies are excluded as much as possible, and research topics that will solve problems challengingly and will have a ripple effect if successful are mainly explored.

For the successful operation of the project, a promotion team has been established and is being operated. The name of the promotion team is KARPA (Korea Advanced Research Program Accelerator).

There are a total of five detailed criteria for selecting a research topic. "Clarity of Objectives" examines whether the problem to be solved and the objectives of the project are clear and specific. "Challenge" examines whether the business goal is to be world-first or world-class. "Innovativeness" examines whether disruptive innovation can be derived through

R&D. "Differentiation" is reviewed to see if it does not overlap with the government's programs that have already been promoted or are currently being promoted. "Ripple Effect" determines whether a large scientific, technological, industrial, and social ripple effect is expected if R&D succeeds. Among the five detailed criteria, "Ripple Effect" is evaluated as the most important.

Research themes are being discovered through various methods. First, in the case of demand-based research, we are conducting a demand survey for new projects for related ministries and submission of proposals for innovative and challenging research themes for researchers from industry, academia, and research institutes. In particular, for industry-university-research researchers, the CIA (Crazy Idea Accelerator) online forum has been established, where researchers freely present ideas and experts evaluate and develop them, constantly discovering research themes. In the case of top-down, top-down research planning is being carried out based on key scientific and technological issues that need to be resolved nationally. We are pushing ahead with top-down planning to avoid step-by-step improvement of technology and to discover high-impact research themes candidates that can solve national problems and create future innovation-leading industries. By comprehensively analyzing reports related to domestic and foreign future strategies and promising technologies, promising research themes are derived, and blank areas that are missing from existing R&D projects are derived. In the case of the excellent researcher base, candidates for research themes are discovered by recruiting researchers with excellent ideas and insights. In addition, we are jointly discovering new research themes through collaboration with major research management organizations that are leading the planning of new projects.

When a topic is selected, a planning report is prepared through a detailed planning process over several months. The best industry-academic-research experts in Korea participate in the planning process. Detailed planning of the project is carried out so that the R&D project can proceed in the most efficient and effective way.

When the project implementation is confirmed through the government budget deliberation process, a project management team is launched for efficient project management, planning and evaluation are carried out centering on the head of the project management team (= Project Manager, PM). Flexible research methods are applied as much as possible to the selection of the research team necessary to achieve the project goals, the execution of the research, the execution of the research funds, and the evaluation.

After the inauguration of the project management team, the progress of detailed tasks are monitored, and feedback and follow-up measures are implemented so that the project can be operated as originally intended. A PM sharing meeting was held with the participation of the PM of each project management team to share the research direction, themes, progress, and to discuss and to adjust differentiation and related matters.

Institutionally, we are preparing a R&D support system that can maximize the creativity and autonomy of researchers by applying a research environment that does not blame failure and a flexible research method through this project. We plan to explore a total of 20 projects over 4 years, reflecting the government's R&D budget and implementing it. Topics discovered so far include about 10 convergence and original research, such as stratospheric drones for constant disaster monitoring, hypertube technology development for high-speed transportation, and CAR-T source technology development for solid cancer treatment. The topics discovered in 2020 and 2021 have been officially launched after planning and budget deliberation, and R&D is being actively carried out.

The current innovative and challenging project is being operated as a pilot project, and the promotion system needs to be improved in order to maximize operational efficiency and performance. It is necessary to prepare an operational plan for the second innovative and challenging project, such as securing separate financial resources for innovation challenge-type R&D and establishing a separate institution for efficient operation and management.

In this presentation, the purpose, progress, and significance of the innovative and challenging project carried out to create a more challenging R&D culture in South Korea will be analyzed. We would like to introduce the contents of the R&D program of the innovative and challenging project discovered over the past three years, and suggest the direction of future operation, including policy implications and system improvement measures revealed in the process.

[260] *Robot adoption and innovation activities*

Davide Antonioli (University of Ferrara), Alberto Marzucchi (Gran Sasso Science Institute, L'Aquila (IT)), Francesco Rentocchini (JRC-European Commission Seville) and Simone Vannuccini (SPRU, Science Policy Research Unit - University of Sussex).

Abstract

Background and rationale

Historically, mechanisation of production has always been accompanied by questions about its impact on the incentive to reallocate resources, with a natural focus on the substitutability of labour (Mokyr et al. 2015). However, labour substitution is only one of the effects of automation. In this paper, we study whether the adoption of robot technology influences the rate and direction of innovative activities. In essence, robots are capital goods. However, contemporary robots are depicted as increasingly ‘malleable’, or flexible, capital goods – multi-purpose equipment capable of executing

different tasks with little re-programming. Growing robot flexibility is a clear trend, as robot technology is augmented by other technologies characterising the fourth industrial revolution (Benassi et al. 2022; Martinelli et al. 2021), both hardware (e.g., sensors, or additive manufacturing technologies) and software (e.g., artificial intelligence algorithms). Robots become a component in larger systems, such as cyber physical systems and advanced digital production technologies (UNIDO, 2019). As such, it is possible to hypothesise that robot adoption will induce changes in firms' behaviours that go beyond the well-known replacement and productivity effects on employment (Autor, 2019) and that are more 'enabling' in nature. This hypothesis begins to accumulate empirical support (Hirvonen et al. 2022). At the same time, current robots are "the most recent iteration of industrial automation technologies that have existed for a very long time" (Fernandez-Macias et al. 2021) that continue to operate in specific and constrained environments. Hence, their enabling capability might be limited if firms are not able (or do not plan) to exploit it. We shed some new light on this by measuring how product innovation changes when robots are adopted at the firm level. Excluding robot vendors, for all other firms robots are process technology. Hence, robot adoption might be considered a form of process innovation. From this perspective, our analysis extends the reach of automation studies from the labour market perspective to an innovation one. Studying the interplay of robot adoption and innovation can provide insights on the more general relationship between process and product innovation – whether it is one of substitutability or synergy. At the root of process and product innovation there are different strategic considerations: process innovation is mainly driven by efficiency and cost cutting reasons; product innovation is mainly driven by the capture of value and market shares or creation(penetration) of(in) new markets (Utterback and Abernathy 1975; Klepper 1996; Damanpour and Gopalakrishnan 2001). While theoretical literature has modelled firms' portfolio choice between product and process innovation (Lambertini 2003), the empirical evidence is still scant – even more so for the case of robotisation. In summary, the paper contributes to the growing, yet nascent, strand of studies analysing firm-level data on robot adoption with a unique perspective on the nexus between the adoption of industrial robots and product innovation performance.

Data and methods

We exploit a unique dataset of Spanish firms, coming from the Survey on Firm Strategies (Encuesta Sobre Estrategias Empresariales, ESEE). This is a unique source of information (Kotch et al. 2021), as it: captures whether firms have adopted robots; contains details on innovation performance; is designed as a panel and covers a rather long timeframe. Our analysis in particular focuses on the period 1990-2016, in which different waves of automation have been implemented by Spanish manufacturing firms. Previous studies have highlighted how ESEE data cover approximately 22% of total Spanish employment in manufacturing and that there is a bias towards large companies, as it covers the full population of manufacturing firms with more than 200 employees, whereas only a representative sample of SMEs (between 10 and 200 employees) is covered (Barrios et al. 2003; D'Agostino and Moreno 2019). ESEE has been extensively employed as a data source for applied studies in economics and management at the firm level. We implement an event-study approach (a staggered timing diff-in-diffs model) to relate different indicators of product innovation to robotisation. In other terms, we estimate a two-way fixed effects (TWFE) model with leads and lags (distributed-lag model) which controls for a treatment (robotisation) occurring at different points in time (Angrist and Pischke 2008; Autor 2003; Cerulli and Ventura 2019). We corroborate our results by carefully considering pre treatment trends and strengthening our causal interpretation with an instrumental variable approach, exploiting information on the adoption of robots from foreign competitors.

Results

We show that robot adoption is negatively associated to product innovation. This result occurs immediately after the treatment, and persists in the long term. We explore different channels related to firms' characteristics that could explain our findings at a finer-grained level of disaggregation. We find that the negative association we detect is experienced by larger, established firms, active in sectors that are not high-tech. We interpret the findings in line with mechanisms outlined by established models of industry evolution. As industries mature (and firms grow), the incentive to allocate resources on process improvement to exploit economies of scale prevails on that of expanding variety through product innovation. By adopting robots, larger, established (features that proxy the state of a given industries life cycles) firms bet on capacity expansion – especially if responding to demand growth. Hence, robot adoption can divert resources away from product innovation, as it fuels diseconomies of scope across firm investment types. Furthermore, robots – even when flexible – might display enabling capabilities only when introduced in flexible production processes. More 'classic', standardised (and less high-tech) mass production processes might not benefit from robots' full potential. We take a step further by discussing whether the types of robots under analysis are the 'right' robots to induce innovation. In fact, not all instances of process mechanisation and robotic equipment might be malleable enough to shape technological opportunities and to affect the incentive to engage in new product discovery, design, and development.

[9326] *The Influence of Gender, Work Experience, and Education on the Likelihood of Raising Venture Capital and IPO in Genomics*

Jennifer Woolley (Santa Clara University).

Abstract

This study examines the gender, work experience, and education of founding teams and how these influence the likelihood that a firm will raise venture capital (VC) funding or complete an initial public offering (IPO).

Introduction VC and IPOs are two of the most sought after fundraising techniques for startups not only because of the amount of funding that they can provide, but also because they represent indicators of firm value and increase its chances of survival. Raising VC funding is the sale of a firm's equity to external investors, providing financing to help startups grow. In 2021, VC fundraising reached new highs with 17,000 firms raising over $300 billion (Pitchbook-NVCA, 2022). An IPO is the offering to sell equity (shares) of a privately held firm to public investors for the first time, also providing funding. Over 300 firms complete an IPO raising $286 billion in 2021 (Ritter, 2022). However, women entrepreneurs are conspicuously absent from these deals. Between 2013 and 2021, over 2000 firms went public in the U.S. yet only 25 were led by a female founder-CEO, with seven of those occurring in 2021 (Shontell, 2021; Female Founders Fund, 2022). This is surprising given that over a third of all firms in Europe and the U.S. are founded by women (European Commission, 2014; Morelix et al., 2017; Woolley 2019). The lack of female founder-CEOs of public firms may be due to the lack of VC going to women-founded firms or because women start less than five percent of high technology firms (Cohoon et al., 2010; European Commission, 2008; Wadhwa, 2012), which represent most IPOs (Ritter, 2022). While these facts provide some insight into the current state of VC and IPOs, we know little about the few women who successfully reach these milestones.

Theoretical Background - Summary Work on female founders continues to grow, improving our understanding of the effects of gender on firm outcomes (e.g., Brush et al., 2017; Woolley, 2019). However, while individual characteristics and experiences are recognized as important to firm growth, "gender is rarely considered in these investigations" (see Hechavarria et al., 2019: 6; Jennings and Brush, 2013; Link and Strong, 2016). This is surprising given the volume of work dedicated to firm growth more broadly and the fact that more and more women are becoming entrepreneurs. It is well documented that female entrepreneurs have limited access to VC, and despite considerable attention and efforts made by VC firms to diversify their investments, 2021 hit a 5 year low with only 2% going to firms with founded all-female founding teams and 17.6% of VC went to founding teams with at least one woman (Rubio and Mathur, 2022). Although the human capital of founding teams has been of great interest for those studying VC (Hsu, 1997; Matusik et al., 2008; Da Rin et al., 2011; Gimmons and Levie, 2010), much of the work treats women as a homogenous group. Focusing on high-technology ventures, Woolley (2019) found that while founding teams with women are less likely to obtain VC than their male counterparts, however, firms with women serial entrepreneurs are more likely. Furthermore, women with executive backgrounds were less likely to obtain VC, and men with executive backgrounds were more likely, indicating that the interaction between gender and entrepreneurs' human capital is an important distinguishing factor for firm outcomes. Obtaining VC funding is an important milestone for founders wishing to complete an IPO. Unfortunately, little work has examined the gender composition of founding teams and its influence on IPO. In an experiment, researchers found in an experiment that evaluators considered IPOs led by female founders or CEOs to be less attractive (Bigelow et al., 2014). Others have found little, if any, relationship between the gender of the leadership team and a firm's IPO valuation (Mohan and Chen, 2004). Guzman and Kacperczyk (2019) found that women entrepreneurs were less likely to obtain VC, but there when they do receive VC there was no difference in the likelihood that women and men entrepreneurs completed an IPO. Work has shown that founding teams' functional diversity and work experience increases their likelihood of going public (see Beckman et al., 2007, Beckman and Burton 2008). However, this research is mainly based on male led firms. As mentioned, only 25 of the over 2000 firms that went public on NYSE or NASDAQ between 2013 and 2021 had female-founder CEOs (Shontell, 2021; Female Founders Fund, 2022). Thus, little is known about how the founding team's gender composition influences a firm's likelihood of going public.

Methods We selected the genomics sector of biotechnology firms in the U.S. Genomics is the study of a complete set of genetic information or an organism. 1983 is a starting point since it is the year of earliest relevant startup activity. This ensures that the data are not left-censored (Blossfeld & Rohwer, 2002; Yamaguchi, 1991). A database of all genomics companies started in the U.S. before 2019 was triangulated from many sources including patents, government grants, industry lists, scientific publications, university websites, VC listings, directories, press releases, and articles. To be included, over 50% of its activity such as products, patents, R&D, or sales, must be related to genomics. The firm must also be for-profit and independent. This classification process parallels previous works that identified new technology firms (e.g., Schoonhoven, et al., 1990; Woolley, 2017). The database consists of 619 firms and 36 firms were dropped due to a lack of reliable data for the founding teams resulting in a final sample of 583 firms. Using press releases and deal listings such as Crunchbase, we determine the date of the first VC funding and IPO for each firm. For each, the following variables were collected or constructed: a dichotomous variable of event attainment, year of event, and time between firm founding and event. For the 583 firms, 1071 founders were identified. Demographic, work experience, and education data were gathered for each founder. Data sources included curriculum vitae, resumes, executive profiles, firm websites, university websites, Crunchbase, and LinkedIn. Gender was determined using name and pronoun analysis. Separate binary variables represent the founder's work history and if they were involved in an IPO or acquisition of their immediate previous employment. Education was captured in terms of doctorate, medical degree (MD), or MBA. We also

examined the previous work and education to determine if the founder was affiliated with one of the top ten venture capital backed universities as rated by Pitchbook (2020). Binary variables indicated if at least one person on the team had such work experience or education. Several firm and macro-level controls were included. We used the event history analysis technique using STATA with maximum likelihood estimation, robust standard errors and Weibull distribution.

Findings In total, 59% of the firms obtained VC (57% of male-only teams and 64% of mixed-gender teams) and 18% had an IPO (17.7% of male-only teams and 21.1% of mixed-gender teams). The findings show that female founders benefited from previous executive experience with a company being acquired in terms of being more likely to obtain VC and IPO. Female founders who had previously been entrepreneurs were also more likely to obtain VC and IPO, while male founders who had been entrepreneurs were less likely to obtain VC. Male founders who obtained graduate degrees from top VC funded universities were more likely to obtain VC or complete an IPO.

Significance This study develops our understanding of the relationship among founding team members' gender, work experience, and education and how these influence the likelihood that a firm will raise VC funding or complete an IPO. The findings suggest that women and men experience similar backgrounds differently and that this can influence the outcomes of their firms. Thus, programs and policies designed with the archetypical male entrepreneur may be hindering women entrepreneurs. This suggests that we pay closer attention to how individuals experience their human capital and appreciate the heterogeneous nature of entrepreneurship.

[4935] *The Relationship between Government Innovation Funding and the Likelihood of Venture Capital, IPO, and Acquisition in Genomics*

Jennifer Woolley (Santa Clara University).

Abstract

While governments seek to spur innovation and technology commercialization through funding programs, we have little insight into other outcomes that these programs may enable. This study examines the relationship between the U.S. government's SBIR program and the long-term success of participating firms.

Introduction Many governments support innovation and technology commercialization in firms through funding programs that target promising technologies. Two such programs in the US are the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) program created to support R&D in small firms. The secondary objective of these programs is to help organizations cross the "valley of death" in which innovation is promising, but too expensive to pursue for private investors (Bonvillian, 2011). Research exploring the long term effects of such programs provide mixed results (e.g., Kapsali, 2011; Qian and Haynes, 2014; Lanahan et al., 2022; Dutta et al., 2022). Work has shown the positive impact of these programs such as increased commercialization of innovations (Audretsch, Link, & Scott, 2002), and increased commercial success of these innovations (Archibald, & Finifter, 2003), but long-term studies are rare. Given that the US government spends over a billion dollars each year on these programs, more insight is warranted. For example, we do not know the extent to which resources from SBIR and STTR programs influence the success of ventures in terms of VC, IPO and being acquired.

Theoretical Background - Summary The SBIR and STTR programs are two of the latest and biggest programs that the U.S. government has enacted to support small business development (Bonvillian, 2011). Through 2021, SBIR and STTR have cumulatively provided almost $60 billion in funding (Small Business Administration, 2022). While both programs fund R&D, the SBIR focuses on innovation in small businesses while the STTR focuses on innovation in public/private collaborations, particularly between small businesses and nonprofit research institutions. Both programs are coordinated by the U.S. Small Business Administration. The SBIR program supports innovation activities in small, often nascent organizations. Implemented in 1982, the SBIR program seeks to promote high-technology innovation in small businesses by funding R&D projects. Federal agencies in the U.S. government with an R&D budget over $100 million must allocate 3.2% of their budget to SBIR grants. The agencies then solicit proposals from small businesses related to the agencies' needs. In 1982, the program provided over $38 million for R&D in small businesses through 789 awards. Through 2021, over 170,000 awards have been made totaling more than $53 billion (SBIR.gov, 2022). The STTR program was established in 1992 to support innovation collaborations between firms and public organizations such as universities and government labs and facilitate the transfer of intellectual property from research institutions to the market. Federal agencies with R&D budgets over $1 billion must allocate 0.45% to funding STTR grants. Five federal agencies participate in the STTR program. Through 2021, the program has grown to provide over $5 billion with 16000 grants. The overarching objective of these programs is to support R&D activity that is often expensive, at times beyond the means of small, nascent ventures (Link & Scott, 2010; Bonvillian, 2011). Thus the programs enable these firms to better compete with larger firms with more resources, encourage technology commercialization and support economic growth (Small Business Administration, 2013). While basic science lays the foundation for this technology, government projects tend to build applications of basic science work, usually having a proof of concept to get government funding (Rogers et al. 2001). Thus, these projects are vetted by an experienced audience and are closer to commercialization than academic projects

based on foundational scientific research. This can help firms build social capital in addition to helping them commercialize innovations (Gray et al., 2022). Additionally, the SBIR awarding agencies choose to fund firms that they believe are viable and potentially successful bringing their technology to market (Lanahan et al., 2022). Giga et al. (2022) found that these grants correlated to higher patenting rates for small businesses. Hypothesis 1: Technology firms supported by SBIR and SBIR grants have a higher likelihood of success than other technology firms.

Obtaining VC funding is an important milestone for founders wishing to complete an IPO. Raising VC funding is the sale of a firm's equity to external investors, providing financing to help startups grow. In 2021, VC fundraising reached new highs with 17,000 firms raising over $300 billion (Pitchbook-NVCA, 2022). VC funding acts as a signal to external stakeholders on the value of the firm and its likelihood of growth. VC backing can lead to high growth and IPO (Chemmanur et al. 2021). Obtaining both government grants and VC will support a firm's ability to succeed in the long term. Hypothesis 2: Technology firms supported by SBIR grants and VC have a higher likelihood of success than other firms.

Methods We selected the genomics sector of biotechnology firms in the U.S. Genomics is the study of a complete set of genetic information or an organism. 1983 is a starting point since it is the year of earliest relevant startup activity. This ensures that the data are not left-censored (Blossfeld & Rohwer, 2002; Yamaguchi, 1991). A database of all genomics companies started in the U.S. before 2019 was compiled by triangulating many sources including patents, government grants, industry lists, scientific publications, university websites, VC listings, directories, press releases, and articles. To be included, over 50% of its activity such as products, patents, R&D, or sales, must be related to genomics. The firm must also be for-profit and independent. This classification process parallels previous works that identified new technology firms (e.g., Schoonhoven, et al., 1990; Woolley, 2017). The database consists of 619 firms and 36 firms were dropped due to a lack of reliable data for the founding teams resulting in a final sample of 583 firms. Using press releases and deal listings such as Crunchbase, we determine the date of the first VC funding, IPO, and acquisition for each firm as appropriate. For each, the following variables were collected or constructed: a dichotomous variable of event attainment, year of event, and time between firm founding and event. Several firm and macro level controls were included. We used the event history analysis technique using STATA with maximum likelihood estimation, robust standard errors and Weibull distribution.

Findings In total, 47% of the firms obtained SBIR or STTR funding, 58% obtained VC, 18% had an IPO, and 30% were acquired. The models show that firms with government funding were less likely to obtain VC, go IPO or be acquired. However, when firms with both government funding and VC were almost three times more likely to go IPO than other firms.

Significance This study develops our understanding of the relationship between government support and other measures of firm success: VC, IPO and acquisition. The results indicate that if the government is seeking to support high-growth firms that are acquired or go public, agencies should work with other ecosystem institutions such as other investors to improve the firm's likelihood of success.

[9218] *The Impact of Team Diversity on Research Productivity*

Mehmet Aydeniz (University of Tennessee, Knoxville), W. Carson Byrd (University of Michigan), Olga Churkina (Georgia Institute of Technology) and Ofuma Eze-Echesi (University of Oregon).

Abstract

Background and Rationale

The diversity-innovation paradox is not simply a detriment to scientific progress but also to the careers and livelihoods of scientists coming from different sub-populations. Previous studies note how scientists of color and women face extra hurdles within the scientific community, both in representation and in embracing their contributions to the field (Hofstra et al. 2022, 2020; Kozlowski et al. 2022). Yet, how marginalization manifests within the scientific community often focuses on principal investigators (PIs) of research projects or lead authors, leaving unexamined the research teams behind PIs and lead authors (Chen et al., 2022). Therefore, the current research project takes one step forward and examines how PI characteristics affect the future grant acquisition and publication record mediated by the ethnoracial diversity of the research teams as an important factor for a broader impact of scientific innovation and progress.

Methods and Anticipated Results

In our analysis, we use the Institute for Research on Innovation & Science's (IRIS) Universities: Measuring the Impacts of Research on Innovation, Competitiveness, and Science (UMETRICS) restricted dataset that has an extensive coverage of university financial and personnel administrative data pertaining to sponsored project expenditures as well as federal award details related to DOE, DOD, NASA, NIH, NSF, and USDA spanning between 2001 and 2021 for dozens participating university in the US. In the first stage of our analysis, we investigate how the ethnoracial diversity of the research teams is affected by PI gender and ethnicity characteristics using multivariate regression models with individual and time fixed effects. To evaluate those differences, we construct a diversity index regarding racial/gender composition of the research teams as our main independent variables of interest. We utilize a diversity index developed by Chang and Yamamura

(2006) that accounts for the proportion of each distinctive group represented on research teams and produces a value that ranges from 0 to 1. The closer a research team's diversity level is to 1, the higher the diversity of the team, while the opposite is true for research teams with levels closer to 0. We noticed that the majority of teams are ethnically homogeneous with the most diverse teams having a diversity index of about 0.5 (or ranging from 0.4 to 0.6). For example, preliminary results show the pattern of Hispanic and Middle Eastern male PIs leading the most diverse research teams while European females seem to be the leaders of the least diverse teams, on average. The second stage of our analysis is twofold. Firstly, we employ a negative binomial regression to analyze future grant acquisition overall and by scientific discipline. We found the team diversity to be the most important in STEM disciplines and the least crucial for grants devoted to the administrative needs. At the same time, the PI's prior grant records heavily contribute to the positive future outcomes as expected. Secondly, we evaluate publication records in respect to disparities in the research team diversity. Our preliminary results show heterogeneous effects of the team diversity across different fields of scientific research and topic subgroups. Therefore, our current research activity includes the comparison of research funding practices between various parts of the scientific community as well as the exploration of the project PI's mentoring practices and its effect on young scientists' performance in grant acquisition and publications.

Significance

The outcomes of this project can make several contributions to the scientific field. First, it can show how a team leader's ethnoracial and gender identities impacts team diversity. Considering the influence that a project PI has relative to who is included and who is left out of a project has significant implications for equity efforts within science. Second, the outcomes can reveal useful insights about the project PI's mentoring practices and how such practices inform young scientists' performance in grant acquisition and publications. Third, this study examines the processes of panel review and funding of NSF and NIH, helping these agencies to put in place preventive policies and procedures to ensure equitable distribution of funds to scientists. This study could also lead to the recommendations for restructuring of research teams and improved success rates of grants. Finally, the results of this study could reveal the ways in which team diversity impacts team productivity, creativity, and success more broadly.

[734] *Diversification vs. specialization from the perspective of research programmes: a complexity approach*

Antonio Zinilli (National Research Council of Italy), Emanuela Reale (National Research Council of Italy), Andrea Orazio Spinello (National Research Council of Italy) and Emanuela Varinetti (National Research Council of Italy).

Abstract

In the last few years, research funding instruments have become strategic issues in science, technology and innovation policy studies. This paper presents a new perspective for attempting to further understanding on the relationship between research funding policies and societal priorities through an exploratory study involving a novel dataset called EFIL – European dataset of public R&D funding instruments. The present work tackles the diversification and specialization of government research funding instruments using economic complexity approaches. The paper deepens the diversification/specialisation of ten European countries in SDGs, analysing a part of research public arena, namely the project funding instruments designed and managed by national Research Funding Organizations (RFOs) for the period year from 2016 to 2021.The results show a clear differentiation between agencies and, as a result, between countries. The SDGs instrument orientation in Norway is more diversified, and there is less overlap between the SD goals. This means that there is a clear difference in instrument orientation, as well as between agencies within the same country with distinct and well-defined policy goals. In addition, the volatility of the complexity rating, i.e. its variation over time, was observed for some countries. Other countries, on the other hand, showed little variation in SDGs over time.

[1830] *Resource Dependence Effects in Formalized Inter-organization Exchanges: The Case of University F&A Rates*

Yong In Choi (Georgia Institute of Technology) and John Walsh (Georgia Institute of Technology).

Abstract

Resource Dependence Theory argues that the resource dependencies between organizations, characterized by the degree of power imbalance and of mutual dependence, predict the outcomes of resource exchanges. A primary condition of the theory is that actors should have discretion over resource allocation. It is, however, an open question of whether and to what extent such power and interdependence effects operate in a formalized dependence relation, such as between the government and a government contractor under a highly specified set of procurement rules. While such rules are supposed to take away discretion from the actors and remove informal elements from the organizational relationship, Resource Dependence Theory, combined with prior work on informal processes in organizations, predicts

that power asymmetry and mutual dependence are strong predictors of the outcomes even in such regulated interorganizational relationships. Furthermore, prior work suggests that the degree of informal processes varies across agencies within the same regulated environment. Hence, we will test these competing perspectives on formalized interorganizational relationships. We test these research questions using data on variations in Federal Facilities and Administration (F&A) cost reimbursement rates negotiated between the U.S. federal government and research universities. The results show university's Federally negotiated F&A rates are related to the degree of interdependence and power relation between the university and the cognizant funding agency that sets the rate. Furthermore, this effect varies across agencies, suggesting that the application of the formal regulations and informal processes may depend on the specifics of agency practices. Hence, even a highly regulated system may provide conditions for power asymmetry and mutual dependence to affect the resource exchange, suggesting the presence of informal processes. We conclude with a discussion of the implications of these findings both for organization theory and for science policy.

[9861] *Open Innovation System, Absorptive Capacities, and Sustainable Economic Growth in Africa*

Bernadin Géraud Comlan Ahodode (University of YaoundeII).

Abstract

The current context in African countries is characterized by increasing environmental constraints, unemployment, and poverty, whence the need to achieve sustainable development. Indeed, it will ensure the satisfaction of the needs of the present generation without compromising those of future generations. Thus, countries must achieve sustainable growth, in particular by fostering infrastructure development; promoting research, science, innovation, and technological development; and scaling up global and regional partnerships for development (UN/ECA, 2016a). The recognition of the importance of technical progress and research and development (R&D) in fostering growth has led to the development of neoclassical, evolutionary, Neokeynesian, and institutional theories. Indeed, while the old neoclassical theory of growth integrates technical progress in exogenous form for the improvement of long-term growth (Solow, 1956), new theories do it in the endogenous form with an emphasis on knowledge accumulation (Romer, 1986), human capital (Lucas, 1988; Romer, 1990), public spending on physical capital and social infrastructure (Barro, 1990), and technological innovation related to R&D introduced in different forms (Aghion et Howitt, 1992; Grossman et Helpman, 1989; Romer, 1990). Evolutionary theories focus on supply through the central role of technological change in firms and the generation of novelty (Nelson et Winter, 1982; Silverberg et Verspagen, 1994). Neokeynesians consider the role of demand (the degree of consumer orientation) in technical progress and growth (Kaldor, 1966; Pasinetti, 1994). Finally, the institutional current is based on the economic organizational efficiency in terms of taxation and legislation on property rights, to name just a few, as crucial factors for improved economic growth (North, 1994). In their view, institutions must play the leading role in terms of technological policy to foster innovation behaviors of the most important economic actors through their mode of interaction. Thus, several systemic approaches to innovation have been developed after the national innovation system (NIS). Approaches that provide information on countries' capacity to generate and benefit from innovation (Freeman, 1987; Lundvall, 1992; Nelson, 1993). Indeed, the NIS advocates the interaction between different economic actors such as industries, universities, research centers, public institutions, financial institutions, and end users. Among these actors, industries and governments are considered respectively as the center and the main actor of the innovation process regulation. However, in the context of a knowledge-based economy, the Triple Helix (TH) innovation system views university institutions as leaders when it comes to the innovation process (Etzkowitz et Leydesdorff, 1995 & 1997; Leydesdorff et Etzkowitz, 2000). This approach advocates interactions between university, industry, and government as the key to improving the necessary conditions for technological innovation generation. The extension of the Triple Helix to Quadruple Helix model (Carayannis et Campbell, 2009) by taking into account social contribution has led to the development of the endogenous growth model of the national innovation system (Afonso et Monteiro, 2012; Monteiro, 2013). However, the environment, according to its current constraints in addition to the need to consider additional factors for the explanation of the technological innovation process has led to the extension of the Quadruple Helix model to Quintuple Helix (Carayannis et Campbell, 2010) and Ntuple Helix (Leydesdorff, 2000) that serves as a framework for sustainable improvement of country performance. However, the analysis of African countries' performance reveals the underdevelopment of their national innovation systems as compared to those of developed countries which remain characterized by weak interactions between different spheres (Casadella et Benlahcen-Tlemcani, 2006; Gu, 1999). The studies on innovation systems in Africa also show an important synergistic contribution at the foreign level as compared to domestic and global ones (Mêgnigbêto, 2015; Mezouaghi, 2002). In addition, African countries, particularly those in Sub-Saharan Africa have recorded average growth rates of 5% over the past 15 years. But this growth is mainly due to commodity prices instead of technological innovation. However, the latter occupies the top position in Asia, emerging countries, and other developed countries (NU/CEA, 2016b; WEF, 2016). In terms of sustainability, there is a very poor performance of African countries as compared to those of other parts of the world despite the high natural resources endowment that abounds the continent. In fact, of the 180 countries included in the 2017 global sustainable

competitiveness index report, the top four in Africa are Ethiopia (64th), Ghana (68th), Côte d'Ivoire (77th), and Kenya (80th). There are also 8 African countries in the 20 and occupying the last positions in such ranking (SolAbility, 2017). Notwithstanding, studies show that the development of the innovation system in addition to absorptive capacities (i.e. the different factors that affect the ability of countries to take advantage of foreign technologies) favor the convergence of developing countries towards developed ones (Abramovitz, 1986; Albuquerque, 1999; Archibugi et Coco, 2004; Edquist, 2001; Fagerberg et Srholec, 2008; Fagerberg et Verspagen, 2007; Filippetti et Peyrache, 2011; Godinho et al., 2004; Lee et Lee, 2019; Viotti, 2002). Also appears that the opening of the innovation system with trade, foreign direct investment, and integration determines the improvement of developing countries' competitive performance (Lundvall, 1992 & 2015). Thus, how can the development of the open innovation system and absorptive capacities contribute to sustainable growth improvement in Africa? Therefore, this study aims at contributing to sustainable economic growth policy reinforcement in Africa by analyzing the link between the opening of the innovation system, absorption capacities, and sustainable growth. Thus, the generalized moment's method in the autoregressive vector panel has been used. The data was used to cover a total of 27 countries from 2007 to 2016. The results show that the Open Quintuple Helix's innovation system and the absorptive capacities of firms and universities have a negative impact on the sustainable growth rate in Africa. Moreover, only the increase in firms' absorptive capacity really coevolves with the Open Quintuple Helix innovation system and the sustainable growth rate. Finally, an infrastructure public policy shock leads to an improvement in investments and a sustainable growth rate. However, this shock leads to a decrease in the availability of scientists and engineers, in the firm's absorptive capacity, and the efficiency of the Open quintuple Helix innovation system in the long term. Thus in terms of sustainable growth policy, African countries must strengthen investment and especially technological innovation infrastructure development. They must also ensure that the training of scientists and engineers and the firm's absorptive capacity can be turned towards the acquisition and development of clean or green technological innovation.

[9285] *"Walking the green line": government sponsored R&D and clean technologies in the US*

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Abstract

We examine whether government sponsored R&D affects the development of clean technologies with a higher impact on subsequent technological development. The empirical analysis uses information on USPTO patents granted during the 2005-2015. Starting from patents acknowledged in government funding, we build a control group by matching firm level information on Patstat. We combine linear regression and propensity score methods to control for an eventual sorting of riskier projects into public funded projects by firms and for non-random (public) treatment at technology level. We also assess the distributional impact of government supported R&D in green technologies. Results show that green patents benefiting from public funding have a significantly larger impact that the other patents developed by the firms in the sample, and that this impact becomes larger along the distribution of patent citations. Our results complement the literature on market-pull policies to reduce greenhouse gas emissions, showing that technology-push policies represent a relevant option to determine the speed and direction of technical change in the field of clean technologies.

[1189] *How are GVC-oriented policies different? The Implications for ST&I Policies*

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Abstract

Global value chains (GVC) have taken the policy world by storm with virtually all leading international organizations dedicating flagship publications to the topic. Yet, despite the huge enthusiasm about GVCs, there remains substantial ambiguity about their policy implications. In this article, we argue that the novelty of GVC-oriented policy lies in the elevated role that it gives to tasks, linkages, and firms. Such novelty pushes policymakers to adopt new task-based industrial policies, global connectedness policies and corporate due diligence policies that are challenging the current rule-based trading system.

A first novelty of GVC-oriented policies is the shift of attention from industries to tasks. Global production allows countries to functionally specialize in finer-grained value chain stages instead of entire industries. Yet the disproportionately large value-added that is captured by intangible-intensive tasks (e.g., R&D and marketing) presses policymakers to develop public policies that attract and retain the latter. In both developed and developing countries, policy makers are thus adopting a mix of task-based industrial policies – including ICT infrastructure investments, tax

credits and subsidies – to expediate the upgrading of local industrial activity into more intangible-intensive tasks. For example, the Malaysian government has invested heavily in technology centers like the National Applied R&D Center that houses labs offering a wide range of instruments and infrastructures for advanced ICT testing services accessible to GVC suppliers at subsidized rates.

Second, GVC-oriented policies emphasize the role of linkages. GVCs link domestic and foreign tasks, and these linkages influence domestic firms' economic and social performance. On the positive side, they act as powerful conduits for accessing foreign knowledge and resources that can be leveraged to improve technological and operational capabilities. Decent work parameters imposed by foreign value chain partners can also incentivize firms to improve local labor conditions. On the negative side, these linkages can reduce economic resiliency by transmitting foreign economic shocks to domestic firms. A focal concern of policymakers is thus how to properly regulate, deepen, and strengthen GVC linkages so that they can promote economic and social upgrading while guaranteeing economic resilience. On the one hand, such global connectedness policies aim to improve the access to knowledge and information that is transferred through linkages. On the other hand, they focus on strengthening the absorptive capacity of local firms. For example, for many years the Chilean government has promoted networks of suppliers to enhance inter-firm collaborations and reduce the gap between lead-firms and their input providers.

GVC-oriented policies finally elevate the status of firms. Multinational enterprises (MNEs) have enormous power in GVCs. Sitting at the apex of a hierarchical chain, they have the muscle to select which firms are included or excluded in GVCs, to determine the terms of supply-chain membership and to allocate where, when and by whom value is added. It is this power that allows MNEs to not only enhance the efficiency of the GVC, but also to promote social and environmental conditions extraterritorially. They can remediate poor labor and environmental conditions in global supply chain factories, for example, by pledging to work only with suppliers and sub-suppliers that adhere to strict codes of conduct and collaborate with them to reach this goal. Policymakers not only see this power as a challenge but also as an opportunity. By properly harnessing MNE power within GVCs, governments can use domestic policies that target MNEs to foster changes along GVCs. Several countries, for example, have started to impose strict corporate due diligence principles on MNEs that apply along their entire GVC. For example, the French government in 2017 implemented the Duty of Vigilance Law to impose a legal duty to exercise human rights due diligence.

These new policy directions challenge current trade policy practices in several ways. First, the intricate relations between tasks, linkages and firms require policymakers to move beyond traditional silo thinking where each Ministry pursues its own objectives independently. Now more than ever Governments need to develop coordinated trans-Ministerial efforts to synchronize their trade, innovation, industrial and social policies. Second, the global scope of GVCs requires countries to develop new supra-national policies to avoid distortionary arbitrage strategies that are rampant in GVCs. The recent G20 agreement for a minimum global corporate tax rate to close cross-border tax loopholes is a good example of new steps in this direction. Third, the rule-based multilateral trading system needs to modernize to tackle challenges that GVC-oriented policies pose to the foundational principle of non-discrimination. For example, corporate due diligence policies that apply throughout GVCs represent a legal obstacle to "national treatment" if they lead to the discrimination of imports from non-compliant businesses.

Taken together, even if GVCs reinforce several traditional trade policy elements, they in other areas force a fundamental redesign in policy thinking by accentuating the role of tasks, linkages and firms. We argue that these changes are so profound that the set of GVC-oriented policies has become a truly different concept that challenges the rule-based trading system.

[5675] *Inclusion as Science and Innovation Policy Objective: Comparing Responsible Research and Innovation and Broader Impacts Frameworks*

Helka Kalliomäki (University of Vaasa), Johanna Kalliokoski (University of Vaasa), Leena Kunttu (University of Vaasa) and Jari Kuusisto (University of Vaasa).

Abstract

Background and rationale

In this paper, we analyze the objective of inclusion in the science, technology and innovation (STI) policy context. Inclusion is increasingly gaining importance as STI policy objective aiming at providing equal opportunities for different members of society to benefit from and to participate in innovation, and promoting closer interaction between science and society. Hence, it is valuable to scrutinize its use and symbolic role in the broader STI policy language. We begin the analysis by reviewing the extant STI policy literature. Secondly, we carry out a comparative analysis of the US Broader Impact Criterion (BIC) and the European Responsible Research and Innovation (RRI) frameworks.

The objectives of the research are twofold. Our STI literature analysis aims at synthesizing the scattered knowledge and multiple approaches to inclusion as a policy objective. Secondly, we analyze how inclusion as a science and innovation policy objective is both defined and operationalized in the BIC and RRI evaluation frameworks.

The rationale for the comparative approach arises from the different ways in which inclusion is conceptualized, understood, pursued and evaluated in different policy contexts. In other words, we are interested in the different contextual and systemic realities and value-bases in which inclusion is promoted as a science and innovation policy objective. We hypothesize that these realities have an effect not only on the development of the societal impact itself, but also the actual evaluation practices as focusing devices in understanding the impacts.

Methods

Our empirical research is based on comparative analysis that focuses on the contextual differences in policy formulation and implementation. In addition, it focuses on the policy instruments, the broader innovation system and its elements that influence innovation processes and outcomes, and sheds light on the conceptual ambiguity characterizing innovation concept and inclusive policies in general. The co-existence of multiple definitions in academic literature and among practitioners hampers the understanding of these terms and their further uptake in both the private and public sector.

The comparison analyzes the concept of inclusion in the context of two different frameworks. Our theoretical literature based conceptual framework synthesizes the key dimensions of the broad science and innovation policy literature. This helps to compare the cases in terms of their approaches to inclusion. In practice, we analyze the extant research on BIC and RRI. Additionally, we analyze the key policy documents related to the frameworks and the evaluation criteria operationalizing objectives related to inclusion and evaluation practices. The document analysis is based on the principles of theory-driven content analysis, utilizing the conceptual framework built in the theoretical section of the paper.

Results

The findings present different approaches to conceptualize and operationalize inclusion as a science and innovation policy objective. RRI and BIC are importantly different criteria in terms of their approaches to inclusion, the former taking a more process-oriented and the latter more outcome-oriented approach to promoting inclusiveness. While RRI focuses on collaboration, partnerships and interactive processes as a part of the research, BIC aims primarily at benefiting e.g. science, technology, engineering, and mathematics by means of concrete outcomes of the research. In the RRI framework, inclusion refers primarily to public engagement and "inclusive participatory approaches". Instead in the BIC, inclusion is approached primarily as the participation of different marginalized groups in research and education activities, disseminating research results to wider audiences, and collaboration and networking activity with external actors.

Significance

The paper contributes to the STI policy literature by presenting a conceptual framework of inclusion as an STI policy objective. Research on the different ways to understand and operationalize inclusion as part of the wider policy attempts to increase the societal impact of science and innovation can contribute to the ongoing academic debates on societal impact as well as its evaluation amidst increasing societal complexity. It sheds light on the embeddedness of policies in different systemic contexts and value-bases that affect not only the creation and use of the policy language but also the concrete evaluation practices attempting to capture the impacts of policymaking.

The analytical distinction between inclusion as means and inclusion as an objective is useful especially in light of STI policies emphasizing the societal impact of research and innovation. In the process-based view on inclusion, inclusive processes appear as a means to increase the societal impact and legitimacy of STI policies, whereas the output related view emphasizes inclusion as a goal in itself. These different meanings given for inclusion are adding to conceptual ambiguity.

Altogether, extant research has identified diverse disconnections not only between the policy and practice of increasingly complex innovation space but also between the agency and structures that direct attention e.g. to the lacking acknowledgement of the role of users and consumers (including minorities and disadvantaged groups) in transformative innovation policy discussions. These disconnections, combined with the growing complexity of policy concepts, are decreasing the legitimacy of STI policies. Inclusion can be a powerful policy concept in promoting societal impact of research, and research on its conceptualization and operationalization can increase its value as an integrative policy concept. However, in addition to the identified need for transformative policies to be more inclusive, future research needs to account for the growing complexity and ambiguity of policy language regarding inclusive policies.

[3524] *Obstacles to innovation and labor productivity: evidence for Latin American and Caribbean SMEs*

Florencia Barletta (Universidad Nacional de General Sarmiento), Diana Suárez (Universidad Nacional de General Sarmiento) and Florencia Fiorentin (Universidad Nacional de General Sarmiento).

Abstract

Introduction and background

The objective of this paper is to analyse the relationship between obstacles to innovation and firms' productivity, focusing on Latin America and Caribbean SMEs. On one hand, the relationship between innovation and productivity has been widely studied by literature. Results point to a robust correlation between both variables, particularly for developed countries (Griffith et al., 2006). From an empirical perspective, studies based on the CDM approach (Crépon et al., 1998) estimate the impact of firms' R&D investments on the propensity to innovate and then the impact of innovation on labor

productivity. However, in developing countries innovation propensity is more frequently explained by other innovative efforts -such us training, design, engineering, and machinery acquisition- than by R&D spending. Because of that, new empirical approximations to this triple relationship have also been implemented (Crespi & Zuniga, 2012). On the other hand, literature on innovation barriers is mostly oriented to the study of the relationship between different categories of obstacles and innovation results (Blanchard et al., 2013; D'Este et al., 2012; Galia & Legros, 2004; Hölzl & Janger, 2014; Mohnen et al., 2008; Pellegrino & Savona, 2017). Initially, studies have focused on the impact of financial barriers, derived from the market failures approach. Then, following capabilities and systemic failures approaches, other obstacles were added, to address other systemic barriers that are assumed to inhibit innovation -such us institutional, knowledge and market structure obstacles (D'Este et al., 2012; Pellegrino & Savona, 2017). Taking this background into account, and assuming that barriers affect the possibility and propensity to innovate, the objective of this paper is to study the direct relationship between innovation barriers and labour productivity in Latin American and Caribbean firms. In addition, given the high micro-heterogeneity that characterizes innovative processes, we expect that the relationship between different types of obstacles (financial, knowledge, market, institutional) and firm productivity will be different according to the level of productivity of the firm. For the empirical exercise, we use a quantile regression framework. This approximation allows us to explore the presence of heterogeneous effects across the (conditional) productivity distribution instead of an average impact "for a representative" firm (Alex Coad et al., 2016). Empirical model and preliminary results The empirical analysis is based on the Latin American Innovation Surveys dataset (LAIS), compiled by Inter-American Development Bank (IDB) . Since we will look at obstacles to innovation, only SMEs that declare innovation expenditures were included. The result is a subsample of 15,033 SMEs located in 8 different Latin American countries with information for the period 2007-2017. LAIS includes 23 obstacle dummy variables grouped into four sets of obstacles to innovation: knowledge, institutional, financial and market related. In order to test the association between each set of obstacles and firm's productivity we estimated a quantile regression model (Chamberlain, 1994; Roger & Bassett, 1978). Following Coad et al (2016), estimations will be done for the .10, .25, .50, .75 and .90 quantiles. On average, all obstacles are negatively and significantly associated with firm productivity, except the financial ones. Higher coefficients are verified for institutional obstacles, followed by market and knowledge ones. However, when different levels of productivity are considered, the coefficients and levels of significance changes, although significant impacts remain negative. Knowledge obstacles are significant at the middle levels of productivity, with similar coefficients in the quantiles .25 and .50 and higher in the quantile 0.75. Market obstacles show a similar path, being not significant for the highest and lowest levels of productivity and ranging from -0.027 in quantile .25 to -0.045 in .75. Institutional obstacles have a negative and significant association with productivity in all quantiles except from the lowest one, showing the highest coefficient for the quantile of highest productivity (-0.066). These findings confirm the presence of heterogeneous results depending on the level of labor productivity of the firm. Hence, additional heterogeneity might be expected if other attributes of the firm are considered. In this respect, results confirm the impact of obstacles on firms' productivity except from financial ones, where the impact is not significant. Different explanations might apply to the different obstacles. In the case of knowledge, it might not be relevant within the lowest quantile since these firms operate at low levels of technological complexity, therefore knowledge is not a key asset. However, contrary to the expected results, knowledge barriers seem to have no impact on firms with higher productivity levels that usually operate in knowledge and technology-intensive markets. Within intermediate quantiles, this might be the micro-economic explanation of Lee's (2013) middle income trap and significant increments in technological capabilities are to move upwards in the technological complexity of firms. Similar results are observed in the case of market and institutional obstacles and similar explanations might be provide. Once firm's productivity has crossed a minimum threshold (in this paper, the .10 quantile), as they compete in higher productivity levels connected to greater technological complexity, regulatory, systemic and market related obstacles became more relevant. In this context, firms that manage to overcome them reach higher levels of competitiveness. The lack of significance of financial obstacles might be derived from the selected sample. Innovative firms must overcome financial obstacles to innovation to become so. Then new obstacles gain relevance in terms of impacts on productivity. In addition, and similar to D'Este et al. (2012), this exercise might contribute to identify blockages to innovation. Regarding this research, the lack of significance does not mean that firms did not perceived cost as an obstacle but the fact that this type of obstacles is not associated with productivity. To conclude, preliminary results presented in this paper contribute to provide some elements for the implementation of empirical evidence-based policy. Historically, in the framework of the market failures approach, innovation policy instruments were focused on overcome financial obstacles. However, results show that financial barriers are not significant, being more relevant other types of obstacles such as regulatory, knowledge or institutional ones. References Blanchard, P., Huiban, J.-P., Musolesi, A., & Sevestre, P. (2013). 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[5472] *Talking and Walking Interdisciplinarity Across Fields*

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Abstract

Institutional leaders have long championed interdisciplinary research; however, researchers have paid relatively little attention to the people responding to such calls and their subsequent career outcomes. With the benefit of two large datasets spanning from 1986 through 2016, we show that interdisciplinary dissertations have become consistently more common in recent years as institutional leaders have highlighted the value of boundary-spanning research for solving important and emergent problems. With the benefit of survey data from a near-complete population of all dissertators in the US starting in 2001 through 2016, we observe a consistent upward trend in interdisciplinary dissertations. Unfortunately, we show that these interdisciplinary dissertators have experienced a comparably persistent penalty when considering salaries for their first year after earning the PhD. We also show that among interdisciplinary dissertators, individuals in lower-paying fields tend to earn more when choosing distantly related topic-combinations whereas researchers in higher-paying fields tend to be most rewarded for staying within relatively narrow disciplinary silos.

[4607] *A methodological contribution to activate the trajectory of productive interactions between science and society. Application in two case studies and comparison of results.*

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Abstract

This paper presents the main background on which the Anticipatory Evaluation (AE) methodological proposal is built and the results of its application in two research programmes: The Rice Research Programme (RRP) and the Food Security Research Programme (FSRP). AE is a technique for orienting evaluation towards strategic learning by analysing mechanisms for achieving impact. It contributes to the formation of a strategic perspective for researchers to initiate and energise the trajectory of productive interactions (PI) with society.

Background and justification

In 2018, the first approach to the impact assessment of the research institute: Latitud foundation was carried out. For this purpose, a set of traditional science impact indicators were constructed, such as: number of patents, number of publications, number of completed doctorates, etc.

While these indicators were useful for accountability, we were able to identify that this way of assessing the impact of the institute did not respond to the information needs of researchers in terms of learning strategically to anticipate and achieve the expected impact of their projects. This identified limitation in evaluation practice is related to a problem that the scientific literature had clearly identified: traditional evaluation approaches have been limited in responding to the growing expectations about the capacity of science, technology, and innovation (STI) to generate impacts on society.

When we talk about traditional approaches, we refer to those that use reductionist indicators (Ràfols, 2018) and that present the classic problems of temporality (Buxton, 2011), as well as a lack of knowledge of the mechanisms and processes for achieving impact (Molas Gallart and Tang, 2011). This is in a context of increasing expectations about the capacity of science to generate impacts on society and where current science policies are often concerned with the relationships between scientific and societal actors (Smit and Hessels, 2021). This also translates into an increasing variety of users (Castro Martínez et al., 2016) and uses (Cozzens and Snoek, 2010) of science. At the end of the day, this puts more pressure on researchers, who face the challenge of fulfilling both their scientific mission and their social mission (D'Este et al., 2018). While there are authors with a constructivist stance who claim that the social and scientific value of research are strongly related (Smit and Hessels, 2021), it is by no means well-established that scientific excellence is an adequate predictor of social value (Buxton, 2011).

Methods

We take up the proposal of productive interactions, the result of the Social Impact Assessment Methods for research and funding instruments through the study of Productive Interactions between science and society (SIAMPI) project (Spaapen and van Drooge, 2011) and add an anticipatory dimension using the specific method of the actors' game (Mactor) belonging to the toolbox of anticipation or strategic foresight. The AE is composed of ten steps grouped into three stages. Stage I includes the steps: 1) Identification of the researcher and the evaluator and 2) Definition and delimitation of the evaluation unit. Stage II includes the steps: 3) Identification of the broad set of actors of interest and classification of environment, 4). IP and its typology, depth and bidirectionality, 5) descriptive summary indicators and 6) intermediate recommendations resulting from steps I and II. Finally, stage III includes the steps: 7) Identification of the reduced set of actors to apply the Mactor method, 8) Application of the Mactor method (software), 9) Synthesis of the Mactor method analysis and 10) Formulation of recommendations of an AE process.

Results and importance

In both case studies, the identification of the theory of the research programme and the set of key actors with whom it is necessary to establish PIs provided strategic perspective to the researchers. This makes it possible to streamline the trajectory of the PIs and initiate new ones. When we apply the Mactor method, we identify those nodes of convergence where the actors of interest are positioned. In the case of the RRP, the main convergence node is established around the reduction of arsenic in rice grain. This specific information on the interest of the actors allows the researcher to initiate those pending PIs, as well as to dynamize the trajectory of the existing ones.

AE is a formative methodology that enables strategic learning through impact analysis. In one case study, specifically in step 7, the RRP researcher recognises the difficulty of communication that limits her in linking with the actors in the policy. She does not know how to translate the relationship between what she does in the RRP laboratory and the design of the sectoral public policy in rice. When these actors are interviewed - in step 8 - information is collected to improve the way of communicating with them.

The AE is a mixed methodology that combines quantitative indicators with qualitative analysis. In step 6 descriptive indicators of the existing and pending PI scheme are constructed, while in step 8 semi-structured interviews with in-depth qualitative enquiry are conducted to formulate the recommendations in step 10. The application of AE contributes evidence on the variety of science users. For both research programmes we found more than 100 actors from a variety of settings, in addition to those from the research domain. The anticipatory nature of AE offers the advantage of alleviating the classic problem of temporality. This form of evaluation is flexible in nature and allows for intermediate positioning between an ex-ante and an ex-post approach. In the two case studies it was applied at two different points in the life cycles of the research programmes, one at the beginning of implementation and the other in the middle. The AE makes it possible to work at different levels of aggregation and focuses the analysis on the individual researcher. In our case studies we have worked at the research programme level.

The application of AE can help to alleviate the pressure researchers face in having to fulfil their scientific and social mission at the same time. In the case studies, researchers work in peer review processes, generating metrics that can account for the fulfilment of their scientific mission. In relation to their social mission, once the AE has been implemented, the researcher can also account for progress through, for example, coverage indicators (58% for RRP and 88% for FSRP) that show the ratio between existing and pending PIs. Under the fundamental assumption that PIs are predictors of successful impact, these indicators contribute to the accountability of the significant progress made in implementing AE.

[8547] *Quantifying gender and retention patterns among U.S. faculty*

Katie Spoon (University of Colorado Boulder), Nicholas LaBerge (University of Colorado, Boulder), K. Hunter Wapman (University of Colorado Boulder), Sam Zhang (Sam Zhang), Allison Morgan (University of Colorado Boulder), Mirta Galesic (Santa Fe Institute), Joanna Mendy (University of Colorado Boulder), Maria Martinez (University of Colorado Boulder), Lauren Rivera (Northwestern University), Daniel Larremore (University of Colorado Boulder) and Aaron Clauset (University of Colorado Boulder).

Abstract

Background In most academic fields, women remain substantially underrepresented among tenured and tenure-track faculty compared to the U.S. population [1]. Despite broad interest in measuring, explaining, and mitigating gendered retention in faculty careers, evidence for its magnitude, ubiquity, and causes remains controversial. Past work has tended to examine separate aspects of retention dynamics, using either large-scale statistical analyses [2-4] that report within- or cross-disciplinary gendered retention rates but cannot explain them, or small-scale surveys or ethnographies [5, 6] that provide detailed explanations for why women leave academia, but do not provide large-scale evidence or systematic conclusions. Moreover, many studies report conflicting conclusions, depending on discipline, study design, and sample size. A deeper understanding of cross-disciplinary gendered faculty retention patterns would help illuminate the social processes that drive systemic underrepresentation, and would inform policies to improve retention and to mitigate the induced asymmetric loss of talent and concomitant scientific discoveries [7].

Data & Methods We describe the results of a unique large-scale study of women's retention in academia that combines the generality of a multidisciplinary, census-scale statistical analysis of administrative retention data with the explanatory power of deep survey data on gendered reasons for leaving faculty jobs. We quantify gendered retention using detailed employment data from a census of 282,759 tenure-track faculty who were active in their roles between 2011-2020, spanning all domains of academia, including science, technology, engineering, and mathematics (STEM) fields, the social sciences, the humanities, and medicine, and representing all 391 PhD-granting institutions in the U.S. First, we consider retention across academia as a whole, then analyze large groups of disciplines, then each discipline itself. We then identify detailed explanations for these retention patterns using 10,071 responses to a new survey of former and current tenure-track professors across 17 disciplines, sampled from the larger census dataset. Finally, we complement these findings with a qualitative analysis of nearly 7,000 free-text responses by the survey respondents, which highlight the issues faculty identify as driving gendered retention, and specific policy recommendations to improve retention.

Results I. Longitudinal Analysis We find that across 10 years of observation, at every career age, women faculty are more likely to leave their academic jobs than men—7% more likely as assistant professors, 21% more likely as associate professors, and 29% more likely as full professors—and less likely to be promoted than men—7% less likely as assistant professors and 12% less likely as associate professors (z-test, all $p < 0.001$). The persistence of gendered attrition and promotion patterns across career age contrasts claims that a lack of gender diversity among senior faculty is primarily due to slow demographic change and long career lengths [8]. The gendered attrition pattern we observe predicts that, for a hypothetical gender-parity cohort of new faculty, women's representation would fall to 40.6% after 35 years, a loss of nearly 1 in every 5 women faculty. Together, these results show a systematic effect in which women faculty leave academia at significantly higher rates than men, in all years of a faculty career. However, this large-scale statistical analysis says little about the reasons that women and men faculty leave academia.

II. Survey Analysis To understand why women faculty leave academia at higher rates than men, we applied an exploratory factor analysis to responses to our broad survey, based on four categories of faculty stress, grounded in the literature: research pressures related to the job itself (i.e., obtaining funding, scholarly productivity), work-life balance stressors related to juggling work and life (i.e., caring responsibilities, hours worked), workplace culture stressors related to how an academic feels around their colleagues (i.e., dysfunctional departmental culture or leadership, harassment), and departmental support stressors related to the (lack of) external support by their departments (i.e., salary, lack of administrative support).

We find that women leave in response to different stressors than men. Women who left academia selected workplace culture reasons for leaving 1.3 times more often than research pressures, 1.6 times more often than work-life balance, and 1.9 times more often than departmental support. Across nearly all career ages, women identify workplace culture as the most prevalent reason for leaving academia, except in the very early career, when work-life balance briefly dominates. In contrast, men who left academia selected reasons from all four categories with roughly equal frequency throughout their careers. Both current and former women faculty are also more likely to feel pushed out of their jobs than pulled into better jobs, compared to men (t-test, $p < 0.001$). This was especially true for women of color. While there are some meaningful discipline-level differences, these findings hold true across academia, even in disciplines where the majority of faculty are women.

Via free response, we asked respondents to explain what needed to be different in their former or current jobs in order to reduce the stress they felt in their positions (current), or for them to stay in their positions (former). We characterized

the responses, then we estimated the themes and their relative frequencies. This qualitative analysis further emphasized the differential impact of workplace culture on women's retention, and also allowed us to derive additional insights about the causes of stress and leaving that are not fully captured by the survey.

Significance Individual faculty experience academia differently depending on their gender, race, and career stage. Our results broadly quantify the complex and structural nature of retention, and show that gendered retention patterns are ubiquitous, significant, and driven by differences in how different faculty experience academia and their disciplines. Specifically, while past studies focus on work-life balance reasons for women's differential attrition, our work shows that issues with workplace culture are the most common reasons, especially for older women. To achieve equity in academia, departments and institutions will need to address the underlying reasons, across all career stages, that drive these unequal outcomes.

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[7550] *Labor advantages drive the greater productivity of faculty at elite universities*

Sam Zhang (Sam Zhang), K. Hunter Wapman (University of Colorado Boulder), Daniel Larremore (University of Colorado Boulder) and Aaron Clauset (University of Colorado Boulder).

Abstract

Researchers at elite universities tend to dominate scientific discourse, with higher productivity and far greater prominence, and thus shapes the direction and pace of scientific discovery as a whole. Such dramatic disparities could be due to simple meritocratic sorting, reflecting genuine differences in individual scientific ability, but they could also reflect non-meritocratic factors like luck and structural advantages. Understanding which mechanisms drive this prestige-productivity pattern would shed critical new light on efforts to accelerate scientific discovery, and inform policies aimed at broadening participation.

Past work has shown that among early-career faculty researchers, placement at a more prestigious institution can cause greater productivity and prominence. That is, where you work is the greater determinant of your impact than where you trained. However, the particular mechanism through which prestige underlies this pattern remains unknown. Through multiple lines of evidence, we show that differences in available funded non-faculty scientific labor drive substantial prestige-productivity inequalities, and the scientific dominance of elite universities can be explained by their substantial labor advantage over researchers at less prestigious institutions, primarily in disciplines where faculty lead and collaborate with a research group. Our analysis leverages cross-disciplinary, longitudinal data on the education, employment, and publications of 78,802 tenured or tenure-track faculty spanning 4,492 departments across 25 disciplines in science, engineering, and the social sciences at 292 PhD-granting U.S.-based universities, over the period 2011--2017, which we combine with researcher-level productivity data encompassing 1.6 million publications from the Web of Science. We complement these data with institution-discipline-level counts of graduate and postgraduate (non-faculty) researchers, institutional covariates, and discipline-specific measures of prestige.

First, we show that faculty's annual productivity, measured crudely as their mean publications per year, increases substantially with environmental prestige, with elite researchers being roughly twice as productive as researchers at the least prestigious institutions. We isolate the component of total productivity that could be driven by differences in labor by partitioning each faculty's ``total'' productivity into two sources: (i)~group productivity (publications coauthored with non-faculty research group members), and (ii)~individual productivity (all other publications). In disciplines with group collaboration norms, a larger group will tend to drive greater group productivity, but not in disciplines without such norms. We show that in such disciplines, group productivity is both substantial and grows systematically with prestige, even as the individual group members are no more or less productive. Finally, we show that research labor is highly concentrated within the most prestigious environments, indicating that elite researchers tend to have larger research groups.

We then test this ``labor advantage'' hypothesis using a series of predictive models, showing that funded labor consistently plays a significant role in predicting productivity and group sizes in disciplines with research group

collaboration norms, but not in disciplines that lack these norms. Next, using a matching experiment on mid-career moves, we show that faculty who move to an environment with more available funded labor tend to have groups that are significantly larger after the move than those who go to environments with less labor. Finally, we quantify a systematic relationship between larger faculty group sizes and greater group productivity that is independent of prestige.

Taken together, these results identify the environmental mechanism by which prestige drives greater scientific productivity, and show that it is the profound labor advantage of elite working environments that allows their scientists to dominate scientific discourse. More broadly, our findings suggest relatively simple interventions for both increasing scientific productivity and increasing the diversity of scientific advances. Accounting for the non-meritocratic effects of research environments will be an important component in developing predictive theories of knowledge production.

[4043] *Labor-market placement of doctorate degree holders in Norway*

Eric J. Iversen (Nordic Institute for Studies in Innovation, Research and Education) and Zacharias Andreadakis (Oslo Metropolitan University).

Abstract

The paper follows a complete population of doctorate holders ("Phds") in the Norwegian labor market across the period 2009-2018. Firm-level labor data (LEED) is used to study how PhDs change jobs within and between economic sectors across time in the Norwegian economy. Observing that an increasing share of PhDs move into non-academic sectors, we explore what the non-academic labor-flows of PhDs reveal about innovation in the modern (knowledge) economy. We find that PhDs tend to cluster into a set of distinct, 'skill-related' sets of industries (NACE), with the largest centered around the university. Our findings can help to orient the current policy discussion about this important part of the labor-force and to suggest empirical approaches going forward.

[6848] *Obstacles to Innovate and the Role of Public Funding: Evidence from Chile*

Juan Carlos Castillo (UNICAMP (Universidade Estadual de Campinas)) and Nicholas Vonortas (The George Washington University).

Abstract

Background and rationale Public funding for Science, Technology and Innovation (STI) is generally assessed in terms of its pertinence for the successful termination of inventive outcomes. Nonetheless, its projected influence on other key factors that might also shape innovation performance across companies remains largely unexplored. These include the role played by such subsidies in stimulating likelihood to innovate and even in fostering a higher resilience to sort out those financial and non-financial obstacles usually encountered by firms along the road. The primary purpose of this paper is to fill such existing gap.

We therefore study firm-level elements configuring propensity to engage on innovation strategies (product and process innovation), together with the adaptability of these in the presence of barriers to innovate, both for the case of firms subject to public funding as well as for those that are not. Chile's Innovation System is herein referred as a case study due to its recent noteworthy performance as one of Latin America's inventive hubs. The 9th to 11th module of the country's innovation survey (spanning the 2013-2018 period) constitute our main source of micro information.

Methods Our econometric strategy is based upon a Multinomial Logistic Regression analysis (MLR). Two type of model specifications are derived from such approach: a baseline model solely accounting for innovation probability determinants, and a second multinomial regression where each of these latter elements are individually interacted with a given obstacle. In line with the MLR method, our dependent variable (inno_outcome) is built by classifying manufacturing firms into four categories that signal the execution of different innovation alternatives: (1) firms exclusively practicing product innovation; (2) those following process innovation only; (3) companies being able to implement both (top inventive firms), and (4) those other without either strategy. This latter fourth group of companies (labeled as potential innovators) are included in the form of a baseline sample within each of our econometric specifications.

Individual expenditures on intramural and extramural R&D, the use of intellectual property rights, the total amount of labor employed by the establishment (proxy for size), cooperation agreements with other firms along with the presence of scientific ties with research institutions comprise the set of independent variables explaining probability to innovate. Obstacle-related MLR estimators are then generated by interacting each of these with the following barriers: financial difficulties (lack of funding, prohibitive costs to innovate), knowledge disincentives (scant information about the availability of highly skilled personnel and/or latest technologies), network restrictions (failure to cooperate with other economic units) and, market obstacles (prevailing uncertainties with regard to future demand, market being dominated by well-established producers, etc.). Given our research objective, this empirically strategy is applied for two types of firms (Chilean firms with public subsidy and those without).

General results Alleviating size-related limitations to innovate, strengthening the relevance of intramural R&D funding and, encouraging the signing of more cooperation agreements with other firms (in spite of the presence of monetary and non-monetary barriers) represent the main supplementary benefits that stem from access to government support. While extramural R&D and intellectual property protection are found as critical and generally resilient elements to increase likelihood to innovate for the average inventive firm, our research notes that publicly supported (less innovative) companies fail to also utilize these two as pivotal instruments for the completion of scientific outcome (their respective regression coefficients are non-significant). Surprisingly enough, possibility to innovate (for all type of firms) seems to be reduced by the presence of scientific ties with research institutions. Such negative impact is neither drastically deepened by the presence of innovation barriers nor improved by public funds.

Policy implications These general results have strong implications for those developing economies seeking to evaluate the effectiveness of their innovation policy beyond mere indicators of R&D investment and their resulting output. Our empirical evidence illustrates additional indirect effects that can originate from granting public resources to less innovative companies. Alleviating barriers to size, nurturing cooperation skills coupled with the advancement of superior abilities to efficiently exploit intramural R&D investment, irrespective of obstacles of any sort, encompass some of the extra benefits that can be induced by government funding. Areas of innovation policy enhancement are also here put forth. To properly rely on intellectual property protection, extramural R&D as well as on collaborative projects with research institutions, less innovative companies require additional and tailored specific instruments of government support. Public funding, alone, does not seem to have a profound effect on these latter set of factors across Chilean innovators.

[1086] *Biomedical Entrepreneurship in U.S. Regions*

Sang-Min Park (Ministry of Science and ICT) and Nicholas Vonortas (George Washington University).

Abstract

1. Background What are the key factors of a vibrant entrepreneurial ecosystem? In this quest scholars and practitioners have proposed several factors for successful ecosystems (e.g., Feld, 2012; Isenberg, 2011; Kim, 2015; Mack & Mayer, 2016; Spigel, 2017; World Economic Forum, 2013 Policymakers may encounter several challenges in the effort to apply best practices in their contexts. First, would factors singled out in a different location work well in my region? The question becomes relevant in light of the fact that each region has a different condition, development history, and characteristics (Edler & Fagerberg, 2017). A replicated policy may not work in a different environment even though it is considered an essential condition somewhere else. Second, are the factors identified somewhere else sufficient for my region? Policymakers need to consider the set of conditions that identify their regions. Third, what are the effective configurations of regional conditions leading to high levels of entrepreneurship? In this paper, we specifically focus on the biomedical entrepreneurial ecosystem.

2. Methods We construct an analytical model designed to incorporate sets of regional conditions that promote biomedical entrepreneurship. The model is cognizant of the process of biomedical knowledge flows from scientific discoveries to several stages of clinical trials to sales and marketing. We posit that a successful biomedical business critically depends on 1) scientific knowledge, 2) commercialization capacity, 3) extant entrepreneurial base, and 4) supporting infrastructure. We extract ten key factors: public biomedical R&D, private biomedical R&D, human capital, translational research, biomedical patents, clinical trials, per capita income, population density, the local presence of established large biomedical firms, and venture capital investment. We argue that these factors collectively contribute to the regional biomedical entrepreneurship as approximated by the number of the National Institutes of Health (NIH) Small Business Innovation Research (SBIR) program grants. The data cover a period of ten years, from 2006 and 2015, and they have been collected from diverse sources including the NIH, National Science Foundation (NSF), U.S. Patent and Trademark Office, U.S. Census, U.S. Bureau of Economic Analysis, Pitchbook, and Compustat.

We use the fuzzy-set qualitative comparative analysis (fsQCA) in order to identify the configurations that are linked to high levels of biomedical entrepreneurship in all 381 U.S. metropolitan areas. Our conjecture is that different sets of conditions could lead to the same outcome, and that individual factors cannot decide the outcome since each condition could have a different effect on the others, depending on the often-complex development history and policies of a region.

3. Results Three pathways are identified to lead to high levels of biomedical entrepreneurship in a region. The first combines public biomedical R&D, biomedical patents, and human capital, thus stressing the conditions that promote scientific activities in the biomedical sector. This configuration is consistent with the literature emphasizing the role of science and human capital in the biotech business (Pisano, 2006; Zucker et al., 1998). Additionally, it sheds light on the core role of biomedical IPR (patents) in promoting biomedical entrepreneurship, in line with the knowledge spillover theory of entrepreneurship, which indicates that more knowledge production would lead to higher levels of entrepreneurship (Acs et al., 2009; Audretsch, 1995).

The second combines public biomedical R&D, biomedical patents, clinical trials, and venture capital investment, thus placing more emphasis on the regional infrastructure that promote entrepreneurial activity. As Qian et al. (2013) have noted, population density can facilitate knowledge flow through the close and frequent interactions among potential entrepreneurs. The size of the regional venture investment reflects whether a region can provide the sufficient financial support such as through the market, the banking sector, or other sources of risk capital. The inclusion of clinical trials may reflect the concentration of infrastructural facilities (e.g., hospitals) that carry out clinical trials.

The third combines private sector biomedical R&D, biomedical patents, human capital, per capita income, population density, and venture capital investment. Interestingly, biomedical R&D by private firms appears in the configuration. This configuration, without the public biomedical R&D component, implies that regions with strong private firms conducting biomedical R&D may also have a vibrant biomedical ecosystem with other complements presented above. This inclusion of private firms' role may support the anchor tenant hypothesis by Agrawal and Cockburn (2003), and Feldman (2003), that suggest the extensive roles of the established firms.

4. Significance and discussion The identification of the three primary pathways for regional biomedical entrepreneurship engenders several significant implications. First, there is no single recipe for a region to increase its level of biomedical entrepreneurship. Second, a region does not necessarily need to possess all (ten) examined factors in order to have a vibrant biomedical business sector. It is also important that a region must assemble the proper set of conditions for success. Proper interaction between such conditions will generate the desired outcome. Third, a few core conditions are key for most of the pathways: public and public biomedical R&D, related IPR (patents), and venture capital. The three configurations emerging in the previous section, with their respective combined conditions, are sufficient to achieve high levels of biomedical entrepreneurship.

The findings in this analysis can certainly inform regional policymakers. Assuming reasonable presence, the regional officers need to identify the supplementary conditions that will allow them to choose the pathway more relevant to their region. They may, then, embark on a more well-planned journey to acquiring them in order to achieve sustainable levels of biomedical entrepreneurship. Regional policy to that effect should focus on increasing research capacities in the biomedical field. For instance, state governments could help research institutions by initiating research funding programs with emphasis on biomedical and life science fields. Furthermore, given that research in this high technology field depends heavily on sophisticated and large infrastructure, it might also be important to support regional research institutions obtain access to state-of-the-art facilities. Supporting activities for intellectual property protection in the biomedical field should also be in focus. Such support can come through various channels such as public awareness, IP identification, and legal and financial support.

[3194] *Gender and attrition in the changing nature of scientific work*

Seokkyun Woo (Northwestern University) and You-Na Lee (Georgia Institute of Technology).

Abstract

Under-representation of women in science has been a longstanding phenomenon (Bayer & Astin, 1975; Etzkowitz et al., 2000; Larivière et al., 2013; Long & Fox, 1995; Preston, 2004; Zuckerman & Cole, 1975). Not only do women face more structural obstacles when entering science (Cimpian et al., 2020; Leslie et al., 2015; Reuben et al., 2014; Zuckerman & Cole, 1975), but they are also more likely to leave science and pursue non-scientific careers (Etzkowitz et al., 2000; Huang et al., 2020; Preston, 2004).

Prior studies examine gender inequality in science in terms of non-universalistic evaluation standards (Jappelli et al., 2017; Long et al., 1993; Long & Fox, 1995) or training opportunities (Moss-Racusin et al., 2012; Sheltzer & Smith, 2014; Stockard et al., 2021), family obligation (Cech & Blair-Loy, 2019; Fox et al., 2011), unequal positions in social network (Fox, 2006; Leahey, 2007; Xie & Shauman, 1998), and returns to their accomplishments (Ghiasi et al., 2015; Hofstra et al., 2020; Lerchenmueller & Sorenson, 2018; Reskin, 1976; Van der Lee & Ellemers, 2015).

Although those prior studies point out important factors that are attributed to perpetuating gender inequality in science, they often view gender inequality among scientific workforce in isolation from the changing nature of scientific work. As science is increasingly becoming a team-based, collaborative activity and the size of teams gets larger and larger (Adams et al., 2005; Wuchty et al., 2007), scientific work becomes increasingly bureaucratized, which is characterized by hierarchy, standardization, and division of labor (Pugh et al., 1968; Walsh & Lee, 2015; Weber, 1978). In particular, division of labor generates specialization in supporting roles (Hackett, 1990; Hagstrom, 1964; Walsh & Lee, 2015). At the same time, the increasing demands for productivity generate a growing need for supporting scientists whose primary role is supporting the leading scientists of projects or labs (Lee & Walsh, 2022). Therefore, the changing nature of science has been generating more and more supporting scientists whose work is critical to the production of science but who holds a more vulnerable status with unstable career paths than the leading scientists, e.g., academic principal investigators (PIs) (Lee & Walsh, 2022; Walsh & Lee, 2022). Milojević et al. (2018) show that a growing fraction of researchers spend their

careers only in supporting roles, measured by those who have never been lead authors in their publications, and that these supporting scientists tend to have shorter careers than lead scientists.

This change in the composition of the scientific workforce may also exacerbate gender inequality in science. If those who have a more vulnerable status may get pushed into more vulnerable positions, female scientists may be more likely to be supporting scientists, and further have higher attribution than male scientists. Therefore, in this study, we empirically explore gender and attrition in science in terms of different roles in research collaboration, i.e., leading scientist vs. supporting scientist.

Using data on publishing careers from 1971 to 2012 from selected natural and social science fields (2,268,176 scientists in total), we find that women were historically more likely to spend their careers as supporting authors. However, we find this gap has been converging over time and recently flipped in natural sciences. Interestingly, this convergence has been overwhelmingly driven by a decreasing share of lead authors among men. Furthermore, statistical analysis using survival models shows that both women and supporting authors are more likely to leave publishing careers. However, among women, the supporting role has an especially high exit risk in social sciences, while the lead role has an especially high exit risk in natural sciences. In other words, female supporting authors are relatively worse off in social science than in natural sciences. We argue that natural science fields have provided a more rationalized and standardized career path for supporting scientists than social science, which is relatively more beneficial for the group that has traditionally a lower status, i.e., female supporting scientists.

We will further examine the primary tasks performed by male and female supporting scientists and other characteristics such as their novelty at the beginning of their careers and see how these may explain different representation and different rates of attrition. The results of this study will help us understand gender inequality in science in the context of the changing nature of science. Future research can examine how traditional drivers of gender inequality such as non-universalistic evaluation standards, training opportunities, and family obligation can explain representation and attrition in science between male and female scientists in different roles.

[5230] *Induced innovation revisited: the development of US battery storage*

Min-kyeong Cha (Georgia Institute of Technology).

Abstract

Background: This study will focus on how demand-pull drivers (environmental policies and market factors) and knowledge accumulation can affect the innovation of renewable energy technologies. In order to abate greenhouse gas (GHG) emissions and slow climate change, the urge for green transition has risen partly because of skyrocketing oil prices and the insecurity of natural gas. However, what contributes to the progress of green technologies still remains in question. Since its initial development by Hicks (1932), economists have focused on 'induced innovation,' where a change in market factors (such as energy price) spurs innovation to reduce the use of expensive factors. The induced innovation hypothesis has also been expanded to policy intervention: environmental policies can induce technological change (Jaffe, Newell, & Stavins, 2003; Popp, 2002), which leads to increased demand for new technologies. Based on the literature, this study incorporates several factors found in previous research and explores the different scopes of analysis. The literature on induced innovation of renewable energy technologies focuses on two primary topics - how environmental policy or factor price affects innovation at the national level. For instance, Kim & Brown (2019) find that energy-efficient policy and Research Development &Demonstration (RD&D) expenditure lead to lighting technologies patents. Lindman & Söderholm (2016) find positive effects of FIT and public R&D, as well as the interaction of those policies, on wind power patents. In its seminal work, Popp (2002) includes 'knowledge stock,' which is a crucial factor affecting technological innovation, along with energy price and government R&D, and presents the effect of energy price and knowledge stock on the development of energy-efficient technologies.

Model & Data: The study explores how two different channels - ① demand-pull drivers (factor price and renewable energy policy) and ② knowledge stock - influence technological change. The first channel, demand-pull drivers, include energy price and Renewable Portfolio Standards (RPS), a regulatory mandate to increase renewable energy sources. In the second channel, knowledge stock is the accumulation of knowledge, which is another crucial factor in innovation. The focus of the study is battery storage technology in the United States. The battery storage technology, one of the essential components in the transition to renewable energy as complements to solar panels and electric vehicles, would be a great example. The development of battery storage technology has occurred rapidly in recent years. The patent activities have increased quickly while the cost of batteries has dropped. In addition, each state has different battery storage capacities: a few states, including California or Texas, account for more than half of the total battery storage power capacity. The study focuses on states, unlike previous induced innovation studies primarily with national-level analysis. Therefore, it could reflect the characteristics of the new green transition. The main impact of renewable energy is that it promotes a distributed, decentralized system as opposed to a conventional centralized market. Unlike homogenous fossil fuel electricity generation, regions differ in developing different kinds of renewable energy according to their geographic

features. At the same time, consumers purchase solar panels in their home and generate their electricity and even sell it back to the grid, in contrast to traditional electricity that is provided to consumers solely by power plants. Using energy price data from EIA, state RPS data, patents from USPTO, and other state-specific data, the effect of two channels and possible interaction is considered.

Anticipated Results & Contribution: The study expects to present multiple dimensions of induced innovation. First, the results would show how different channels, demand-pull factors and knowledge stock, each influence the increase in battery storage patent activities. Second, it will also show interaction effects within channels, for instance, RPS affecting energy price and patent activities simultaneously. I believe this study could contribute to the current literature on induced innovation by (1) capturing the inclusive dynamic of induced innovation, including different channels that have been found to spur technological change, and (2) looking into state-level actors, reflecting the market which has been becoming more segmented and decentralized due to the characteristics of renewable energy.

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[8858] *Changes and characteristics of science and technology policy due to COVID-19 -Focusing on the case of Korean government R&D investment-*

Minki Kim (Korea Institute of S&T Evaluation and Planning) and Jonghwa Park (Korea Institute of S&T Evaluation and Planning).

Abstract

Science and technology have played a leading role in preparing for a new era at each stage of Korea's economic and social development for the past half century. The government-led strong technology drive policy has become a driving force for Korea's major industries such as automobiles and semiconductors.

In this study, we will look at changes through science and technology, which is a sure preparation for the huge social changes caused by COVID-19 and an uncertain future, and analyze how the direction of innovation policies across social and industrial fields is changing due to COVID-19. .

Due to COVID-19, non-face-to-face and remote culture has spread, competitiveness in the bio field has become more important, nationalism has been strengthened, and risks have become routine.

Therefore, this study analyzes how these changes have affected Korea's science and technology innovation policy and suggests a direction of policy change.

The Korean government has presented the following major policy directions to strengthen the role of science and technology in a national crisis. In order to turn a crisis into an opportunity, the R&D model centered on the private sector was spread, and the industry's ability to respond to digital transformation and strengthen its self-reliance. In addition, a crisis response system in which industry, academia and research institutes cooperate based on science and technology has been established for crisis response.

First, in order to spread the R&D model centered on the private sector, a new R&D model was introduced and spread by delegating the full power of planning and management to private experts and supporting innovative system improvement such as competitive methods and internarional evaluation.

In order to accelerate the digital transformation, infrastructure investment through the Digital New Deal and the spread of various convergence services supported the smartization of industries (automation and intelligence) and enhancement of regional innovation capabilities. It is promoting digital transformation by supporting R&D for next-generation Data-Network-AI (DNA) core technology and spreading convergence to all industries. Expanding for the application of DNA technology to overcoming limitations in each industry and solving social problems, and apply digital innovative technologies such as cloud, IoT, digital twin, and block chain to various fields such as finance, medical care, manufacturing, and automobiles to create new industries and services.

To revitalize the non-face-to-face economy, we are strengthening support for core technology development and commercialization, and strengthening support for core technology development such as XR and 5G-based immersive content technology (high-quality voice and image quality technology, personal media technology, etc.) necessary for digitization of social and economic activities. . The government is also expanding support for the creation of non-face-to-face innovative services, focusing on areas with high non-face-to-face demand, such as education, distribution, and medical care. In addition, in order to improve efficiency and stability through digitalization of public infrastructure, it is

preparing to improve the productivity of public infrastructure by securing the basic technology for smartization of aviation, road, railway, and city management and port and construction.

In preparation for periodic national crises that affect national life and national security, the crisis response system was strengthened in which the science and technology circles rapidly mobilize their capabilities to predict and respond in advance, and to suggest solutions to crisis situations. In each major crisis situation, government research institutes are designated as dedicated research institutes, and based on technical monitoring method setting and information sharing, proactive monitoring and crisis response R&D functions are strengthened and rapid emergency response research promotion system was established.

We are responding to global issues such as carbon neutrality in order to strengthen R&D for solving social problems based on social problems and to contribute to improving the quality of life. In addition, in order to promote structural transformation of society and economy, it is focusing on strengthening the industrial ecosystem and supporting technological innovation.

Responding to changes in the future social structure such as a super-aged society, strengthen R&D to improve the health and enjoy a pleasant life of the elderly population, systematically predict and manage disasters, and invest in the prevention, response, and recovery of accidents at construction and industrial sites It is also expanding R&D investment to secure public safety.

Before the corona pandemic, basic research, research for industrial development, and challenging research were emphasized by era, but recently, mission-oriented research to solve problems tends to be emphasized. As economic growth is slowing and investment in R&D is stagnant, it can be seen as a tendency to more clearly emphasize the direction of R&D.

As a concept that emphasizes the problem-solving function of R&D, mission-oriented research is emerging. It is a method of deriving a specific mission from a problem, identifying the science and technology necessary to achieve the mission, and conducting necessary research. Mission-oriented research is research carried out with the resolution of very difficult problems as its mission. It tends to be pursued with the goal of solving regional or national and social problems.

[1346] *The impact of innovation cluster policies on Energy-transition: Learning from leading energy clusters in Germany.*

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Abstract

Introduction:

Innovation clusters are often known as innovation ecosystems and have a significant impact on the German economy and regional development. Different federal states already have placed various cluster policies to support the cluster initiative. These policies are designed to congregate diverse actors (e.g., SMEs, large companies, research institutes, and regional institutions) with similar interests in particular demographic proximity [1]. Moreover, clusters with excellence in energy topics also lead territorial energy-transition and support multiple actors to develop rapid and scalable innovations. Seen in this light it became a natural interest for policymakers, investors, and firms to analyze the ongoing activities of leading energy clusters. Such analysis could give a broader overview of current trends and the mutual interest of a diverse set of stakeholders. In this context, the present work considers analyzing energy clusters with different perspectives such as geographical scope, members companies, and focus topics. A total of 44 energy clusters along with 4524 members are taken into account in this study.

Background and Context:

In the literature, the theory of innovation clusters has been widely studied by various scholars. There are different approaches have been developed to analyze an innovation cluster. These methods include namely qualitative analysis, interviews, patents, etc. Nevertheless, the majority of approaches rely on either controlled input (e.g., cluster manager interview) or a lack of updated activities (e.g., patent analysis) [2]. Along these dimensions, previous studies were unable to provide ground activities of energy clusters and lacked providing the real impact of various energy cluster policies. Following the discussion above the present work has tried to answer the following research questions.

Research questions:

1-Who are the major actors involved in setting up an energy innovation cluster and how these clusters are organized to meet the goal of various participants? 2-How unstructured data from the cluster and their member's websites can be used to gain insight into recent innovative activities in the energy sector?

From the theoretical point of the view, the work has provided a comprehensive overview of major cluster policies in different federal states of Germany.

Methodology:

Over time website data is thriving and is considered as an essential source to measure emerging innovative actions. In this context, the energy-cluster website contains the most updated about cluster activities such as ongoing activities, events, projects, and publications. Therefore, the proposed methodology primarily banks on the website data. As an initial step, a list of energy clusters is obtained from the Cluster platform Germany [3]. A total of 44 energy clusters along with 4524 members are taken into account in this study. Furthermore, an internally developed web-scraping tool is used to crawl the cluster and member's data. The tool performs systematic and guided web-scraping for searching a keyword presence on the particular web-page. Two distinct sources namely European Structural and Investment Funds (ESIF) and Scival platform are used to mine energy-innovation related keywords. Different categories and sub-categories are assigned to cover a wide range of topics and actions related to major energy fields. Moreover, a commercially available company database is used for matching firms in the member's list. Python based natural language toolkit (NLTK) is used to clean the data and different analytics such as co-relation analysis of topics, decile ranking, and frequency analysis is done by utilizing text data.

Main outcomes: The main result highlights are summarized below:

• The work has analyzed the major actors driving cleantech innovation clusters in Germany. To this end, the composition of different clusters has been analyzed. Similar to innovation clusters active in other fields, the key members in an energy cluster are firms (Large, Medium, Small, and Startups), research institutes, universities, public organizations, and financing actors. However, cluster composition in the energy sector is also populated with several other actors (e.g., Training centers, Innovation matchmakers, co-working facilities, innovation consulting, etc.) and individuals.

• The overall results have indicated that the majority of energy clusters are very specialized in certain topics such as hydrogen, carbon, and bioenergy and are getting notable attention from various stakeholders. In addition, various cross-sectoral topics (e.g., bio-hydrogen, Organic solar cells) are also emerging due to the growing interaction between different sectors.

• Energy clusters and their member count is unevenly distributed in Germany. Therefore, new policy measures are required to create a supportive framework for the regions with relatively lower participation.

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[400] *Funding excellence and universities' staff recruitment: evidence from the Italian 'Department of Excellence' program*

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Abstract

'Excellence' rhetoric has been pervading science policy in recent years, with funding increasingly concentrated due to its allocation mainly based on scientific performance indicators. This work aims to investigate the effect on staff recruitment of a policy of excellence directed towards Italian university departments. We observe 289 Italian university departments over the period 2013-2020, with about half of them receiving the excellence award. Our empirical strategy looks at changes in annual positions filled in the departments receiving the award relative to the non-receiving departments before and after the official start of the program (2018). We estimate this using an event study model in a non-staggered timing setting (all departments were treated in the same year) that allows us to assess the evolution of relative outcomes while controlling for fixed differences across departments and national trends over time. Results show that receiving the award, on average, generates more hires. However these hires mostly concern career advancement. Additionally, second tier departments tend to benefit more from the award than first tier departments, and in particular they hire more tenured track researchers. This evidence raises important food for thought with respect to the dissemination of policy initiatives for financing excellence.

[6106] *Cross-category spillovers in medical research*

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Abstract

Whether research funding is targetable is one of the central unresolved questions of science policy. A particular question is how often research aimed at understanding one disease or problem spills over to others. This has been a perennial topic of debate at the world's largest single funding body of biomedical research, the U.S. National Institutes of Health (NIH). Critics of the agency's priority-setting process have repeatedly called for better alignment between funding and disease burden, and patient advocates for specific diseases for more funding for their causes. In response, opponents of planning have argued that research in one area frequently leads to advances in others. In this paper, we provide new evidence to inform these debates by examining the extent to which research funding (grants) in one scientific or disease area leads to research findings (publications) in another. We used the NIH's Research, Condition, and Disease Categorization (RCDC) to identify categories for NIH grants awarded between 2008 and 2016. We applied machine-learning to map text to these categories and use this model to categorize publications resulting from these grants. We categorized over 1.2 million publications, resulting from over 90,000 grants. We found that 70% of the publications have at least one RCDC category not in its grant, which we termed "unexpected" categories. On average, 40% of categories assigned to a publication were unexpected. After adjusting for similarity across some of the RCDC categories by empirically clustering the categories, we found 58% of the publications had at least one unexpected category and, on average, 33% of publication categories were unexpected. Our results suggest that disease-orientation and clinical research were less likely to be associated with spillovers. Grants resulting from targeted requests for applications were more likely to result in publications with unexpected categories, though the magnitude of the differences was relatively small.

[8171] *Did Education Policymakers Overlook Relevant Scholarly Research during COVID-19?*

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Abstract

Introduction

During the COVID-19 pandemic, policymakers in education have been tasked with creating policies to mitigate the impact on students' learning outcomes. The availability of new research related to COVID-19 has presented an opportunity for education policymakers to use the most up-to-date information when making decisions. However, it has been found that despite the large number of scholarly papers published during the pandemic, education policies tend to cite older pre-pandemic research. This case study aimed to investigate if education policymakers' preference for citing older research is due to a lack of relevant newer research or if older research is of higher quality.

Methodology

We began by identifying 2,452 COVID-19 education policies from 176 governmental sources worldwide on Overton. Next, we extracted the DOI of each cited scholarly paper in these policies, matching them with 8,818 records using Elsevier's International Centre for the Study of Research (ICSR) Lab database. An initial analysis found that over 75% of scholarly papers cited in COVID-19 education policies were published before 2020, despite the availability of over 450,000 papers on various aspects of the COVID-19 pandemic indexed on Scopus.

To test our hypothesis that policy makers cited older studies because new research published during the pandemic was not relevant or of poorer quality, we used a combination of citation analysis, natural language processing, and regressions. Specifically, we identified the Scival Topic ID for each cited paper published before 2020, and then filtered each topic for uncited papers published after 2020. This resulted in grouping 6,600 cited papers into 2,589 topics, and matching these to 5.2 million uncited publications published after 2020.

However, processing over 5.2 million publications is a resource-intensive task. To minimize computational demands, we reduced our database to topics where the ratio of cited to uncited papers was at least 1 in 500. This reduced the corpus to 695 topics covering 7,131 cited papers and 555,259 uncited papers. Applying this filter captured over 80% of the cited papers while reducing the computational requirement by at least 90%.

For the reduced corpus, we vectorized the abstracts of both the cited and uncited papers using term frequency-inverse document frequency (TF-IDF) and calculated the cosine similarity between the vectorized abstracts of cited papers and the uncited papers within each Topic ID. After a stepwise manual validation, we considered two abstracts similar if they had a cosine similarity score of at least 0.25.

To test the influence of research quality on policy impact, we ran two regressions, a logistic and Support Vector Regression, on the papers matched in the previous step. For both regressions, our dependent variable was whether a paper was cited in policy or not, while our independent variables comprised a mixture of quantitative proxies of research quality, including a paper's field weighted citation index (FWCI), the publishing journal's CiteScore, and the average h-index of a paper's co-authors. We also added open access level as an independent variable to control for possible issues with access to research.

Results

Our results reveal a significant disparity between fields in terms of policymakers' ability to cite new research. Specifically, education policymakers were better at citing new medical research over social science research, including education research. Our initial analysis showed that most cited papers that were published after 2020 were medical, while the majority of cited social science papers, including education research, were published before the pandemic.

Furthermore, our analysis showed that policymakers' preference for citing older papers is not due to a lack of relevant modern research. In fact, we found that 51.2% (3,397 of 6,627) of the cited papers published before 2020 were matched with at least one similar paper published during the pandemic. This rate varied significantly between fields, with sociology research having the lowest matching rate of 33%, while cited paediatric papers had the highest matching rate of 77.8%. On average, there were over 70 similar papers published during the pandemic for each of the matched pre-pandemic papers.

We also found no observable relationship between research quality and policy impact. Both regression models failed at predicting policy impact, and a machine learning prediction model had a very low recall rate (<10%) for identifying papers that would be cited in policy based purely on the research excellence parameters used in the model. Only FWCI and average author h-index were statistically significant variables. However, the high coefficient for FWCI (0.23) can be explained by the fact that newer research papers have had less time to accrue citations. These results indicate that research quality does not necessarily translate into policy impact in the context of COVID-19 education policy-making, and that other, non-academic factors could be influencing which research was cited in education policy.

Discussion

The case study was able to empirically show that policy makers often rely on a narrow range of scholarly evidence, rather than drawing upon the full range of available research. Education policymakers have not taken full advantage of the vast volume of COVID-19 research published during the pandemic, instead relying primarily on older research. One interesting finding is that education policymakers were better at citing new medical research over social science research, pointing to structural issues in the diffusion of knowledge from academia to policy. This finding highlights the importance of not only conducting research but also disseminating and communicating it effectively to policymakers in different fields.

The matching algorithm also found that policymakers' preference for citing older papers is not due to a lack of modern research. Instead, the algorithm was able to identify similar papers published during the pandemic for over 50% of the cited papers published before 2020.Our analysis of the relationship between research quality and policy impact yielded surprising results. We found no observable relationship between research quality, as measured by various quantitative indicators, and policy impact. This implies that the impact of research on education policy is not solely determined by its quality, but other factors may also come into play, such as the perceived relevance of research to specific policy goals or the interests and values of policymakers.

Our study has important implications for education policymaking during crises. It highlights the importance of effective dissemination and communication of research to policymakers, particularly in social sciences. In the future, policymakers may need to adjust their approach to incorporate a wider range of scholarly evidence to ensure that policy decisions are based on the most up-to-date and relevant research.

[2658] *How Willing are Consumers to Electrify Their Households? Case Study of the U.S. State of Georgia*

Marilyn Brown (Georgia Tech), Cory Struthers (UGA), Snehal Kale (Georgia Tech), Min Cha-Kyeong (Georgia Tech) and Oliver Chapman (Georgia Tech).

Abstract

INTRODUCTION. Climate change goals cannot be met without electrifying large segments of the energy economy. Different energy subsystems vary in their ease of conversion to electric power. Rising to the top of many lists of

promising electrification opportunities are three household technologies that can reduce energy bills: electric vehicles (EVs), rooftop solar (RPV), and air-source heat pumps (HPs). These three technologies are on the innovation frontier of the low-carbon transition. In addition, they are potentially transformational because they are market-ready, their energy savings can exceed their upfront costs in many markets, and they could displace significant greenhouse gas (GHG) emissions.

MODEL AND HYPOTHESES. We develop a two-step nuanced model to examine a household's willingness-to-pay (WTP) for electrification technologies. The first step focuses on whether or not a consumer might pay for an EV, RPV, or HP. The "internal" variables highlighted in the theories of innovation diffusion and planned behavior are expected to be impactful (e.g., knowledge, attitudes, and social norms). In addition, various enablers and constraints are hypothesized to play significant roles. These are often overlooked, perhaps partly because they may be unique to specific technologies (e.g., access to charging stations for EVs, and home heating with natural gas or propane for RPVs and HPs).

The second step applies to those respondents who indicate a willingness-to-pay (WTP) for a particular electrification technology. It focuses on the minimum "return-on-investment" (ROI) from energy savings, that make these consumers willing to consider the adoption of an electrification technology. The internal variables highlighted in the theories of innovation diffusion [8] and planned behavior are expected to influence these minimum ROIs.

METHODOLOGY. We use the two-step Heckman model with two dependent variables that operate sequentially to test the validity of our WTP framework. This approach addresses selection bias by introducing two steps: in the first step, probit is used to examine the probability of "entering a sample," and in the second step, the dependent variable and the linear model that is the focus of the study is analyzed using OLS. In this process, the inverse Mills ratio (IMR), a selection parameter, is computed and added to step 2 to cope with selection bias. Our results indicate that the two-step model better reflects consumer preferences in our case study, compared to a one-step approach. Similar two-step frameworks have successfully used the Heckman model to deal with true zeros and selection bias, but we are unaware of any applications in the field of household decision-making with respect to EVs, RPVs, or HPs. We test this nuanced two-step model using data from an original survey of 1,800 adults living in Georgia, USA in 2021.

FINDINGS. Overall, attitudes, beliefs, and knowledge had greater predictive strength than socio-demographic variables. The most consistently significant predictors of being unwilling to pay for EVs, RPVs, and HPs are having low knowledge, being a Republican, having a low sustainable lifestyle, and not sensing a climate urgency.

Additionally, the probit models for each of the three technologies has one technology-specific constraint that significantly impacts respondents' willingness or unwillingness to pay (i.e., low mileage for EVs, heating with propane for rooftop solar, and heating with natural gas for HPs). This confirms our hypothesis that external constraints influence the perceived WTP for major household electrification technologies.

The second step of the WTP decision conjoins respondents' willingness to pay if their energy savings are sufficient and those willing to pay if a supportive policy were available. By facilitating a WTP for an additional 35% to 46% of respondents, both pay-as-you-save programs for rooftop solar and HPs and rebates for EVs appear to play a significant role in expanding the adoption of these technologies. With appropriate policy support, traditional barriers and constraints such as income are less significant predictors of adoption. Income levels were not found to be a significant predictor of ROI in the second step analysis that estimates the required savings to motivate WTP. The income effect was limited to only one technology – rooftop solar – and only correlated with the level of saving required for adoption.

Additional insight for defining a household's WTP for these technologies can be found by examining education levels and knowledge. High academic attainment does not necessarily equate to high knowledge of the three technologies and how Georgia produces and manages its energy. For all three technologies, knowledge was seen to be either a barrier to WTP or was correlated with the required savings; however, academic attainment was not. This finding suggests that policy focus should be placed on specific knowledge instead of formal education when targeting adoption.

The only common variables for all three electrification technologies were "sustainable lifestyle" and "age." In each case, more sustainable lifestyles and younger individuals were associated with a greater WTP. For age, younger respondents tended to be more enthusiastic about new technology and more willing to take on longer-term investments. Older respondents were found to be more risk-averse with shorter investment time horizons.

Targeting these common attributes in future policies and deployment programs warrants further consideration. These same common traits may be helpful to achieving adoption of other household electrification technologies and they may help promote product bundling, co-adoption, and sector coupling.

[8524] *Interactions among societal and professional RTDI actors in four different futures*

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Abstract

Background and Rationale There is a growing consensus in the literature that it is crucial to better align research, technology, development and innovation (RTDI) activities with societal needs. Hence, in Daimer et al. (2021) we focussed on the interactions between societal and professional actors (ISPA) in RTDI activities. These interactions can evolve by taking radically different directions, and thus we opted for developing scenarios to consider the possible futures of society, research, and innovation in the EU. Having considered 16 major factors that are likely to shape the future of societally engaged RTDI activities, workshop participants had concluded that the most influential factors are the prevailing ideological stances and political practices; in brief, the future of democracy in the EU member states. Thus, the political system, which is treated as an external condition in the innovation system literature, had been considered to have more impact on ISPA than other factors considered at the workshop. For example, the research and discussion about the future of responsible research and innovation (RRI), where our work stems from, takes place to a large part at an instrumental level, e.g., about developing and introducing the appropriate tools, methods, and policies to promote inclusive and transparent participation, or devising and applying the adequate evaluation instruments to identify and assess its benefits. However, these aspects are of secondary significance compared to the external conditions, especially the dominant ideology and the concomitant political system. We identified four radically different types of political systems: participatory, libertarian, authoritarian/ populist, and technocratic. In the Kingdom of RRI citizens participate directly in decision-making processes; Fortress Europe depicts a liberal-with-tendency-to-libertarian system; Failed Democracy is a populist-with-tendency-to-autocratic regime; while Benevolent Green Eurocrats describes a strong, technocratically coordinated state. Clearly, the idea of RRI as an anticipatory, reflexive, deliberative and inclusive approach is completely ignored, manipulated, or very selectively applied in the latter three scenarios. These scenarios depict somewhat extreme versions of distinct political regimes, relying on the dominant ideological stance, and hence they imply different ISPA framings. These four scenarios offered novel insights into the nature and repercussions of possible policy problems. We discussed issues related to efficacy of STI policies, efficiency of policy-making processes; legitimacy of research and innovation activities; societal involvement in RTDI activities; equity (as access to novel, superior solutions; and freedom of research in each scenario.

Methods All the (groups of) actors have some leeway to shape ISPA in these four different scenarios. The proposed presentation would extend Daimer et al. (2021) by considering the future of ISPA in these four futures. This simple exercise would juxtapose the aims, types, and forms of ISPA, on the one hand, and the major features of the four futures, on the other. Thus, we propose a deeper analysis of the scenarios presented in the paper. While scenario analysis can take different forms (e.g. participatory/ co-creative, qualitative literature-based extension, indicator development and quantitative modelling), our approach will be to substantiate different forms and developments of ISPA based on STS and political science literature.

(Anticipated) Results The main aims of a particular interaction range from popularisation of science and technology, dissemination of scientific and technological results, demonstrating their benefits to societies, and attracting young talents to start a career in research. More ambitious aims are to consider ethical and gender aspects of RTDI activities; assess emerging technologies, e.g. their expected societal, economic, and environmental impacts; discuss or jointly set research agendas at various levels (single organisations, regions, countries or group of countries); conduct and/or evaluate RTDI projects in collaboration; deliberate on current and future policy tools aimed at promoting RTDI activities and ISPA, as well as improving their framework conditions; and decide on public funds to support RTDI activities (again, at various levels). Achieving these goals would necessitate different types and forms of ISPA. For some, one-way communications might be sufficient, while others would require genuine dialogues or even collaboration among partners mobilising their different kinds of expertise, experience, aspirations, values and norms, worldviews, and ways of thinking. Clearly, various means and channels of communications and different types of activities would be appropriate for the above objectives of ISPA. Further, ISPA can be regular or ad hoc; formal or informal; open or closed (in terms of participation); systemic or sporadic; and transparent or opaque. Finally, ISPA can be genuine and substantive vs. tokenistic, even deceptive; inclusive and responsive vs. condescending and patronising; might develop vs. neglect citizens' capacities; and rely or not on co-creation of knowledge with citizens.

Significance With this approach in Daimer et al (2021) we contributed to the RRI literature in two ways: i) we considered possible, fundamentally different futures of society, research, and innovation, as opposed to analysing current or recent RRI practices and STI policies; and ii) we put the emphasis on the political conditions, as opposed to proposing future RRI principles and instruments per se. With the proposed presentation we aim to add to this by deepening insights on types, forms, and functions of ISPA in different political framework conditions. This would not only allow to revisit and deepen implications for policy as done in Daimer et al (2021), but also to discuss potential implications for societal and professional actors in RTDI, for example as regards required resources, capabilities, and institutions (formal and informal). The broader background this knowledge should be connected to, are the more fundamental changes in our societies, perceived and factual inequalities, leading to mistrust in actors and institutions (political ones but also other building blocks of societies, like the science system), and ultimately the fact that democratic systems are being challenged by these developments (as we saw again in the recent Swedish and Italian elections). Scenario analysis, and in particular the systematic derivation of 'action spaces' that can be shaped by the different actors sheds a new light on the responsibility of professional RTDI actors that matters already for todays' actions.

Reference Daimer, S, A Havas, K Cuhls, M Yorulmaz, P Vrgovic (2021): Multiple futures for society, research, and innovation in the European Union: jumping to 2038, Journal of Responsible Innovation, 8 (2): 148–174, DOI: 10.1080/23299460.2021.1978692

[7028] *Revisiting Research and Innovation Futures 10 years after: Devising policy insights against the backdrop of actual developments*

Stephanie Daimer (Fraunhofer) and Matthias Weber (AIT Austrian Institute of Technlogy).

Abstract

Background and rationale Introduced in the year 2000, the European Research Area has become the overarching framework for research and innovation policy (R&I policy) in the European Union. In a nutshell, it aims to better harmonize national and EU-level R&I policy in order to avoid duplication and contribute to the formation of critical mass in research and innovation in Europe. Even if the support for the ERA framework has varied with the changing mandates of the European Commission, it was renewed and updated first in 2010 and most recently in 2020 with a view to the time horizon 2030. The future of R&I, of European R&I policy and of the European Research Area was also the focus of two forward-looking projects funded by the European Framework Programme for R&I between 2012 and 2014: RIF (Research and Innovation Futures 2030: From Explorative to Transformative Scenarios) and VERA (Visions of the European Research Area 2030). Both projects explored alternative scenarios of how practices, organizational forms and institutional frameworks of research and innovation might evolve up to a time horizon of 2030, and what implications these scenarios may entail for R&I policy. The focus of analysis differs somewhat between the two projects, with RIF putting more weight on the practice and organization of research and innovation in a global context, and VERA focusing on the practices, organization and governance of R&I at the European level, but both projects focused at the future of European R&I policy and the European Research Area in particular. In this paper, we analyse the findings of these two projects with a twofold intention. First of all, we want to compare in what regards the two projects cohere in terms of anticipating a departure from strongly held beliefs in what should characterize European R&I policy in the early 2010s, i.e. whether the projected future scenarios differ or resemble each other in terms of their underlying principles (what we call "key tenets"). Secondly, we compare the scenarios with what was actually decided in 2020 as the guiding orientations for the European Research Area in 2030, i.e. at the time horizon that the projects addressed.

Approach and method The methodology of the paper is based on four main elements. Starting point are the fundamental principles of European Research Areas policy (key tenets) in the early 2010s. As a second step, and using these key tenets as a reference point, a meta-analysis of the RIF and VERA scenarios was conducted in order to analyse whether the scenarios maintained or departed from these key tenets. The insights from both projects are used in combination in order to have a more reliable and comprehensive basis of emerging ideas in relation to the future of R&I (policy) in Europe. The third step consists of analyzing the most recent update of ERA policy targeting a time horizon of 2030, and again focused on the five key tenets of ERA policy (and on possible new ones). Finally, by comparing the findings of RIF and VERA with those of the actual evolution of ERA policy, we are able to assess whether the two foresight projects were able to anticipate the actual evolution of ERA policy as part of the portfolio of scenarios developed.

Results The first result of our approach consists of the identification of fives key tenets of ERA policy in the early 2010s: • Key tenet 1 "Scientific excellence is a central pillar on which European RTI policy builds and from which major long-term benefits are expected." • Key tenet 2 "Public funding of basic and frontier research is justified by market failure arguments, and is not questioned." • Key tenet 3 "(Academic) scientific knowledge is claiming primacy over other forms of knowledge production." • Key tenet 4 "The integration and/or coordination of resources at European level are a pre-condition for effective and efficient ways of organizing research by avoiding duplication of efforts, concentrating on harmonized roadmaps, and ensuring critical mass." • Key tenet 5 "The main purpose of R&I is to create jobs and growth (in the old industrial economy)." The analysis of the five (RIF), respectively four (VERA) scenarios indicate first of all, that the emerging changes and weak signals in the ways of doing and organizing research and innovation point to the possibility of much more transformative changes ahead. We conclude that we should not take current wisdom on the fundamental beliefs in what makes up good R&I at face value, but continuously explore and question whether these beliefs are still valid. Secondly, RIF and VERA are quite coherent in terms of the projections and underlying principles of what might characterise R&I in 2030. The scenarios from the two projects do not provide identical views on how the five key tenets might change in the future, but the majority of projected future features are similar. Moreover, three pairs of scenarios feature similar characteristics and implications. As the projects drew on similar conceptual foundations and applied different, but mutually compatible methods for scenario-building, finding this congruence of internal scenario logics supports the overall consistency and validity of the two scenario sets. As regards the most recent revision of ERA Policy 2030, several of its novel elements were already identified in at least one of the two foresight projects. This also underlines the usefulness of foresight in anticipating sensible futures, even if they were regarded as "unrealistic" at the time of development. We also look into how the results of the RIF and VERA were taken into account in the design of ERA policy 2030, which would support the ambition of the ERA Policy 2030. In parallel, looking at the fundamental principles

("key tenets"), which remained untouched in the policy development so far, can give focus to policy discussions today. These principles should be revisited whether they are indeed still "things we can take for granted" or would need political attention and policy change as well.

Significance of findings The paper provides two significant insights into the anticipatory quality of the scenario development approaches used: (1) Scenario approaches with scenarios co-created by stakeholders and experts are suitable to develop disruptive future projections that question fundamental beliefs (i.e. they can go well beyond incremental change); (2) While disruptive projections in scenarios shall serve at the time of scenario-making mainly as tools to challenge current thinking and implicit assumptions, and thus do not need to be realistic, from a hindsight perspective as we take it here, it is relevant to know how future projections have materialized in order to assess the further ambitions of policy development and identify open issues that still should be on the political menu.

[2210] *The Geographic Content of Research: Stylized facts on the places that get studied*

Christian Chacua (Harvard University), Richard B. Freeman (Harvard University), Ricardo Hausmann (Harvard University), Vincent Larriviere (University of Montreal) and Cassidy Sugimoto (Georgia Institute of Technology).

Abstract

An increasing amount of works have studied the geographic dimension of research using publication data. Most of them traditionally rely on metadata associated with authors' affiliations, as they usually assign publications to the geographic location of their authors' institutions. Although this approach is useful for identifying the places where scientific knowledge is produced, it tells little about the places that get studied. The latter dimension is crucial, although often disregarded, as there is a potential mismatch between the places where authors work and the places they write about; the places that fund research and the places that get direct benefits from it; and, more generally, between the social demand for research where it is more needed and researchers' supply where it gets higher individual rewards.

We advance the understanding of the places that get studied, based on the geographic content embedded in research documents. In particular, we extract mentions of geographic places from titles and abstracts of scientific publications (geographic content) to identify broad empirical regularities worth further explanation (stylized facts). Our analysis concentrates on three main categories of stylized facts: what places get studied, who studies them, and who uses them. Besides listing general empirical patterns, we link our findings with ongoing debates on knowledge inequalities and knowledge diffusion to provide avenues for further research. Moreover, we discuss the potential implications for science policy of moving from a production-assigned to a content-based conception of geography.

We rely on Natural Language Processing (NLP) models for Name Entity Recognition (NER) to identify references to geographic places in the whole universe of documents in Microsoft Academic Graph (MAG). Specifically, we extract words that refer to geographic places from titles and abstracts in 13 languages, based on their contextual and grammatical role. In this way, we overcome some of the main constraints of related efforts, which usually rely on small samples of documents written in English, focus primarily on social and environmental sciences, and consider a bounded set of geographic locations.

We find that the places where knowledge is produced differ from the places that get studied. On average, 40% of all journal articles written in a country study foreign geographies. Likewise, 73% of all documents written about a country come from foreign-affiliated authors. By discipline, studying foreign geographies is more common in philosophy, physics, and arts, while it is less frequent in medicine, psychology, and business.

Most geographic attention concentrates disproportionately on a handful of countries. In absolute terms, geographic attention is concentrated in the US and China, as measured by the number of papers about these countries. Regarding their relative share in the world's population, the US, Australia, and European countries receive disproportionate attention. Relative to their share in the global GDP, the US and Nordic countries still received higher-than-average attention, although results vary according to the studied academic field. In all cases, African countries are the most neglected areas. Overall, geographic attention aligns with a country's income more than its population's share, and dollars of income tend to deserve more attention than individuals.

Our work has significant implications for research on the geography of knowledge. Until now, the geographic dimension of research has been reduced to the places where knowledge is produced. However, in an era of improved access to communication technologies, rise in collaborations, and increased high-skilled migration, we should expect a wide mismatch between where authors work and where they write about. Hence, understanding the empirical regularities of the places that get studied creates a new lens to raise new questions and develop alternative explanations on the geographic distribution of research.

For policymakers, understanding geographic content could reveal how research efforts translate into direct knowledge for the places they govern. In addition, geographic content analyses can help monitor how actors perceive specific geographies and how places benefit from the research produced (and funded) by others. Although increasing the number

of documents about a place should not become the main objective of science policy, unveiling what and why places get studied expands the analytical toolbox to assess the social impacts of research.

[8313] *Building resilient technology policy through public participation: The case of the Chilean National AI Strategy*

Jose A. Guridi (Cornell University), Julio A. Pertuze (Pontificia Universidad Catolica de Chile) and Cristobal Cheyre (Cornell University).

Abstract

Background The emergence of artificial intelligence (AI) as new general-purpose technology is influencing how societies shape their development models for the next decade (Bresnahan & Trajtenberg, 1995; Klinger et al., 2018; Trajtenberg, 2018). Even though the concept of AI was conceived in 1956, it was not until the last decade that AI's adoption scale, speed, and risks became a central policy challenge for governments (Taeihagh, 2021). Since the first national AI strategies publication in 2017, there has been an explosive increase to over 700 policy initiatives in more than 60 countries (OECD, 2021).

Recent studies and international discussions on AI governance have emphasized the need to build broad societal consensus around ethical principles and institutions (e.g., Calo, 2017; Gasser & Almeida, 2017; OECD, 2019; UNESCO, 2021). However, members of society with different imaginaries and expectations have different opportunities to frame what is relevant, urgent, possible, or inevitable in technology policy (Sand, 2019; Konrad & Boyle, 2019). Moreover, most AI policies have been developed by "domain experts," leaving "lay people" on the margin, failing to incorporate multiple visions. The latter is problematic because multi-stakeholder processes are becoming ubiquitous amid crises of trust and social unrest that have proliferated during the last few years.

Countries face difficulties in implementing and ensuring the continuity of AI strategies due to changes in governing coalitions and competing social priorities. For example, Mexico and Argentina published their strategies in 2018 and 2019, in the last year of their governments, and were not implemented in depth nor continued by the next governing coalition (Gómez Mont et al., 2020). This manuscript discusses how a participatory approach to AI policymaking can enable policies to achieve higher consensus and resilience. To do so, we conducted an in-depth analysis of the building process of the Chilean National AI policy, in which approximately 10,000 people participated through different mechanisms and stages. This is an interesting case to study as, unlike other AI policies in the region, the Chilean AI policy achieved a high degree of consensus–as measured during a public consultation before the policy was enacted–and has been able to withstand changes in government coalitions to date.

Methods We undertook a longitudinal case study research approach, accompanying and participating in the development of the AI policy between 2019 and 2022. Utilizing interview data, official documents, and transcripts of grassroots discussions, we mapped the AI policy development utilizing process tracing techniques (Garud, Berends, & Tuertscher, 2018; Langley, 1999, 2007; Van de Ven & Huber, 1990; Van de Ven & Poole, 2005). We chose this design because case studies have been used for modeling and assessing complex causal relationships (George & Bennet, 2005) and have been found helpful in illuminating decisions (Yin, 2017), both of which enable an understanding of how technology and innovation policy is developed. Longitudinal case studies also enable us to explore AI's technological and social contexts, and the collection of qualitative evidence allows us to identify key process variables.

We divided the policy development process into four stages using an engineering systems architecture approach (Selva, Cameron & Crawley, 2015). In the "Conceive" stage, stakeholders address the challenges and opportunities of AI systems and think of possible solutions to them (e.g., regulations and strategies). In the "Design" stage, stakeholders design a roadmap and build the solution chosen during the Conceive stage. In the "Implement" stage, stakeholders start executing the actions developed in the Design stage. Finally, in the "Operate" stage, the solution owner monitors results, identifies future opportunities and challenges, and can decide to initiate a new policy process. We acknowledge that this framework can simplify uncertain and messy real-world politics. However, practitioners can use this framework to guide AI governance discussions.

Results and discussion Chile's AI strategy was initially conceived as a top-down, expert-driven process. However, two external crises (Chile's social riots of 2019 and the COVID-19 pandemic) lowered the barriers to adopting a bottom-up approach as there were mounting pressures from different stakeholders demanding involvement and requesting specific policy outcomes. The government responded by adapting the process and its governance to address the bottom-up pressure and navigate the conflicting demands of heterogeneous stakeholders. Furthermore, authorities agreed to foster self-convocated roundtables and organize regional discussions to gather information for the draft, leaving the expert committee only as a consultative group.

The constant relation between demands and responses shaped the AI development process and defined the level of overlap between the four stages (i.e., Conceive, Design, Implement, and Operate). To convince heterogeneous groups to participate, the government purposely developed tools to generate trust and lowered barriers to participation. For

example, in the Design phase, there was an open deliberation period in which everyone could discuss and contribute content for the policy. Public officials developed the first draft with that deliberation input, which was later presented for consultation to the public. The option to review and comment on the draft was open to the public. This two-staged model gave the public more accountability and fostered trust in the AI strategy. Another trust-building example was when the government actively argued against the expert/non-expert dichotomy, responding to domain expert groups complaining because of the involvement of "lay people" in the process.

The process generates insights into how the intertwined nature of technology and development in emerging countries shapes public deliberation and moves processes beyond the expert/non-expert dichotomy. Deliberation during the process was usually framed based on Chile's singularities, deficits (Pfotenhauer et al., 2019), and opportunities to address social goals, all of which directed the AI's development (Schot & Steinmueller, 2018). Key initiatives in the policy's action plan are a US $5 million grant for economic reactivation through AI, a public-private enterprise to foster AI and data science using Chile's unique astronomical potential (see Guridi et al., 2020), and the prioritization of three industrial sectors for an AI Sandbox (i.e., healthcare, logistics, and fintech). Thus, the discussion focused on how AI contributed to the country's overall development, which contrasts with other policy narratives based on developing science and technology for its own sake.

The resulting policy achieved a high level of consensus and acceptance and has survived for more than a year since its publication. Nearly 90% of the people who participated in the consultation highly agreed or agreed with the proposed objective, and more than 80% with the topics and objectives proposed. Furthermore, the policy survived through a change in the country's governing coalition, and to date, the new administration has continued implementing it and engaging in international outreach activities.

We contribute to technology and innovation policy literature by providing insights on how to enable participatory processes to build more resilient technology policies. Governments should acknowledge citizens' reflexive agency to build democratic legitimacy in technology discussions (Biale & Liveriero, 2017). Furthermore, public discussion allows the creation of technology policy with a focus on anticipation, experimentation, participation, and directionality, following Schot & Steinmueller's (2018) transformative change framework. Finally, we show how crises and social unrest can be leveraged to foster participation and innovation when constructing technology policies.

[6410] *What is in It for Us? Institutional Trustworthiness and Facial Recognition Technology in Policing*

Robin Guohuibin Li (Arizona State University).

Abstract

Amid the current transformation toward data-driven and AI-enabled public services, governments and public entities are adopting new technologies like Facial Recognition Technology (FRT) to inform better public service processes and provision. This development may bring benefits, such as improved operational efficiency (e.g., process automation), enhanced information/ data processing capacity (e.g., big data analytics and algorithmic learning and decisions), and enhanced public service outcomes (e.g., predictive policing with real-time information). Meanwhile, FRT has expanded beyond secured verification, and FRT applications and systems have been integrated into many smart city initiatives and frameworks (e.g., smart transit, smart campus, and smart parking).

However, those benefits and opportunities may come with risks, potentially threatening civil rights (e.g., privacy and freedom of speech), democratic processes (e.g., transparency and accountability), legitimacy (public support), and public values (e.g., equity and inclusion), resulting in undesired and even unintended consequences, especially to vulnerable and underrepresented populations. Therefore, realizing the benefits and addressing the challenges of adopting, implementing, and using FRT in public environments is important and requires rethinking management, policy, and governance.

Nevertheless, FRT, to date, has received insufficient academic attention from public administration, management, and policy scholars. As an intrusive technology that brings both values and challenges, comprehensive examinations of FRT use in the public sector are needed to further build ethical, responsible, transparent, and accountable approaches, policies, and practices to advance public administrative goals, the welfare of the people under serve, and democratic values.

Among other public entities, police have used various types of FRT applications. In the U.S., one of four local law enforcement agencies has access to FRT. Around 47% of law enforcement agencies at the federal and municipal levels had adopted body-worn cameras as of 2016. FRT applications are assumed to enhance policing accuracy, efficiency, and accountability. Unfortunately, recent evidence based on major U.S. metropolitan areas and cities suggests the promising benefits on the surface are unwarranted. Indeed, FRT and A.I. in policing have been a significant focus for the U.S. media and law enforcement communities over the decades.

Many questions center around whether police shall use FRT and associated algorithmic biases, systematic discrimination, and privacy and data breach concerns. In academia, studies on public attitudes towards FRT for police have received increasing attention. LItature has studied FRT legitimacy use (Bradford et al., 2020), FRT effectiveness in reducing crimes (Miethe et al., 2023), FRT privacy concerns (Miethe et al., 2023), and FRT in policing arrest rates (Johnson et al., 2022).

Given the contentious debates about FRT, citizens are key stakeholders and are vulnerable to FRT employment in policing. Their voices should be heard/ included. Yet, this area has received little attention from public administration perspectives. To make an addition to this study field, this essay examines public attitudes to FRT adoption in U.S. policing through the lens of the institutional trustworthiness framework. A recent study has shown that two institutional trustworthiness constructs affect FRT's public acceptability in U.S. policing. By extending that study, this essay explores moderating effects between institutional trustworthiness and public acceptability of FRT. Serval individual and environmental characteristics will be considered, such as race, gender, and knowledge about FRT in policing scenarios.

Replying on U.S. representative cross-sectional survey data and quantitative analysis, this study aims to contribute to public administration literature on public trust in new intrusive technology use in public agencies by considering social and demographical characteristics of individuals and their perceived institutional trustworthiness.The findings also aim to inform better FRT policy-making regarding FRT deployment, use, and regulation at local law enforcement agencies.

[3545] *Bibliometric Analysis of Nanotechnology Applications for Coronavirus Treatment from 2000-2022*

Swaneet Jha (Stony Brook University) and Thomas Woodson (Stony Brook University).

Abstract

Introduction Nanotechnology is considered to be one of the most promising technologies of the 21st century. With applications in nearly every scientific discipline, scientists can use nanotechnology to measure, manipulate, and manufacture at the atomic, molecular, and supramolecular levels. Over the past 20 years, there has been major investment in global R&D funding for nanotechnologies directed towards the improvement of health diagnostics, drug delivery, nano-biopharmaceuticals, and vaccine development. In a race to handle the COVID-19 pandemic, many scientists turned to nanomedicine innovations to develop novel drugs. Thus, it is critical to understand the evolving role that nanomedical innovations have played in combating COVID-19 and other coronaviruses over the past 2 decades.

Rationale In our study, we conduct a bibliometric analysis of nanotechnology and coronavirus research in order to understand how these technologies have evolved over since 2000. Bibliometric analysis is a research method for exploring and analyzing large volumes of text scientific data, enabling scholars to decipher and map connections in the data. Given the volume of scientific literature produced over the past two decades in the fields of coronaviruses and nanotechnologies, we believe that a bibliometric analysis of coronaviruses and nanotechnology offers a comprehensive and efficient approach to analyzing data.

In the winter/spring of 2020, COVID-19, swept across the world, killing millions of people and shuttering almost every institution, business, school, and organization. Scientists immediately began finding cures and vaccines for this deadly virus. Soon scholars of science policy began researching trends in COVID-19 research. Over the past year, there have been many bibliometric analyses of COVID-19 and over the past 20 years, there are even more bibliometric studies of nanotechnology. However, there is limited bibliometric research on the applications of nanotechnology for combating COVID-19 and there are no bibliometric analyses of nanotechnology for coronaviruses in general, including the Severe Acute Respiratory Syndrome (SARS) and the Middle-East Respiratory Syndrome (MERS). The pool of publications we examine is a larger dataset than most bibliometric studies have examined with respect to nanotechnology and COVID-19. This study fills that gap by showing trends in nano-coronavirus research since 2000.

We have three hypotheses: 1) From 2000-2018, there would be a low volume of scientific publications that discuss nanotechnology and coronaviruses (nano-coronavirus research). 2) In 2020, we expect the amount of nanotechnology research on coronaviruses to spiked after the COVID-19 pandemic. 3) In response to the SARS and MERS outbreaks, we expect the global scientific production of nano-coronavirus publications to temporarily increase.

Methods This study uses PubMed as the source for nano-coronavirus articles. PubMed is a publicly accessible database of medical-related research. PubMed is hosted by the National Institutes of Health and contains over 34 million citations and abstracts. PubMed is a common database for bibliometric analyses related to medical fields.

Our first step was developing a search query to find nanotechnology and coronavirus articles. The team conducted an extensive literature review of nanotechnology and coronavirus bibliometrics articles to find keywords. After collecting the most relevant keywords, we tested the accuracy of each keyword to ensure it had the necessary recall and precision. Once we developed the keywords, the team downloaded the articles from Pubmed on July 18, 2022. We found 3,446 nano-coronavirus articles from January 2000- July 2022. The raw data was then imported to Biblioshiny Software to perform bibliometric analysis on publication trends. We analyzed the annual scientific production of nano-coronavirus research, the corresponding author's country of origin, the multiple-country publication ratio, and the analysis of

keywords within publication abstracts. The raw data generated by Biblioshiny was exported to Microsoft Excel through which figures were generated.

Results/Discussion Upon analysis of the bibliometric data, we found our first two hypotheses to be validated. Between 2000-2018 there was a low volume of nano-coronavirus scientific publications and by 2020 the volume of scientific production skyrocketed. However, we could not find evidence to support the third hypothesis. There was no rise in nano-coronavirus scientific production after the SARS outbreak (2002-2004) nor the MERS outbreak (2012-2016). Additionally, analysis of the corresponding author's country of origin reveals that the US, China, and India are the top three leading countries in total nano-coronavirus scientific production. Unexpected findings in total scientific production between 2001 and 2022 include the United Kingdom ranked low at 20th and Iran ranking high at 4th.

Future Research Over the next few months, we are going to compare our keyword data for nano-coronavirus literature with nano-influenza scientific literature produced over the same time interval. Our initial hypothesis is that the two domains will have different patterns in research topics and keywords; however, in contrast to nano-coronavirus research that spiked in recent years, we expect nano-influenza scientific literature to have a steady rise in production. Moreover, we expect nano-influenza research to have been produced in countries that are traditionally regarded as powerhouses in general scientific research as opposed to countries such as Iran and Saudi Arabia. The findings of our complete study may be used to help policymakers allocate funding for emerging nanotechnologies that are designed to combat coronaviruses as well as other infectious diseases. Our ultimate goal is to ensure that countries are better prepared to handle scientific R&D in response to future pandemics and public health emergencies.

[7281] *A guiding framework for University-Industry partnerships to strengthen innovation and technology transfer ecosystem…a case study from India*

Radhika Trikha (Indian Institute of Sciences Bangalore, India).

Abstract

The socioeconomic advancement of any country is largely dependent on the science, technology, and innovation ecosystem of the country. Scientific and technological advancements are crucial in bringing technological and economic progress. This knowledge from the universities should flow to the industry for knowledge translation to address current challenges faced by society and also for bringing societal upgradation. The universities are the knowledge generators, and the industry is the knowledge consumers. There is a need to build strong university-industry linkages to enhance the STI ecosystem of the country. Although India has shown a significant rise in innovation capabilities by attaining the 40th global innovation ranking out of 136 economies worldwide, top innovation ranks amongst the low-middle-income countries and central and south Asian countries (Global Innovation Index Report, 2021-22). Despite that, India seriously faces challenges in university-industry linkages (at present, India stands at 41st global positioning in this parameter of GII, 2020-2021). Therefore there is a need to bridge gaps between universities and industry.

One of the key impediments in university-industry linkages is the lack of a facilitation platform and channels for translating university knowledge to the industry as industrial expectations are not met, and the innovation dies in the valley of death as per the innovation life cycle. To cater to the problem mentioned above, a detailed analysis of the university research in terms of Technology Readiness Levels (TRLs) has to be carried out to bridge the gap between TRLs levels. University research projects generally fall from TRL 1-4, and industry to take up the project required TRL 7-9; hence there is an immediate need to develop partnership mechanisms between industry and university to bridge this TRL gap from university to industry. The current paper focuses on collating the challenges faced by academia and the industry in terms of Science, Technology, and Innovation (STI) diffusion from university to industry and the necessary facilitation and enabling mechanisms required to bridge the same. The paper aims to bring out the university-industry linkages framework that can be explored for stimulating the university-industry linkage culture in India.

This guiding framework is developed after undertaking secondary research, and interview sessions with experts from academia (Panjab University, Chandigarh; Chitkara University, Baddi; Indian Institute of Sciences, Bangalore; Indian Institute of Technology (IIT), Delhi and Indian Institute of Chemical Technology (ICT), Mumbai) and industry, open questionnaire-based feedback from industry and academia and undertaking various academic case studies. This framework can be practiced by universities in India to set up strong interconnects with Industry and explore university-industry linkages for innovation and technology transfer. Interview questionnaires and case studies were used as primary instruments, along with desk research for collating the information to understand the challenges faced by universities and industries in collaborating. Further, the best practice framework outline is proposed that will play a significant role in connecting the university and industry.

A Guiding framework to develop University-Industry Linkages is developed by 6 step process that comprises of following steps: • Step 1 Mapping of potential academic institutes and industry needs and challenges that will open the scope for collaboration between university and industry: Potential academic institutes in India were mapped for Expertise available (Faculty/scientific staff, trained researchers); Research Infrastructure (Facilities and instruments available); Intellectual

Property (filed and granted); Technologies/products developed; Technologies available for licensing/commercialization and R&D status (R&D projects with TRL levels, etc.). On the other hand, the industry perspective was mapped by sessions of interviews with select Industrial associations (regional and national); Industrial clusters (regional and national; sector-wise); government recognized Industrial R&D units, and Industry (big corporations, MSMEs, start-ups, etc.). • Step 2 Develop Communicating Channels between Industry and Academia (I-A Enablers) Individually: To develop the communicating channels following source points can be explored by the university as Alumni association; Dean/Departmental head; Research and Consultancy Cell; Technology Transfer/Commercialization/Licensing Cell, with Legal/IP Cell; Corporate Laboratories; Centers of Excellence (as per industrial needs); I-A Clubs; Industry involvement in academic activities such as curriculum design and review, teaching and training, research advisory, etc.; Industrial Chairs and Industrial Fellowships; Entrepreneurship Cells/Clubs, Research Parks, and Technology Business Incubators (TBIs). • Step 3 Match Making (Industrial Needs/problems & Academic expertise/solutions): Dedicated team of I-A managers/officers have to be administered for the required job. Scouting of potential academic partners as per industrial challenge and requirements This can be done through Open Innovation Challenges, Industry hackathons, Networking by a Liaison officer/manager at I-A cell, One to one meetings with industry counterparts, Industrial surveys (open/closed), and Communicating science. • Step 4: Drafting MoUs and Agreements: Once the potential Industry-academia linkage is established, exclusive agreements defining the role and responsibilities of each partner, along with timelines and deliverables expected, will be drafted. A team comprising the legal adviser, IP advisers, Tech Transfer advisers, and financial advisers will be formulated to assist the I-A cell in drafting agreements. The agreement should address: Project aims and detailed scope, Risks and responsibilities to manage, Rights and remedies, Project management, IP management, Regulatory norms, Expenses and payments, Supervision, Schedules, Exit, and termination. • Step 5: Collaborative Action: The collaborative research will be undertaken with defined goals and objectives, resource allocation, and deliverables sought as per the timelines. Regular monitoring of the progress of the research work will be carried out, and evaluation in terms of the timely delivery of the project objectives by an external committee will be undertaken. • Step 6: Technology Transfer: Deliverables from the collaborative research undertaken in technology transfer or licensing will be explored. The culmination of the project with technology commercialization from academic entity to industrial entity will be laid out, and future long-term engagement plans for the same will also be discussed.

The study recommends the establishment of dedicated entities for facilitating the translational research ecosystem. The dedicated team will undertake the task of Liasoning between the university and industry. This will require and will cater to human resource and capacity-building initiatives. Each university should establish such translational research facilitation bodies. They can be named Technology Transfer Offices, Industry-academia cells, etc. Specific training in leadership and management human resources should be carried out to facilitate university-industry linkages and technology transfer agreements between the university and the industry. A dedicated platform (preferably virtual) should be set up where academic expertise can be highlighted, and industry problems/challenges can be posted. Specific mechanisms for connecting industry with academia as per their needs and priorities should also be developed and managed by a dedicated office/team. Regular display of academic knowledge through exhibitions, fairs, tech displays, and repositories should be maintained by the university portfolio. This guiding framework is developed after undertaking secondary research, interview sessions with experts from academia and industry, open questionnaire-based feedback from industry and academia, and undertaking various academic case studies. This framework can be practiced by universities in India to set up strong interconnects with Industry and explore university-industry linkages for innovation and technology transfer.

[2742] *Gender bias in team formation: The case of the European Science Foundation's grants*

Michele Pezzoni (Universite' Cote d'Azur) and Fabiana Visentin (UNU-MERIT).

Abstract

This paper investigates gender bias (if any) when teams are formed. Data from the European Science Foundation are used to estimate if female scientists have the same opportunities as their male colleagues to join a team when applying for funds. To assess gender bias, we construct a control group of scientists with the competencies for being invited to join the team by the project leader, the researcher in charge of forming the team for the grant application. By comparing the proportion of female scientists in the control group with the one in the observed teams, we find a gender bias against female scientists only when the project leader is a man, while we do not observe any gender bias when the project leader is a woman.

[4968] *Rationality of export promotion policies in Costa Rica: is this a mix of GVC, innovation system and middle income trap approaches?*

Jeffrey Orozco (CINPE-UNA) and Keynor Ruiz-Mejías (CINPE-UNA).

Abstract

The Costa Rican economy has long been regarded as one of the region's most stable and socially developed economies. In this paper we made an analysis of the evolution of Costa Rica's strategy of economic diversification and capabilities building traying to analyse the rationality of the policies in different stages.

Most of the literature on the phenomena known as the "middle income trap" (MIT) suggests the relevant roles of capabilities, structural change and technological progress as the key factors able to better positioning a middle income country moving to better conditions (Vivarelli, 2014). A general argument, as suggested by Perez-Sebastian, 2007; Agenor and Canuto, 2012, is that once some countries reach the middle-income level, the pool of unemployed and underemployed rural workers drain out, wages start to rise, but an significant problem is that benefits from imitation and importing foreign mature technologies decrease in importance. In this condition, changing the structure of the economy (diversification from low productivity sectors into high-productivity ones) and on the types of product exported are the most important drivers in the strategies to overcome MIT (Gill and Bhattasali, 2007). It is important to consider that capability building and catch-up by domestic firms depend greatly upon the nature and features of innovation systems and it is necessary to consider the heterogeneous nature of the knowledge base, the specificity of the national, sectoral, and regional contexts, and the role of institutions in which innovative activities occur (Malerba and Lee, 2021). In the innovation system approach, the set of interrelated components is understood as a system working towards a common objective. Therefore, the set of parts and aspects of the economic structure and institutional set-up that affect learning and research are understood as the Innovation System (Lundvall, 1992). Chaminade and Edquist (2010) understand innovation policies as those public actions that drive innovation processes, both for development and dissemination processes. The rationality of innovation policies is based on trying to solve system problems. There are some failures in the system that hinder the possibility to reach these objectives. System problems to meet those objectives can usually be understood as problems of: infrastructure provision and investment problems; of transition; of "lock-in"; institutional; network problems; skills and learning; exploration-exploitation imbalance; complementarity problems (Chaminade and Edquist, 2010). Borrás and Edquist (2013), suggest a possible way to group policies and instruments to foster innovation, considering: regulations (intellectual property, regulations), economic transfers (competitive funds, exemptions), soft instruments (alliances, agreements). Orozco (2017) argues that to increase the efficiency of such policies and instruments, it is important to consider the geographical, sectoral or firm size specificities. The rationality of policies in GVC approaches is aimed mainly to facilitate trade. According to OECD (2012) and Catteneo et al (2013), in the approach of GVC there are two main objectives for policies: suppressing/reducing obstacles to trade at the border, including trade facilitation and increasing the accessibility and connectivity of the domestic market, and the security, predictability, reliability and efficiency of transports/logistics, telecommunications and ICT. More specific to innovation and building capacity, the approach recognizes that GVCs facilitate capacity constraints, since a country does not need to develop a fully integrated industry to participate in international trade. But capacities and productivity remain key factors for foreign investors and lead firms. In the new context, lead firms have to define strategies where innovation centres are decentralised. Lead firms need to innovate in developing countries, and solve their specific needs and eventually, they can bring the results back home, thereby contributing to boosting the developing countries' exports (Govindarajan and Trimble, 2012). This requires the host developing country to develop innovation capacities, based on education and skills. There is a strong connection between the policy approaches of innovation systems and GVC. It is clearer for the approach of sectoral systems of innovation. But it is also clear that for more geographical approaches of innovation systems, it is also necessary to consider both the challenges and the opportunities from the conditions of international trade. Most of the challenges for economic and social upgrading in GVC require strong innovation systems. Considering the rationality of both approaches, it is clear that Costa Rica's export promotion and foreigner investment attraction policies have been mainly based on the GVC approach. Indeed, the strategy has focused on lowering barriers to international trade and consolidating an institutional framework to attract investment and promote new export products. From the point of view of the innovation system approach, there are still many gaps in the country's policies, as will be discussed in the paper. Our argument is that these gaps have contributed to the MIT in the country. We develop an historical analysis of the policies in the country and present some data to show the main changes in the structure of the economy and the exports.

[9098] ***Evaluating the quality of non-written research outputs***

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Abstract

Background and Objectives

A publication is the standard output of research and the most prominent measure of scholarly performance. However, research outputs can take various forms and in some research fields - such as Architecture, Design, or the Creative Arts – the non-written research outputs (NWRO) are much more common than scientific papers or books. At the same time, we

have very little knowledge about NWROs since current social studies of research generally overlook this significant form of research production. We know particularly little about how quality of NWROs is recognised, understood and evaluated.

The aim of this research is to explore quality criteria in the field where NWROs are particularly common – the Creative Arts (CA). Outputs in the CA comprise different forms of creative expression such as musical compositions, dance performances, photographic exhibitions, digital creative works, etc. There have been several efforts to expand the concept of research quality in evaluations (e.g. Franssen, 2022; Ochsner et al., 2013), but they focus on traditional research fields (STEM & SSH) and do not include the field of Creative Arts (CA) which has traditionally been located beyond the context of university research.

Methods

Our study uses a mixed-method approach to assess the relevance of quality criteria used in ten (10) performance-based research funding systems (PRFSs) to evaluate the NWROs. We analyse qualitative and quantitative data gathered during two waves of interviews (N=67) with Polish researchers in the Creative Arts field. The first wave included 37 individual in-depth interviews and the second wave included 30 questionnaire-based interviews. In-depth interviews conducted during the first wave were semi-structured and based on an open-ended interviewing technique. Questionnaire-based interviews (the second wave) were conducted using an online questionnaire. The questionnaire listed 12 quality criteria used in ten PRFSs (in Australia, the Czech Republic, Italy, Lithuania, New Zealand, Poland, Portugal, Slovakia, Spain, the United Kingdom) to evaluate NWROs. The criteria were identified through an analysis of evaluation guidelines published online by the national evaluating agencies (see for more details Lewandowska, Kulczycki and Ochsner 2022). During questionnaire-based interviews, the respondents completed the questionnaire by rating the importance of each quality criterion on a 5-point Likert scale. Respondents also explained how they understood the criteria and why they considered them as (ir)relevant.

Qualitative data were content-analysed with the assistance of MAXQDA and the quantitative data were recorded in Excel and analysed using R and Stata 16. Given the small sample size, the Joint Correspondence Analysis (JCA) was applied as it is especially robust for small-n high-dimensional analyses (Fithian and Josse, 2017). The JCA in the Benzecri tradition, i.e., as merely a graphical representation of the data at hand, was used. For the JCA to converge, we had to simplify the data structure by recoding the 5-point Likert scale into dummies (Di Franco, 2015). Due to the small sample size, we conducted robustness tests: first, the JCA was rerun taking out two cases (cases were put into pairs randomly). Second, we rerun the JCA 18 times by randomly dropping two cases with replacement (i.e., the same case could be dropped in two different renditions). Finally, a principal component analysis was conducted with oblimin rotation to see whether the choice to use dummies makes a difference.

Preliminary Results

Drawing on the qualitative analysis of interviews and using the percentage distribution of survey responses, we discovered that four criteria were assessed as important (Significance for development of the discipline, Contribution to knowledge/understanding, Creative or intellectual context, Peer recognition), three criteria were assessed as adequate (Originality: extrinsic, World-class level, International exposure) and four criteria were assessed as contentious (Significance for research, Rigour, Scale of work, Output type). This result suggests that when NWROs are evaluated in the context of academic research, both the traditional indicators of professional quality (prizes, market success, etc.) and the cognitive/ research-related aspects are believed to be significant.

The JCA analysis revealed patterns how researchers see the relevance of quality criteria. It allowed to identify six (6) groups of researchers. Group (1) is represented by researchers who do not believe that criteria used in PRFSs are adequate. Group (2) included respondents who find traditional forms of professional validation relevant, but do not find research-related criteria adequate for making assessments in the CA; they represent what we call the Isolationist approach (we borrow this term from Biggs and Büchler 2008). Group (3) represents researchers who find criteria related to reputation and prestige (extrinsic quality) relevant but also some criteria related to the cognitive aspects of NWROs; however, not necessarily the ones associated with traditional research, such as Rigour. This group represents a more nuanced ("soft") Isolationist approach. Groups (4) and (5) find most criteria relevant, both reputation-based as well as research-based, and may correspond both with what we call the Isolationist or Situated perspective. Finally, Group (6) represents researchers with the least pronounced characteristic – they have a tendency to find intrinsic criteria relevant and some of the reputation-oriented criteria.

Overall, our study revealed a diversity of approaches concerning the evaluation of NWROs in the CA: the Isolationist perspective ("non-written artistic outputs are not research"), the Situated-soft ("non-written artistic outputs can be research"), the Situated-hard ("non-written artistic outputs are research"). This results suggest that the definition of research used in the PRFSs – as well as the research-defining criteria, such as Rigour, which are frequently reduced to the narrow definitions of "scientificity" – should be revisited and refined to include the diversity of research practices and outputs.

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[2324] *How does SDG related research differ?*

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Abstract

Scientific research has contributed to increasing human prosperity 1, as well as to creating new human challenges, including environmental sustainability. However, these benefits and challenges are not evenly distributed across the population 2. This is due to how research priorities are directed. For instance, in health, R&D (public and private) focuses mainly on the diseases that mostly affect people from the richest parts of the world, even if these are not the diseases with the highest burden on human life 3,4. In agriculture, 'revealed' research priorities in agriculture only partially relate to 'revealed' demands for new science7.

There are several reason why research directions do not align well with the societal demands, including: path dependence8, difficulty in navigating the sheer complexity of research and societal demands, as priorities are influenced by several, competing and related factors and actors9–15, with different interests and incentives 16,17, which are unequally represented in research and decision making organisations 18–21.

Behind these systemic reasons is also how researchers themselves respond to incentives that shape their research trajectories. The evaluation of research based on the scientific excellence of its outputs, reduces funder's decision making to only one of the potential objectives of investment in research. And in evaluating this objective, it misses out the multiple, combinatorial ways, in which research may advance the frontier and, equally importantly, its multiple directions22 and their potential impacts on societies.

In this paper we compare the research that is related to the Sustainable Development Goals (SDGs) with the rest of the published research. Alongside scientific excellence metrics, we use indicators that measure potentially broader contributions of scientific research to societies. We ask the following questions. Are there specific characteristics that make some research more likely to be SDG-related and that funders should target? Are there characteristics of SDG-related research that makes it more likely to be used in industry or policy reports? Does SDG-related research also appear in "excellent" publications using standard bibliometric measures?

To identify research related to the SDGs we devised a method to assign research areas/clusters to specific SDGs. This approach reduces the uncertainty and ambiguity of assigning individual publications to an SDG, and allows us to include publications that contribute to SDG-related research even if they do not use SDG-specific language in the title or abstract. First, we built a query with a set of terms that are strongly associated with each SDG, using policy reports, grey literature, scientific publications and web forums, alongside United Nations sources. We extracted relevant fragments from these texts, then selected keywords within them, first using text-mining techniques and then a manual selection. We then used those SDG-related queries to search 4,013 clusters of publications in the Web of Science (WoS) published between 2015 and 2019. A cluster comprises a number of published documents which are related to each other because of their citation pattern. Each cluster, then, represents a research area covering broadly similar topics. Based on the results of the search, we connected each research area to one or more SDGs, depending on the proportion of publications that included our SDG query terms in their title and abstracts. For example, 22% of publications in the 'multidimensional poverty' research area used terms relating to SDG1. The proportion of publications for each SDG was determined by manually reviewing the topic of the research area, and the title and abstract of the most cited publications.

To better understand how different types of research 23, are related to different SDGs, we used publications meta-data and citations to characterize publications according to four measurable features associated with the potential societal impact of research 24,25: • Collaborations 26–28 o extent of international collaborations (co-authors from more than one country) o extent of collaborations between high income countries and the rest of the world (co-authors from more than one country) o funding (extracted from acknowledgments) o industry authorship (co-authors from industry) • Public use 29,30 o industry (citations in patents, Patstat) o policy documents (citation in policy documents, Overtone) o news

stories and Twitter posts (citations in news and twitters) • Open access 31,32 (open access paper); and • Multidisciplinarity 33 (Rao-Stirling diversity measure across subject categories 34)

We then compared these measures to standard measures of academic reputation 30,35.

Next, we clustered SDGs based on the similarity in each of the above indicators of all publications related to that SDG. This resulted in three clusters: a cluster of social challenges related SDGs (red): SDG 1 (no poverty), SDG 4 (quality education), SDG5 (gender equality), SDG10 (reduced inequalities) and SDG16 (peace, justice and strong institutions), also including growth (SDG 8) and innovation (SDG 9); a cluster of social functions and technical solutions (yellow): SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy), SDG11 (sustainable cities and communities), SDG 12 (responsible consumption and production), also including SDG 2 (zero hunger); a cluster of natural environment and health (green): SDG 13 (climate action), SDG 14 (life below water) and SDG 15 (life on land), which shares features with health publications (SDG 3).

Here we briefly summarise the main findings. Research related to social challenge SDGs, is more used in policy, potentially more impactful in society, and is the most multidisciplinary. Despite this, and despite being of at least as high quality as the average publication in WoS, it attracts less funding than average, and does not benefit from the same level of collaborations across countries. Research related to social functions and technical solutions SDGs is the most focused on basic sciences and technology applications, and the closest to industry. However, it does not attract much public or policy interest. Research related to natural environment and health SDGs is highly used in policy and society, attracts the most funding, and is most likely to be co-authored internationally and to be open access. SDG-related research, on average, is published in top cited journals as the WoS average

Taken together, the results indicate a need for greater public funding for research that focuses on the complex social determinants of sustainability, to complement, rather than follow, private funding.

As with all studies that map research published in academic journals, the methods are subject to certain limitations. In particular, the WoS does not cover most non-English language journals or those with high local relevance, and much research, especially in low-income contexts, is not published in academic journals. However, our findings are still crucial in mapping and characterizing the contribution to the SDGs of academic research, which accounts for a large proportion of research funding and is widely used in policy and industry. In Rafols et al (2021), we suggest a tool and method that allows users to review the results in this paper using different interpretations of SDG-related research.

[4710] *The participation of the Global South in Ocean transnational science networks: evidences from the Brazilian state of Santa Catarina*

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Abstract

BACKGROUND AND RATIONALE

Global South participation in transnational science networks (TSNs) has long been studied by scholars from a wide range of disciplines. Whereas many have not only shown, but also celebrated, the fact that Southern countries have been increasing participation in such networks, others are not so optimistic. Critical literature on the coexistence between scientific collaborative and state competitive interests has shown, for instance, the connection between TSNs and intelligence gathering. North-South collaboration can also promote brain drain or biodiversity data gathering that will be later patented in developed countries. Differently from game theories that inform studies on international cooperation, according to which cooperation and competition are excluding dynamics, critical studies have shown that collaboration can enhance a state competitiveness towards the very partners involved in TSNs.

Currently ocean science support figures among the highest priorities mobilizing the international community. In line with liberal approaches according to which epistemic communities help promote international cooperation, scientists and TSNs are seen as crucial to dealing with environmental and social impacts of economic and geopolitical competition towards the Oceans. The United Nations Decade of Ocean Science for Sustainable Development (2021-2030) calls for more data gathering, standardization and sharing to deal with the fact that the Oceans, despite covering two thirds of the Earth and being essential to climate regulation, biodiversity conservation and human subsistence, are still greatly unknown. Though a growing number of scientific publications show that awareness is raising, Ocean research funding is still inadequate, and access to infrastructure and knowledge is unevenly distributed across the globe. Therefore the Ocean Decade aims at promoting TSNs involving developing countries. To which extent is such inclusion happening and to which extent it is enough to deal with inequalities in Ocean science and its applications? In order to answer those questions our research gathers empirical evidence on TSNs involving the Brazilian state of Santa Catarina, where the research team is based.

Located in Southern Brazil and in the South Atlantic, one of the word least known marine spaces, Santa Catarina hosts one of the most dynamic national regional innovation systems. It is a key player in ocean economy, especially in tourism, fisheries and port infrastructure. Researchers based in Santa Catarina take part in the definition of public policies, including Brazil's position in the Ocean Decade. They also integrate TSNs, such as the ones sponsored by Mission Atlantic, a EU-funded project aiming at assessing the impact of climate change and exploitation in Atlantic marine ecosystems; and Bio-Bridge Initiative LEAP, a project led by Universidade Federal de Santa Catarina involving experts from Argentina, Brazil and Uruguay aimed at providing decision makers with innovative risk assessment methodologies.

METHODS

Using Web of Science (WoS), we mapped Ocean TSNs involving researchers based in Santa Catarina. The fact that Ocean science is a multidisciplinary field prevented selecting specific WoS areas, therefore we used boolean research to search words related to the Ocean in abstracts. We then systematized the mapped material (almost 500 articles) at first relying on WoS algorithms. Some of them had to be manually corrected (for instance, financing agencies that were not declared by authors appeared in automatic retrievals). Articles were also tagged according to a categorization built upon a broad review of literature containing proposals to classify the Ocean, an emerging global policy field whose measurement does not rely on consensual categorizations. Finally network analysis has been conducted, and currently qualitative research is being undertaken.

RESULTS

Santa Catarina Ocean TSNs involves 24 different areas. Marine Freshwater Biology ranked first (126 occurrences), followed by Environmental Sciences (76), Ecology (53), Fisheries (34), and Oceanography (34). The interdisciplinary character of TSNs has also been identified, as articles with co-authors from the same areas are rare. Though there has been a growing recognition of the role played by social scientists in Ocean science, no co-authors from that area have been identified. This can reflect limitations of using WoS, though Scopus can also limited, specially when co-authors are based on the South. Therefore regional research platforms such as Scielo should also be used in order to arrive at more significant results, including considering languages other than English, which in our WoS research represented 98,4% of retrievals.

The involvement of researchers based in Santa Catarina in TSNs has raised exponentially during the last decade (excluding the pandemic period), confirming patterns already found by other researchers investigating TSNs in general or specific ones involving Southern countries. Growing co-authorships also correlates with incentives towards internationalization as criteria for research grant concessions in Brazil. Global articulations on the Ocean agenda might also have influenced the expansion of Ocean TSNs.

Countries geographically close to Santa Catarina do not rank firs; most articles are co-authored by scientists based in the US (144), Australia (78), Spain (75), Portugal (67), and France (66). Europe represents 43,4% of co-authors, followed by North America (22,9%) and only then Latin America (14,4%). Northern dominance in co-authorships can reflect historical patterns (for instance, US-Brazil science collaboration has happened for decades, and US scientists have helped build universities and research programs in Brazil, initially supported by initiatives deriving from the Point IV Program during the Cold War) or emerging science diplomacy strategies, especially from countries that have higher outflows of young researchers and are not competitive in attracting talents from core STI countries. Lack of South-South TSNs can also result from historical processes directing those regions to priorities from countries that have, for centuries, managed to identify and use oversees knowledge, contributing to the latter's enduring STI leadership.

Environment is by far the most tagged area (more than 70%). Areas that are representative of Santa Catarina's ocean economy are more significant in food, ranking second (11,7%), than in transport and shipping (1,4%) or tourism (no articles, as in the case of sports). Biotechnology is the third mostly tagged area (6,2%), followed by health (2,5%), whereas energy, infrastructure and public policy were tagged at 1% of articles each.

From the 92,2% articles that were funded, 59,1% of them declared international funding. A correlation has been found between most frequent co-authors and most frequent national funding institutions – respectively, US National Science Foundation, Australian Research Council, Spain Consejo Superior de Investigaciones Científicas, Portugal Fundação para a Ciência e a Tecnologia, and French agencies. About 9% of research is financed by countries whose researchers did not figure among co-authors. When financing comes from international organizations, European ones are by far the leaders. Among Brazilian funding agencies, the National Council Scientific and Technological Development (CNPq) ranks first, followed by the Coordination for the Improvement of Higher Education Personnel (Capes). Private research funding is not frequent in Brazil, and few articles counted on it. International private research funding is larger, but not as significant as public funding.

Qualitative research on Santa Catarina's laboratories whose researchers have been identified as key nodes in Ocean TSNs is being undertaken to assess risks and opportunities of taking part at TSNs. It is believed that, even if most research agendas are internationally induced, TSNs impacts on local problem solving are higher when the researcher is part of local networks with communities, entrepreneurs and policy-makers. It is also believed that when research is applied the retention potential of young scientists can be higher.

[5927] *Evaluation of the innovation incentive program.*

Juan Manuel Corona (UNIVERSIDAD AUTONOMA METROPOLITANA UNIDAD XOCHIMILCO) and Carlos Alfonso Hernandez (UNIVERSIDAD AUTONOMA METROPOLITANA).

Abstract

1.Introduction

The design and implementation of public policies to promote innovation capabilities and technological development have a long history in Mexico. The first initiatives aimed at promoting technological development in the industrial sector aimed at reducing national technological dependency from developed countries date back to the formulation of the National Indicative Plan for Science and Technology launched in 1974, however, it was not until the 1990s that Mexican government began to design and implement programs with specific objectives and financial resources oriented to promote technology development and innovation, such as the Fund for Research and Development and Technological Modernization (FIDETEC), the Support Program for Technological Modernization of Industry (PROMTEC); the Technology-Based Business Incubator Program. By the year 2000, several of these programs were canceled or modified, giving rise to new programs and instruments with the purpose of giving a greater boost to private investment in R&D and other innovation activities in the industry. Among the most important programs of this new stage are the Fiscal Incentives Program, and the Incentives Program for Research, Technological Development and Innovation, known as PEI (Spanish Acronym)

After World War II, several developed countries had already implemented policies to promote industrial development and innovation (Cunningham and Laredo, 2013), and by the mid-1970s they had consolidate as an important part of the government's policy portfolio to maintain and strengthen national leadership.

In Mexico, as in other Latin American countries, the implementation of STI policies has been an imitative reaction that has sought to replicate the actions of developed countries, although the results have been less successful for two reasons: first, because the resources allocated to the promotion of science, technology and innovation activities have been historically very low, and second, because of a persistent and chronic decoupling between industrial and commercial development policies, and STI policies. The limited results generated by these policies and their economic and social justification have been at the center of an intense debate in recent years, not only among the specialized academic community, but also among broader sectors of society.

The controversy has focused on four main aspects: a) The economic and social justification for the relevance in allocating public resources to promote technological development and innovation activities in the private sector, b) the design and objectives orientation of these programs, c) the mechanisms and management of the programs and associated instruments, and d) the evaluation of the programs from the perspective of contrasting objectives and goals achievement with the effectiveness and efficiency utilization of the resources allocated by the public agencies responsible for their implementation.

In terms of design, implementation and outcomes, the PEI has been one of the most controversial programs, however, beyond the information on the results of the program and the successful cases that have been documented and disseminated by CONACYT (2019), and other independent evaluations (Calderón, 2009; Dávila-Borbón, 2019; Farias, 2012); there has not been yet a systematic evaluation that provides significant evidence, on the design, the relevance and the results of this program. The fragmentary and in many cases distorted information that has circulated in the mass media has not only generated a negative social perception of this type of program, but also, very importantly, an adverse appreciation of the role of the Mexican government as a promoter of science, technology and innovation in the private sector.

2. Paper objective

The objective of this study is to offer a PEI's systematic evaluation PEI, in order to provide evidence, that may contribute to the debate on the economic and social justification of implementing government innovation policies aimed at encourage an increasing involvement of Mexican firms in technological and innovation developments.

We have selected the PEI among several programs implemented by CONACYT, as it is an emblematic program operated for ten years (2009-2018), enough time to evaluate some of its results. In addition, we have been able to access the program database, which has more than six thousand records, with relevant information on the beneficiaries of the program. Critical information that allows to carry out a systematic evaluation.

3.Methodology

The evaluation focuses on three main aspects: 1. the design of the program, that is, the analysis of the relevance of the objectives based on the diagnosis, the coherence with the support instruments and the definition of the target population. 2. The operation of the program, which seeks to explore to what extent the implementation of the program by the agency followed the design of the PEI, and 3. objectives-output-output analysis.

The research methodology used is mixed. We use a quantitative and qualitative approach. The quantitative analytical approach is possible thanks to the availability of the program's database, which contains information on the number and type of projects supported, the size, location and industrial sector of the beneficiary companies, the financial amount granted, and whether they had links with the academic sector. This information has made it possible to analyze the effects of the program by company size, geographical location and industrial sector using Pavitt's taxonomy (1984). What has yielded valuable information on the type of innovation carried out by the companies that have been supported. The qualitative analysis is based on a series of in-depth interviews with those involved, mainly the implementers of the program and the beneficiaries. This part of the study has made it possible to validate part of the quantitative information and enrich our perception of the operation and results of the program.

3.Preliminary Findings

1. 6,472 companies supported by the PEI during the period (2009-2010), of which; 27% were large companies, 23% micro, 37% small and 11% medium. 2. The financing granted by the PEI for ten years was 1,300 million dollars. An average of 13 million dollars per year, and about 200 thousand dollars of average financing per company. However, it must be considered that funding was concentrated in a handful of companies. 3. The PEI began with few resources in 2019 and reached the maximum of resources allocated between 2016, as of that year, the allocation of financial resources to the program collapsed in synchrony with the government's financial crisis, a situation that would affect several of the innovation projects supported. 4. According to Pavitt's taxonomy, the benefited companies belonging to the science-based sector was the most numerous (2,342); followed by the sector of specialized suppliers (2,001); the scale-intensive sector (1,315), and finally the provider-dominated sector (814). Which allows us to conclude that, according to the objectives, the program effectively supports innovation in companies with knowledge-intensive projects. References

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[3341] *Equality of Opportunity as a Driver of Innovation: Conceptualization and Cross-Country Econometric Evidence*

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Abstract

Background and Rationale

This paper focuses on a somewhat unconventional and less researched driver of innovation, namely the equality of opportunity (EOO) prevalent in a society. Studies on inequality and innovation mostly focus on the consequences of innovation for inequality, not the other way round. The limited number of studies exploring this reverse relationship have restricted their attention to the role of equality of outcomes as opposed to equality of opportunity (EOO).

EOO prevails when two persons with similar levels of capabilities face equal opportunities to acquire human capital. In reality, access to human capital is often determined by a multitude of exogenous factors such as gender, class, race, family background etc., all of which get determined by circumstances at birth. These may constrain EOO. In the absence of EOO to acquire even the threshold level of human capital, individuals belonging to deprived backgrounds may not be able to make the best use of their innate capabilities and talents. Correspondingly, unequal distribution of opportunities can prevent many bright and talented individuals from contributing to the national innovation pool according to their full potential. This will ultimately get manifested at the aggregate level of innovation output produced in a country. In other words, lower EOO will lead to less innovations.

Only a handful of empirical studies have explicitly focused on this EOO aspect of the innovation eco-system, although only indirectly and from micro-level and anecdotal evidence. These studies essentially establish the importance of privileged pedigree to become successful innovators and conclude that EOO for the underprivileged would go a long way in boosting the innovation potential of a nation. There are no studies that conceptualize a general macro-level causal relationship between EOO and innovation and estimate the same in a research production function framework using cross-country econometric evidence. In recent years, there have only been a few macro-level studies that explicitly introduce the concept of EOO (using inter-generational mobility as an indirect indicator or signal) to explore its impact on growth and other outcomes such as health, all pointing towards the adverse impact of the lack of EOO. None of these few studies has explored how EOO may contribute to aggregate innovation in a country.

The present paper is an attempt to fill this important gap in the literature by exploring how EOO drives innovation using cross country econometric analysis that not only allows us to examine the overall impact of EOO on innovation at the macro level but also makes it possible to investigate potential moderation effects of this impact operating through country specific covariates, such as the country's overall R&D infrastructure and its level of development.

Conceptual Framework

We conceptualize how innovation may be stunted in unequal societies characterized by the absence of EOO through various channels. Our conceptual framework is based on the notion of the research production function linking innovation outputs to innovation inputs. We formulate testable hypotheses regarding the impact of EOO on innovation output for given levels of innovation infrastructure and other controls, as well as possible moderation effects determined by contextual factors.

Empirical Design

To estimate the research production function at a cross-country level, we develop a comprehensive and quantifiable measure of EOO at the country level by combining various global data bases. We also construct appropriate measures of other variables (independent, dependent and controls) for cross country regressions. Our baseline econometric specification takes the following form: $InnovationOutput_i = \beta_0 + \beta_1 R\&D infrastructure_i + \beta_2 EOO_i + \beta_3 R\&D infrastructure_i * EOO_i + \beta_4 X_i + u_i$ where $InnovationOutput_i$, $R\&D infrastructure_i$ and EOO_i are the levels of innovation output, R&D infrastructure and EOO of country i and X_i is a set of control covariates. It includes standard covariates that have been suggested in the innovation literature to influence country-wide levels of innovation, such as, the strength of the intellectual property right regime, university-industry collaboration, and the overall level of development of an economy proxied by cross-country estimates of per capita GDP at PPP. This model may suffer from potential endogeneity problems as the explanatory variable R&D infrastructure may not be truly exogenous and hence non-orthogonal to the error term. To take care of this potential endogeneity, we use Instrumental Variables method to estimate our model. The two instruments that we choose are logistic infrastructure and military expenditure – both are expected to be correlated with R&D infrastructure but not expected to influence innovation output directly or through any channel other than R&D infrastructure, given that we are controlling for per capita GDP.

We use 2SLS-IV regression to estimate our model, robust to possible heteroskedasticty. We conduct several post estimation diagnostics to test for the strength and validity of the instruments and the presence of endogeneity in the model. These include the standard F-test on the first stage of regression and the Sanderson-Windmeijer multivariate F test of excluded instruments using the Stock-Yogo weak ID F test critical values to test for instrument strength. To confirm instruments validity, we use heteroskedasticity consistent Sargan-Hansen J statistics for overidentifying restrictions. We also look at the Anderson-Rubin Wald F-test and the Stock-Wright LM test for instrument validity – both tests are robust to the presence of weak instruments. Next, we carry out the $\chi 2$ test for endogeneity that is robust to violations of conditional homoskedasticity (unlike the Hausman–Wu test which assumes conditional homoskedasticity). Depending on the outcome of this $\chi 2$ test for ex-post presence of endogeneity, we either accept the 2SLS-IV results or re-estimate the model using OLS. After estimating the main model, we perform robustness checks using alternative specifications – presence of non-linearities and using intergenerational mobility as an alternative measure of EOO.

Results and Significance

The results firmly establish our core hypothesis that EOO has a strong and significant positive impact on innovation. The results also confirm that the role of EOO is more prominent for creative output compared to knowledge output. R&DInfrastructure also plays a role, although its impact is much lower than that of EOO and it is visible for knowledge output and overall innovation output only. Turning to the moderation effects, we find that the positive impact of EOO on overall and creative outputs is negatively moderated by R&D infrastructure and positively moderated by the level of development.

The results provide important pointers to development policy making. For promoting innovation, although it is important to improve R&D infrastructure, but it is even more important to ensure equality of opportunity. To nurture innovation for economic prosperity, it is essential to focus on social development with a clear commitment to reduce inequality of opportunity in a multitude of dimensions – social and economic. Contrary to popular belief, this paper establishes that there is no inherent conflict between social justice and economic efficiency. Rather, social justice provides a positive impetus to efficiency through creativity and innovation. In a democracy, development policy makers must, therefore, keep in mind that policy focus on EOO and social justice is not only good politics but also good economics.

[4345] *Research misconduct investigations in China's science funding system*

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Abstract

As stewards of public money, government funding agencies have the obligation and responsibility to uphold the integrity of funded research. Despite an increasing number of empirical research deals with misconducts, a majority of them focus on retracted publications. How agencies spot funding-relevant wrongdoing and what happens next to those responsible remains unexplored, particularly for emerging science powers. Following a chronology of China's anti-misconduct policies, we retrieved and analyzed all publicized investigation results from China's largest basic research funding agency over the period from 2005–2021. Our findings reveal that both the "police patrol" and "fire alarm" approaches are adopted in identifying misconduct and deterring fraud. The principal reasons for investigations are journal article retractions, whistleblowing, and plagiarism detection software. Among six funding-related misconduct types punished and publicized, the top three are fraudulent paper, information fabrication and falsification in the research proposal, and proposal plagiarism. The most frequent administrative sanctions are debarment and recouping of grants. This article argues that more systematic research and cooperation among stakeholders is needed to cultivate research integrity. Specific training and education should be provided for young scientists and researchers in less-developed regions, both of whom make up a large share of funding-relevant research offences.

[2428] *Informetric methods for studying the diversity of the scientific workforce: Towards a state-of-the-art*

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Abstract

Background and rationale Evaluative processes struggle with the notion of diversity of a scientific workforce (Walsh et al., 2019). Despite overwhelming evidence on the need for diverse teams in terms of division of labor (Robinson-Garcia et al., 2020), ethnic mix (Freeman & Huang, 2015) or gender (Díaz-García et al., 2013; Maddi & Gingras, 2021) among others, bibliometric methods have traditionally been focused on the development of impact and productivity indicators. Recently, the development of machine learning algorithms, new data sources and strong calls for action favoring an open and diverse scientific ecosystem, have given room to a stream of studies focused on studying different aspects of career trajectories, diversity of profiles or biases in science. In this paper we attempt at reviewing recent advances in the development of novel informetric approaches and methods to study diversity in science. Specifically, we focus on those related to the scientific workforce.

This focus on diversity of the scientific workforce differentiates this work from other reviews focused on individual level indicators (Gauffriau, 2020; Wildgaard et al., 2014), as we deliberately ignore productivity or impact indicators to focus on methods and approaches aimed at characterizing individuals and the context in which they work. For this, we first review the changes with regard to data sources which have made possible such approaches. Here we focus on two specific aspects: 1) the expansion of author identifiers, and 2) the improvements made with regard to author name disambiguation algorithms. Then we revise the different proposals made by organizing these approaches into three groups: 1) informetric methods related to individuals' characteristics (e..g, gender, age, mobility); 2) methods related to

individuals' context (e.g., career trajectory, social engagement); and 3) approaches related to team dynamics (e.g., author position, contribution statements). We then conclude by identifying the main gaps in the literature and pointing towards potential areas to explore. Data sources The development and expansion of individual level-metrics is closely linked to that of data sources. Their inclusion of metrics, the launch of author profiles and the improvement of the bibliographic metadata have expanded both the popularity of certain metrics and the possibilities for quantitatively studying individuals' academic activities. Here we review the main milestones on how data providers have contributed to expand the use (and misuse) of individual level metrics (Haddow & Hammarfelt, 2019), while at the same time increasing the opportunities for more detailed and fine-grained analyses. We specifically focus on two phenomena that are key to understanding the renewed interest of scientometric studies on individuals: the expansion of author identifiers and the development of name disambiguation algorithms. Individual characteristics The context surrounding the researcher should be considered to offer a more holistic view of the individual level performance (Ràfols, 2019). This section discusses works which have studied intersecting individual categories (age, gender, ethnicity or national background, or cultural identity) influencing the academic career and their activities, aiming to clarify which indicators have been used to study the context and personal features of the researcher. Context Two factors have been essential for the study of individuals' context. First, the development of author identifiers and name disambiguation algorithms. These have allowed the study of changes in the bibliographic metadata associated with publications of a single individual. These changes are monitored by studies using bibliometric methods to study career trajectories. For instance, we find studies focusing on geographic mobility (Moed et al., 2013), changes between sectors (Jurowetzki et al., 2021) or topic mobility (Yu et al., 2021). The second development has been the launch and expansion of new data sources. For instance, altmetric data allows mapping interactions of academics with other stakeholders (Robinson-Garcia et al., 2018), open access data allows the study of open practices (Ramos-Vielba et al., 2022), and author registries allow looking into individual funding (Costas et al., 2021). Team Dynamics There is an abundance of literature with regard to team dynamics. Since Derek de Solla Price published his seminal work 'Little Science, Big Science' (1963), a field has grown in relation with team science (Hall et al., 2018). Here we discuss on approaches related to individuals' and their role when collaborating. We focus on four specific aspects: the use of author order, contribution statements, disciplinary differences and types of collaborations. Conclusions The present study represents a first attempt at compiling recent developments in the field of scientometrics with regard to the development of new approaches and methods to characterize the diversity of the scientific workforce. These new developments represent a unique opportunity to better study and understand how new scientific knowledge is produced from a sociological point of view. From an evaluative perspective, the present review has important implications, as it allows us to identify major methodological gaps and limitations when approaching research evaluation from a quantitative perspective. We conclude by suggesting an agenda for further development and potential areas of interest in which these methods can be applied. References Costas, R., Corona, C., & Robinson-Garcia, N. (forthcoming). 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[4837] *Female researchers report more overall responsibility in teamwork*

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Abstract

Background

A recently published large-scale study in Nature provided evidence from three independent data sources that women in research teams are significantly less likely than men to be credited with authorship (Ross et al., 2022). This new finding may explain part of the often-studied gender gap in productivity and citation impact. Another recent study has shown that women perceive that they receive less credit as co-authors than deserved, while men report the opposite (Ni et al., 2021). We recently performed a global survey among active researchers with results that supplement the two other studies. We asked the researchers about their contributions to the teamwork behind co-authored publications and found indications that female researchers report more overall responsibility in the teamwork they are credited for with authorship.

Our study is part of larger project with the more general aim to gain new knowledge about individual contributions to collaborative research projects and to validate how the contributions of co-authors are represented by bibliometric counting methods. Our general finding is that self-reported degrees of contributions to co-authored publications come closest to be simulated by so-called Modified Fractional Counting (Sivertsen, et al., 2019) and is underestimated by traditional fractional counting, indicating that tasks and responsibilities overlap in research based on teamwork. Preliminary results from the project were presented at the STI 2022 conference in Granada (Sivertsen et al., 2022) without focus on gender. The Atlanta Conference on Science and Innovation Policy provides an opportunity to discuss the gender dimension in our findings, which are more interesting than we expected.

Methods

We conducted a global survey among selected active researchers publishing in all areas of research and used Scopus data to prepare the survey and collect other information about the respondents. We selected 49,455 authors worldwide in all areas of research by applying four filters:

1) Active with at least one publication each year 2016-2020 2) At least one publication with a CRediT statement recorded in 2020 or 2021 3) Variations in the numbers and names of co-authors among their publications 4) A recorded email address

The respondents were contacted by email with a cover letter addressing them individually. The cover letter provided them with a list of the three publications we selected for them and a link to the online survey. They were asked three questions for each publication:

1) On a scale from 0 to 100, to what degree were you involved in the work leading to this publication? 2) Who was involved in which tasks (of eight alternatives)? (Both 'Me' and 'Other authors' could be ticked if tasks were shared). 3) To what degree were you involved? (In each of eight tasks on a scale from 0 to 100)

We listed eight tasks that represented a condensation of the 14 roles in CRediT, the Contributor Roles Taxonomy): Conceptualization, Methodology, Investigation, Data curation, Formal analysis and validation, Writing – original draft, Writing – review & editing, and Project administration and supervision. Gender was self-reported by the survey respondents.

Results

With valid responses from 2,812 respondents, 1,914 men and 830 women, the response rate was 5.7%. As expected, the average overall perceived contribution decreases with an increasing number of authors. Less expected is that female researchers consistently report higher degrees of contribution than male researchers. The difference is clearest in groups with between four and ten members. Within all group sizes, women are more likely than men (25% versus 20%) to claim the highest degrees (81-100) of overall contributions. In their answers to the third question, the degree of contribution to specific tasks, female researchers claimed clearly higher degrees of contribution to three of them: Conceptualization, Writing of original draft, and Project administration and supervision.

One explanation for the higher degrees of contribution from female researchers might be that they are less assisted by other members of the team in performing their tasks. Our results are contrary to this hypothesis. While male researchers on average report that 21.9% of their tasks were performed alone, female researchers on average report that 19.3% of their tasks were performed alone.

Conclusions and significance

We find that female researchers, independently of the size of the team, consistently claim higher degrees of overall contribution to research performed as teamwork. The indication is particularly strong for the three core tasks needed to design the project, to organize the work, and to write the publication on behalf of all members. At the same time, we find that female researchers less often than male researchers report that a task was performed only by themselves. Our interpretation of these findings, which we would like to discuss at the conference, is that female researchers actually take more overall responsibility in teamwork. Our study only covers publications where they are credited as co-authors. Combined with the results of the two other studies mentioned above, that women in research teams are significantly less likely than men to be credited with authorship, and that women perceive that they receive less credit as co-authors than deserved, while men report the opposite, we have a general indication that female researchers contribute more to teamwork and take more overall responsibility than is reflected in the present system of credits in scientific publishing. These findings have implications for studies of gender gaps in scientific performance, for research assessment and funding systems based on documentation from scientific publishing, and for leadership and management in team-based science.

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[7868] *How many times should scholars move? The relationship between international academic mobility and research performance in the US and Europe*

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Abstract

Background According to the human capital theory, international mobility is an investment (Becker, 1962), which benefit individuals in different fields including academia (Baruffaldi & Landoni, 2012; Franzoni et al., 2014; Scellato et al., 2015). The implicit assumption is that international academic mobility benefits multiple aspects of scientists' careers, with particular attention devoted to scientific productivity and impact (see Netz et al., (2020) for a comprehensive review). Therefore, the lack of mobility has been commonly accepted as an inhibitor for publication and collaboration patterns (Horta et al., 2010), especially at the early stages of academic career. Most contributions on the effect of international mobility on scientific productivity however are mostly descriptive and provide heterogeneous results. Whereas Franzoni et al. (2014) demonstrate the unquestionable relevance of international mobility for 14,299 research-active scientists located in 16 countries - results which have been mirrored by de Filippo et al. (2009) for Spain, Aksnes et al. (2013) for Norway, and Jonkers & Cruz-Castro (2013) for Argentina – the topic is controversial. For Spanish (Cañibano et al., 2008; Cruz-Castro & Sanz-Menéndez, 2010) and British (Fernández-Zubieta et al., 2016) researchers, international mobility does not enhance publication performance. According to Van Heeringen & Dijkwel (1987) an initial decline in Dutch researchers' productivity just after a job move is instead followed by a rise a few years later yet, no influence on citations has been detected. An analysis of job mobility in Japan, also show that the association between mobility and number of papers is nonlinear, with gains up to the 3rd job move and declining returns afterwards (Horta & Yonezawa, 2013). Concurrently, the specific competitive advantage for scientists who move to the US compared to Europe (Gaulé & Piacentini, 2013; Veugelers, 2010) started to be contested (Dubois et al., 2014; Hunter et al., 2009). Despite past attempts to disentangle the role of international mobility, there are no studies complied with the investigation of the number of international mobility steps. International mobility may thus be beneficial only to a certain extent, after which the favorable effect of exposure to new dynamic context is offset by the impossibility to settle down and exploit the competitive advantage cumulated. As suggested by Jonkers & Tijssen (2008), there may be an optimal time for researchers to stay abroad, but we aim to understand two main issues: 1) how does international mobility impact research productivity? And 2) does this impact change by each international move, and if so, then how? The database created by Horta & Santos (2020) offers the chance to measure the productivity differential derived by each additional

international mobility step. The study has important theoretical and practical implications, by suggesting guarding against the promotion of international mobility at any costs.

Empirical strategy The database developed by Horta & Santos (2020) includes information on 8,806 researchers located all over the world and from all fields of knowledge, collected via an online survey carried out in 2017 and 2018. From this database we retrieve data to track country mobility in their research career from their Ph.D. to their last job. Since the respondents of the survey were obtained from an initial search process in Scopus, it was relatively easy to trace the publication activity of the respondents and cross it with their international mobility and other information of relevance to the analysis. The quality of the publication is achieved by matching the journal and the year of a given publication with the respective SJR indicator reported in the Scimago Journal Rankings. The final database includes a total of 5,480 researchers, who were granted their PhD between 1946 and 2018 and published over 508,030 publications over the period. To make their scientific activities comparable, we consider the yearly average number of publications per author and the yearly average SJR per publications over the two-years period before and after each job considered (from PhD to the fourth different job). Preliminary descriptive statistics denotes that different patterns emerge according to the mobility choices and geographical area considered. A more robust statistical analysis will be conducted to detect the complex relationship existing between research mobility and productivity, by disentangling the effect of any additional job mobility.

Preliminary results and discussion Four different mobility strategies can be detected in the data: a) no mobility: researchers do not move from the country where they got their PhD; b) serial mobility: researchers change country every time they change job ; c) non-serial mobility: researchers change country for the first time (e.g., they got the PhD, work in the same country during job 1, and then move to another country during job 2); d) returnees: researchers who have changed country in the past go back to the country where they got the PhD (e.g., they got the PhD, work in the same country during job 1, move to another country during job 2 and then come back during job 3). Researchers choosing a precise strategy are characterized by different initial scientific profiles, which are described by productivity and impact in the 2-years before a given mobility step. Yet, each international mobility strategy may impact their scientific profiles, by increasing or decreasing the productivity and impact during the 2-years afterwards. Distinguishing between scientific profile before and after mobility is therefore worthwhile (Franzoni et al., 2014). Below we report and discuss some preliminary evidence. We focus on scholars who got the PhD in the US and in Europe to compare the two biggest scientific markets. Strategy a) no mobility Both in the US and in Europe, no mobility just after the PhD (in the first step) results in a better scientific performance. In the US, scientists who do not move show a productivity and an impact equal to 1.36 and an and 1.21 compared to 0.18 and 0.15 of those who decide to move. The figure is similar also for Europe, where the values are 1.53 and 1.21 versus 0.60 and 0.62. According to Cañibano et al. (2008), international mobile scholars are part of broader networks, work more closely with foreign colleagues, and have access to global funding sources. This does not necessarily mean that they are the most productive, though. By considering the growth deriving from the strategy, no mobile scientists increase their research productivity more than the mobile ones (23% in the US and 19% in Europe versus 17% and 16% respectively). So, this implies that neither mobility leads to more productivity, nor more productivity leads to more mobility. The impact of mobile scientists in the US almost double compared to the growth rate for non-mobile. In Europe the difference is considerably lower (33% vs 32%). The different evolution in terms of productivity and impacts denotes that the two phenomena may follow divergent patterns and that international scholars produce less scientific papers which are however impactful, as there may be a greater attention to the quality dimension of science, i.e. publishing in more eminent journals. However, the lack of mobility in the following steps, leads to lower values on average. The productivity decreases from 1.36 (after the PhD) to 0.58 (mobility between the third and fourth job) in the US and from 1.53 to 0.29 in Europe. A similar pattern is shown for the scientific impact; in the US it diminishes from 1.21 to 0.52 and in Europe from 1.21 to 0.29. This is in line with the expectations that non-mobile scholars have less chance to develop scientific and human capital as they have a limited access to diverse and dynamic knowledge and skills but also to relevant professional ties which constitutes the social capital of international mobile scholars (Jonkers & Tijssen, 2008). The growth trend is more nuanced, as whereas in the US productivity variation tends to zero and impact variation decreases over the steps (25% vs 12% in the first and fourth step respectively), in Europe the growth rate increases in correspondence of the fourth mobility step (60% compared to 19% in the first mobility step for productivity, 92% compared to 33% for impact). This implies that staying in Europe longer may favor European PhD graduates, as they have enough time to develop their own network and cumulate scientific skills and competences without international mobility. Strategy b) serial mobility In the US context, each international mobility step decreases productivity up to job 4, when the values are back in line with the post PhD mobility. The impact, on the other hand, continues to decline (0.15 to 0.10 in the first and fourth mobility respectively). The average values of both productivity and impact are higher for those who never move from the US (from 0.58 to 0.23 and from 0.52 to 0.10), which may give insight on the importance of local networks for a career in the US. Yet, mobile scientists increase considerably their impact in the first three steps of the career, as if they move after PhD, they improve their scientific performance by 46% to 107% whereas for productivity the highest growth corresponds to the second mobility step (+24%). This suggest that international mobility impacts different research performance in different ways. By contrast in Europe, the productivity and the impact diminish only in the first two mobility steps. Afterwards, the average values of both productivity and

impact become higher for those who move (0.51 versus 0.29 and 0.63 vs 0.29), by underling the competitive advantage provided by international mobility for European PhD graduates. Interestingly enough, it is the other way round for growth rate. Both productivity and impact grow at a higher pace in the first to mobility steps (22% and 37% in the mobility between the first and second job compared to 10% and 20% in the fourth mobility step). Evidence from serial mobile scientists testifies that mobility in the first career steps allows to grow faster, attesting an initial boost in the growth rate, which in turn becomes higher productivity and higher impact only for European and only after some mobility steps. This may be due to the fact that at the beginning of the career local networks, and ties are those most valuable for scientists. Strategy c) specific mobility Those who move after the PhD but are not serial mobile scientists in the US have almost zero productivity and impact, which reduces from 0.07 when they move between the first and second job, to 0.01 between the third and the fourth. The trend is the same in Europe, even if the average values of productivity and impact are slightly higher (0.17 becoming 0.02). any mobility step increases their productivity and impact without however leading to greater records. This strategy may represent the cohort who fails to succeed in the academic career in the system they are and either try to improve the situation by moving later on or are forced to leave because not compliant with the minimum standards of the system (see Cattaneo et al., 2017 for a comparison between the quality of the Italian mobile and non-mobile scholars). Strategy d) Returnees Those returning to the US or Europe exhibit higher levels of productivity and impact when they return later. In the US, the difference is considerable, as who return at the fourth mobility step has an average productivity and impact equal to 0.16 and 0.20 whereas who return at the second mobility step equal to 0.03 and 0.01. Likewise, in Europe who return at the fourth mobility step has an average productivity and impact equal to 0.46 and 0.43, whereas who return at the second mobility step equal to 0.17 and 0.18. Compared to the strategy c), coming back later corresponds to better scientific profile of the returnees. Thereby, the competitive advantage of returning to the country where they get PhD decreases with the increase of mobility steps, as testified by the growth rate in scientific impact which reduce from 135% to 37% in the US and from 44% to 21% in Europe. Nonetheless, in both the US and Europe, who return have still scientific profiles which are lower than those who remain and those who move, as they both may count to greater amount of knowledge and network either more national or more international. In summary, some key results may be distilled. First, both productivity and impact are higher for those who got the PhD in Europe than in the US, regardless of mobility choice. This is interesting in light of the debate about the supposed superior performance of those moving to the US (Gaulé & Piacentini, 2013; Veugelers, 2010). Second, scholars who got the PhD in the US exhibit higher scientific profiles when they do not move. Scholars who got the PhD in Europe instead exhibit higher scientific profiles when they do not move only in the first stages. Cumulating network, competences, and experience at the early stage of the career may be thus relevant as scientists may decide to move only once they are enough consolidated (or not move at all). Third, new contexts and collaborations may be beneficial once scholars have a well-established reputation and legitimation and can count on an already established network of contacts. Forth, who decide to move anyway since the beginning need to wait before returning, as it is during that time that they may enhance their scientific profile, which however on average result to be less prominent than non-mobile and serial mobile counterparts.

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[7989] *Evaluating Canadian Climate Policy Mix Stringency*

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Abstract

Session: Teaching a virtual dog new tricks – Drawing intelligence from science, technology, innovation and policy documents

Evaluating Canadian Climate Policy Mix Stringency

1) Overview Jurisdictions around the world implement a mix of policies to mitigate climate change, which are increasingly complex and exhibit substantial variation in coverage and stringency. Comparing policy progress and assessing policy impacts requires understanding the relative stringency of climate policy mixes between and within jurisdictions over time. A variety of indicators compare policy effort across countries, though current approaches fail to capture subnational heterogeneity. This project develops a comprehensive Canadian climate policy database and a subnational stringency index.

2) Background The OECD defines environmental policy stringency as "the degree to which environmental policies put an explicit or implicit price on polluting or environmentally harmful behaviour" [1]. Policy stringency measures are used to examine the effect of environmental policy on pollution, employment, health, investment, and trade [2]. There are numerous measures of environmental policy stringency and ways to classify policies [3-8], falling in five categories:

1. Private-sector cost measures. A direct measure of stringency is the private pollution-abatement cost, though distinguishing it from other business expenditures is challenging. o Survey data. Facility-level pollution-abatement costs and expenditure data. o Shadow-price approaches. Prices are readily observable from policies with a set price or tradeable compliance permit. Modelling estimates implicit (shadow) prices of regulations, but is onerous and difficult to include all policy details [8].

2. Outcome measures. Outcomes such as emissions, pollution, or energy use/intensity approximate environmental policy stringency [9]. Simultaneity confounds this approach: does lax environmental regulation lead to high-polluting jurisdictions, or do high-polluting regions regulate more because of pollution?

3. Proxy indicators. Using one metric as a proxy measure for broad policy stringency, e.g., gasoline taxes or lead content [10]. This approach assumes that a jurisdiction with a stringent performance requirement on the chosen measure will be equally stringent in other areas of environmental regulation, not supported by evidence [11].

4. Policy density. A common measure is equating the number of policies (policy density) with stringency [5,12,13]. This enables easily quantifiable comparisons, but fails to account for differences in stringency and design [14], and is unable to account for changes in emissions intensity over time [12].

5. Composite indexes. Using statistical aggregation, generating a single comparable number of the policy-mix stringency. Composite indexes convey information simply, allow for comparison, and can include more policy complexity. They are often criticized for lacking transparency and not being based on theory.

There are longstanding efforts to evaluate environmental policy stringency using composite indices. The most widely used measure is the OECD's Environmental Policy Stringency Index [3], which evaluates the stringency of a sample of policies against the distribution of other jurisdictions. The latest version includes three branches: market-based policies, non-market policies, and technology support policies [15]. There are several issues with the index. It fails to account for subnational heterogeneity. Second, market-based and non-market policies can achieve the same objective, creating an artificial distinction. Third, using the OECD's stringency definition (the price on pollution), technology-support policies and subsidies do not technically contribute to stringency. Fourth, it only accounts for a handful of prioritized policies. To

address these shortcomings we develop a climate policy index to measure stringency and coverage of mitigation policy at the national and subnational level in Canada.

3) Methodology

We use traditional qualitative analysis methods to analyse Canadian climate policy documents. We code national and subnational Canadian climate policies by objective; type of instrument (e.g., pricing system, performance regulations, incentives, innovation programs); scope (e.g., sector); coverage; integration (reference of other policy instruments); mechanism; budget; implementation; and monitoring. This database will be a publicly accessible resource. We will use the information obtained from the policy inventory to develop a climate policy index measuring policy stringency and coverage. The aggregation method for the index will follow the policy classification codebook and be subject to robustness tests. Weighting of diverse instruments is a challenging process as relative weights impose assumptions on the interactions among policies.

4) Anticipated Results

Canada has rapidly expanded climate mitigation policy in recent years. While this has been a consistent trend broadly, the types and stringency of policy implemented varies widely across jurisdictions. This study will provide a detailed analysis of the types, stringency, and design elements of climate policy implemented across jurisdictions in Canada. We expect to find different jurisdictional emphasis on policy "sticks" relative to policy "carrots". We predict that jurisdictions will impose different levels of regulation on sectors, depending on their economic and emissions structure.

Another aspect of climate policy design expected to emerge from this study is the role of policy interactions. In a federation where climate policy is imposed at both the national and sub-national level, in some cases the same emitting activities are regulated by multiple overlapping policies across jurisdictional levels. This can result in unanticipated interactions that may support or undermine policy goals. Examination of the impact of individual policies or automated processes for policy analysis may fail to capture these unintended consequences.

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[5706] *Technological Capabilities and Co-Invention Networks for Regional Diversification: Evidence from Brazil*

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Abstract

Purpose: This paper investigates the role of the regional endowment of technological capabilities and co-invention network structures in the emergence of new regional technological specializations. We consider a region specialized in a technology when its share of patents in a given field is higher than the share in the country.

Literature Review: Regional technological diversification has been addressed in the literature as a path-dependent process where new technologies congruent with the extant local endowment of capabilities are more likely to be successfully implemented in a region (Hidalgo et al., 2007; Neffke et al., 2011). The rationale is that regional

diversification is like a branching process whereby the chances for the successful development or adoption of new technologies rise with the cognitive proximity to those in which the region is already specialized. This, for instance, is the core idea behind the "smart specialization" movement in the European Union. A significant literature has already explored this argument, emphasizing the endogenous dynamics of the regional diversification process. They empirically show that the regional endowment of knowledge and other capabilities is crucial to developing new economic specializations (Balland et al., 2019; Neffke et al., 2011). In parallel, another stream of literature has been pointing out the benefits of inter- and intra-regional co-invention networks for regional innovation performance (Bathelt et al., 2004). However, the impact of these network configurations on regional technological diversification has not yet been widely discussed in a branching process context. While some recent attempts on this matter have concentrated on external linkages (Balland & Boschma, 2021; Whittle et al., 2020), the role of co-invention networks at the inter- and intra-regional levels remains unclear.

Methodological Procedure: We use patent data from Brazil (2000 – 2019) to design two types of networks: one based on inter-regional and the other based on intra-regional co-invention linkages. We then conduct an econometric analysis at the microregional level to examine the effect on regional technological diversification of four main variables: centrality degree, betweenness centrality, transitivity, and technology flexibility. Centrality degree is the number of connections a region establishes with others, capturing the region's access to external knowledge. Betweenness indicates how well-positioned a region is in the inter-regional co-invention flows in Brazil, meaning that the region intermediates knowledge flows between others. Transitivity shows how well knowledge disseminates inside a region based on the network's cohesiveness. Technology flexibility captures the average cognitive proximity between the regional technological capabilities and the technologies in which the region is not specialized.

Findings: Our results indicate that the regional technological endowment and co-invention network structures at both the inter- and intraregional levels are essential for diversification. High inter-regional betweenness is shown to be important in all contexts. High intra-regional transitivity is shown to be important in most contexts. Network centrality is statistically significant and positively affects diversification when interaction terms regarding the regional development level are included. Our results suggest a substitution mechanism between technology flexibility and betweenness, on the one hand, and GDP per capita and betweenness, on the other. This effect also holds when we change betweenness for centrality degree. It means that less developed regions with lower technological capability endowments benefit from establishing inter-regional co-invention linkages in general, regardless of control and intermediate positions. Our analysis corroborates with findings from two strands of literature. First, the literature on evolutionary economic geography which has empirically shown that the diversification process is path-dependent and is strongly impacted by the relatedness between different sectors, technologies, and products, as the current knowledge and capabilities regionally available will support the development of new ones. Second, the literature on regional innovation networks, in which the flows between physically close and distant agents contribute to enhancing knowledge recombination and production, encouraging learning and innovation.

Policy Implications: Our results can enrich regional diversification policies. For well-endowed regions the issue is what to aim for and with who. Less well-endowed regions face additional stress. Designing place-based policies can be especially challenging for them due to fewer knowledge and technological capabilities which, in turn, narrows the options for policymakers regarding diversification targets. Adding network-related aspects broadens the scope of policy by including practices that favor the connections of actors within and across regions.

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[4791] *The Role of Speedier Public Funding for Small High-Tech Firmsentrepreneurial finance; seed funding; SBIR; NIH; public venture capital; entrepreneurial timing*

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Abstract

Technology-based entrepreneurial firms face considerable barriers in commercializing their innovations. Time, in particular, is a scarce resource for start-ups (Levesque & Stephan, 2020). New firms operate under high risk and severe capital constraints as they try to outpace competitors and generate economic profit. Research has shown that start-ups' capital structures influence firm outcomes and development speed (Hecchavaria et al., 2016). This is especially the case during the early stages as a company tries to move from proof of concept to early seed stages when the pot of money available to firms is quite small and their ideas are quite risky. Hearkening to Benjamin Franklin's famous quote, "time is money" quite literally to an entrepreneur. The persistent qualm of the entrepreneur is that they rarely have enough of either.

This is where endogenous growth theory suggests government has a role. Government intervention is seen as necessary to reduce barriers in helping firms develop technologies, based on the idea that the creation of new knowledge is a public good that the private sector will not effectively support due to the high risk entailed (Mazzucato, 2011). Government enters at an earlier, riskier stage than private funding is willing to enter. But public funding operates under different institutional norms than private funding and we posit in this paper that these differences have implications for how the funding impacts firms' subsequent milestones. Qualitative evidence from interviews with entrepreneurs indicates that federal funding through the United States (U.S.) Small Business Administration's (SBA) Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs may be too slow to attract high quality applications relative to alternative sources of early funding (NASEM, 2022). This slowness can be attributed to the nature of the routinized bureaucratic forms that federal agencies follow (Perrow, 1986) which make the minute-by-minute decisions of an angel or venture capitalist difficult, if not impossible, to replicate. Evidence from Europe indicates start-ups that receive public venture capital (VC) sooner have higher sales-growth (Grilli & Murtinu, 2015). These questions have not been investigated in the U.S. context.

In this paper, we ask whether shorter time periods between proof-of concept and seed stages in public VC allow firms to achieve greater technology and financial milestones. We exploit a unique programmatic shift in the U.S. SBIR and STTR funding to answer this question. Owing to the concerns that important technologies were lying dormant, the federal government began experimenting with new models to support high tech firms more swiftly by offered "Fast-Track" awards, which allow firms to bypass Phase I (averaging $150,000) and move directly to Phase II of the program which offers significantly more funding (averaging $1 million). We take an exploratory approach to examine performance differences between firms who secure these special awards, called Fast-Track awards, and comparable firms who received the regular Phase II award after a Phase I. We isolate our setting to SBIR/STTR awards made through the National Institutes of Health (NIH). This allows us to examine a range of firm outcomes.

First, we present a descriptive overview of these special awards, including an exploration of the Fast-Track program to understand which firms are likely to receive them. Next, we estimate a series of two-way fixed effects panel regressions to assess whether speedier SBIR funding increases the likelihood that a firm will a) produce clinical trials or b) medical devices as the result of the funded application; c) obtain patents; d) attract subsequent funding from private sources; and e) be acquired compared to the control group (extensive margin). Finally, we use a unique dataset on state match programs in a differences-in-differences analysis to examine the impact of this exogenous windfall funding (Myers & Lanahan 2022) on the Fast-Track recipients (intensive margin). We use NIH's RePORT data archive for detail on award type and corresponding patents and clinical trials, as well as the USPTO PatentsView database. We construct further outcome measures using the SBA SBIR award database as well as information on VC, angel investment, and other private funding support from Crunchbase. While numerous studies document the impacts of this program on follow-on financing (Lerner, 2000; Howell, 2017), patents (Myers & Lanahan, 2022), and employment (Lanahan et al., 2021), consideration of the influence of the timing of funding rounds is largely absent from the public VC literature.

We find that among firms that receive a NIH SBIR/STTR Phase II or Fast-Track award, the marginal Fast-Track dollar is associated with a greater number of follow-on clinical trials and patents. We also find that among Fast-Track award winners, those that receive an exogenous increase of funding through variably available state match programs have even greater number of clinical trials than those that do not receive the state match funding, but receive less private venture finance. These are important outcomes for small, young firms and illustrate that faster SBIR funding can be beneficial if firms are pursuing clinical trials and patenting as part of their development process.

This paper makes three contributions. First, we contribute to the field of entrepreneurship by responding to recent calls for a "time-based lens for entrepreneurship research" (Lévesque & Stephan, 2020). We offer new insight into the importance of the timing of public, early-stage, proof-of-concept, and seed funding. Second, we contribute to the literature on public VC by exploring a previously understudied method of hastened public funding. Finally, we draw practical implications for entrepreneurs and for policy. We provide new understanding about how the SBIR program may be meaningfully enhanced by quickening the pace of funding, if the SBIR wants to increase products, technologies, and follow-on funding as a goal.

[3018] *Innovation and social welfare: A new research agenda*

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Abstract

Innovation fosters social welfare. Technological and organizational changes create new terrific opportunities to address societal changes and to improve human life. This is the fundamental motivation that has traditionally spurred the development of innovation research and policy-making during the last 50 years or so (Martin, 2016; Nelson, 2011). The proposition that innovation fosters social welfare, though, is implicitly based on two important assumptions that have so far dominated scholarly research and policy-making in the economics of innovation.

The first assumption is that new technologies affect individuals' well-being by increasing income and consumption possibilities. Hence, the field has so far implicitly adopted a notion of individual well-being that focuses on economic determinants and material wealth, and that typically disregards non-economic dimensions. However, this assumption is problematic: innovations have a broad variety of impacts on individuals' quality of life, that comprise multiple economic, social and psychological factors and capabilities (Castellacci & Tveito, 2018; Witt, 2021). An important challenge for future research is thus to adopt a broader notion of well-being that will enable to investigate together economic and non-economic impacts of innovation within the same framework.

The second assumption refers to the notion of aggregate social welfare. Schumpeterian research has so far typically focused on the positive impacts of new technologies on economic performance (GDP per capita, productivity, competitiveness, employment). The focus on efficiency effects is implicitly rooted in a simple utilitarian notion of social welfare, which focuses on the overall net benefits that innovations lead to in a population of representative agents, but it disregards the study of distributional impacts and the equity dimension. This approach is questionable, because we know that the process of creative destruction does affect the relative position of winners and losers, and that these differences tend often to increase and persist over time, sometimes leading to growing inequalities, polarization and social exclusion (Witt, 1996). Thus, it is paramount that future innovation research will question the use of a standard simple utilitarian notion of social welfare, and develop a broader framework that will enable to consider both efficiency and equity dimensions.

Taken together, these twin research challenges call for the development of a new research agenda to study innovation and social welfare. The present paper will first critically review the concept of social welfare in the economics of innovation literature, and it will then outline the main objectives and pillars of this new research program, the novel research directions that it calls for, the conceptual issues that it will face, and its implications for the foundations and objectives of innovation policy. The new agenda will consist of two major pillars. First, it will adopt a broader and more inclusive notion of individual well-being, and so develop a conceptual framework that will seek to study together economic and non-economic effects of innovation (Alkire, 2016). Second, it will adopt a broader notion of social welfare that will give explicit consideration to the distributional impacts of innovation, and hence study the relationships and possible trade-offs between its impacts on efficiency and equity (Weymark, 2016).

This new research program calls for a cross-fertilization of the economics of innovation with two important neighboring fields that have so far been largely neglected in Schumpeterian research: well-being studies, on the one hand, and welfare economics, on the other (Adler & Fleurbaey, 2016). Drawing insights from these well-established fields, innovation research will develop a more thorough understanding of what types of innovation contribute to individual well-being and social welfare, those that do not contribute, the time horizon and trade-offs related to these impacts.

Why is this new research agenda relevant, and what does it seek to achieve? By adopting a broader notion of social welfare, and by investigating how innovation affects economic and non-economic well-being, the creation of economic value and its distribution among agents, this new research program will seek to bring more explicitly the ethical and normative dimensions into the economics of innovation, and thus build up a more solid foundation for R&D and innovation policy. Instead of assuming that innovation will in most cases be beneficial for the society in the long run, and that all kinds of R&D investments should therefore be supported by public policies, the new research program will seek to show that different innovations may have distinct effects on individual well-being and social welfare, and it will therefore provide R&D and innovation policy with better grounded knowledge on those innovations that public policy should support and promote vis-à-vis others. Such grounded knowledge will be obtained by means of empirical analysis that will study ex-post the effects that existing innovations have had on individual well-being and social welfare in the past; and through theoretical research, foresight and scenario studies that will investigate ex-ante new technological trajectories that unfold today, and how these might affect individual well-being and social welfare in the future. These questions are arguably complex, but they need to take a more central position in innovation studies in order to provide a stronger foundation for R&D and innovation policy.

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[8366] ***Collaboration Patterns of Public Research Institutes in Korea and Their Relation to Positioning of Research***

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Abstract

1. Background & Rationale

The last few decades have seen an increase in science and technology (S&T) investment and an expansion of the innovation system (Lepori, et al., 2008). As a result, the roles and functions of different actors in the innovation system are said to have become more diverse and complex. Hence, the "positioning" of actors, including their identity, relationships, complementarities, and immaterial assets, in the innovation system has become more important to understand and represent the current changes in the innovation system (Lepori, et al., 2008). The positioning focuses on flows and linkages between actors in the innovation system rather than input/output rationale from quantitative indicators (Lepori, et al., 2008). The positioning of public and private research institutes is particularly critical as they are an important sub-unit of the innovation system, shaping the flow of research funding and knowledge (Godin, 2009). Positioning is particularly complex for public research institutes (PRIs) since they have more complex goals to achieve compared to private research institutes which focus mostly on economic benefits. PRIs are also a means for governments to achieve their policy goals and shape the research environment for both public and private research (Cruz-castro, et al., 2012). They focus more on social welfare and provide more inclusive processes for knowledge consumption and transfer than private research institutes (Archibugi & Filippetti, 2018). They also have responsibility to respond to the increasing social demands (Torre, et al., 2021), and are required to conduct R&D projects that businesses are not well equipped or incentivised enough to invest in (OECD, 2016). In short, it is even more challenging for PRIs to define their roles and to position themselves not only because of the expansion of the innovation system but also due to the complex nature of public research.

Positioning of actors in innovation systems is multidimensional by its nature. In our previous work, we considered the identity and missions of PRIs to analyse their positioning (Lee, 2022). One other important aspect of PRIs' positioning are their linkages and collaborative relationships (Lepori, et al., 2008) which can provide information about PRIs' roles in relation to other actors. Collaboration is also of interest due to the increasing complexity of research and increasing interdisciplinarity. As most research problems are now multifaceted, they can no longer be solved by only one field of knowledge, and collaboration and interdisciplinarity are essential (Rigby & Edler, 2005). However, this has blurred the traditional boundaries between research disciplines, and has made it more challenging to define roles and disciplinary positions of PRIs. Further considering that access to new knowledge or resources is the main goal of research collaboration (Defazio, et al., 2009; Katz & Martin, 1997; Mote, et al., 2007; Rigby & Edler, 2005), research collaboration is imperative for interdisciplinary research, and provides important insights about how research institutes are positioned within the innovation system, especially in terms of research disciplines. Collaboration is thus not only the main activity to increase interdisciplinarity, but also provides important insights to show the degree of interdisciplinarity.

Recognising their importance, policy makers have made efforts to increase collaboration and interdisciplinarity. For example, in Korea, PRIs focusing on basic research were established (KBSI in 1988, KIAS in 1996, IBS in 2011), and the research council established departments in charge of cooperation and convergence, and interdisciplinary research in 2014 (NST, 2018). Regardless, there were no concrete discussions about how collaboration helps PRIs with their research activities and positioning (e.g. see Goh (2021), and Kim (2010)).

2. Methods & Data

In this context, this study aims to investigate collaboration patterns and their relation to interdisciplinarity and positioning of PRIs. Focusing on the case of Korean PRIs, this provides empirical evidence of the role of collaboration in positioning, and how linkages (network profiles) relate to the roles and positioning of PRIs. For example, a research institute that acts as a bridge between research institutes in two different fields can be said to play a role in facilitating interdisciplinary research in the two fields. Moreover, by examining linkages and collaboration network profiles, it is possible to present empirical evidence that collaboration and interdisciplinarity are empirically related.

Empirically, we focus on the 27 PRIs under control of the Korean Ministry of Science and ICT who perform national research projects, and additional projects that are related to their missions, as assigned by the government at the time of establishment. For all PRIs we collect publication data for the period 2011–2020 from the Web of Science database and investigate the co-authorship network. This resulted in a database of 94,507 publications. Each research institution collaborated with an average of 1230 research institutions over the observed 10-year period, forming about 14,000 networks.

3. Preliminary Results

A first investigation of the publication data using social network analysis shows that co-authorship clusters form around the nature of the research field – basic, applied, and life-science-related research focused research institutes, which corresponds to the Pasteur's quadrant classification (Stokes, 1996). Initial analysis also suggests that research institutes focusing on basic science have different network patterns compared to research institutes focusing on applied science. For example, PRIs with basic research focus tend to have a stronger network with their research partners. Even with the increase of clustering resolution, PRIs located in the basic research group remain as one large group while PRIs located in the applied research group or life-science-related research group split into a number of small clusters. From these

preliminary results, we expect the network profile to also imply the nature of a field of study and start to reveal interdisciplinarity. To this end, we calculate various network measures such as betweenness centrality, closeness centrality, and number of edges (co-authorship network) per nodes (a PRI's research partners). It is noticeable that PRIs focusing on basic research have around 5 times more edges per nodes, which is much higher than the edge to node ratio in the applied research network. This indicates that those PRIs collaborate more with their partners than PRIs with a focus on applied research. As such, by identifying how collaboration patterns differ by discipline, it is possible for the PRIs to clarify their relationship with their research partners and further their identities in the network.

4. Further Analysis and Significance of the Study

By providing information about the relationship between network patterns and the nature of research disciplines, this study can enable research institutes to identify their positioning in today's complex innovation systems. This would also guide policymakers and researchers to allocate limited resources and manpower more efficiently, and provide insights on establishing future development strategy.

Building on the network analysis and measures, we will further analyse how they relate to other elements of PRIs such as their interdisciplinarity. For example, interdisciplinary research and single-discipline research can be identified through clusters; and inter-sectoral and cross-sectoral collaboration can be identified. Also, the characteristics of research partners will be investigated to gain furhter insights into research disciplines. Moreover, the positon of PRIs is not static and additional investigation will specificially look at changes in networks over time. Such a dynamic analysis can help to provide an outlook of how research clusters are formed through collaboration.

[6221] *Exploring Transparency and Openness Through TOP Factors and Citation Indicators*

Ann Beynon (Institute for Scientific Information, Clarivate) and Gali Halevi (Institute for Scientific Information, Clarivate).

Abstract

Background The Open Science movement continues to grow across the globe with support from the European Commission (EC), the OECD (OECD) , the United States National Academies (National Academies of Sciences, 2018), amongst others. The Center for Open Science (COS), a non-profit organization, was founded in 2013 to "increase the openness, integrity, and reproducibility of scientific research" (CoS). In 2015, CoS, with several universities, funders, and publishers, published the Transparency and Openness Promotion (TOP) Guidelines, eight standards scholarly journals can implement to further openness and transparency (Nosek et al., 2015). In 2020, CoS launched the TOP Factor to assess the degree to which journal policies are promoting transparency and reproducibility. The TOP Factor is based on the TOP Guidelines, e.g. transparency of data/code/materials/research design and pre-registration. The TOP Factor is calculated by summing the level of implementation of the 8 original standards plus 2 additional standards (CoS).

The Web of Science Core Collection is a global, multidisciplinary citation index widely used for scientometric analysis. The list of journals in Core Collection is available on the Web of Science Master Journal List (Clarivate). The Core Collection includes 21,879 active journals as of January 2022, covering sciences, social sciences, and arts & humanities. These journals pass a rigorous editorial selection process (Clarivate).

In 2020, Clarivate collaborated with the Center for Open Science to incorporate TOP Factors on the Master Journal List (Clarivate). As of February 2022, 1,232 of the Core Collection's journals (5.6%) have a TOP Factor. Previous studies have analyzed TOP Factor for journals in specific disciplines, including sleep research and chronobiology (Spitschan et al., 2020), herpetology (Marshall & Strine, 2021), and sport science (Hansford et al.), (Hansford et al., 2022), (Hansford et al., 2021). Other studies have found a positive correlation between open data sharing, one aspect of open science, and citation impact (Piwowar et al., 2007), (Piwowar & Vision, 2013). This study explores the relationship between TOP Factor and journal impact measures across all research disciplines.

Methods The TOP Factors were drawn from the Web of Science Master Journal List in February 2022. To calculate TOP Factors, Center for Open Science uses 10 standards scored individually on a scale of 0-3 (disclose=1, require=2, verify=3). These 10 scores are summed to create the overall TOP Factor with a maximum of 30 (CoS). The citation metrics are from InCites Benchmarking & Analytics, a research analytics database based on Web of Science Core Collection data. Institutional Profiles journal categories were used. This category scheme uses 6 broad academic disciplines.

The citation indicator used is Journal Citation Indicator (JCI). The JCI is the mean category normalized citation impact (CNCI) for the journal. CNCIs are calculated at the document level for articles and reviews from the previous three years, counting citations for four years. The JCI is normalized for document type, publication year, and category. The average JCI for any category is 1. A JCI of 2 indicates that a journal is receiving twice the expected number of citations than the average journal in the category.

Results The majority of the 1,232 Web of Science Core Collection journals with a TOP Factor are in social sciences (786), and the fewest are in physical sciences (69). Social sciences also had the highest percentage (12%) of its titles having a

TOP Factor, and physical sciences had the lowest (2%). The median TOP Factor was 1. Very few approached the maximum TOP Factor of 30. Physical sciences has the highest average TOP Factor (4.7) despite having the lowest number of journals and lowest percentage of its category having a TOP Factor. The 2020 JCI for these journals ranges from 0.11 to 11.25 with a median of 1.26. We found no clear correlation between the journals' JCI and TOP Factor, despite previous studies that found a citation advantage for papers with open data. Since open data is only one of the attributes that TOP Factor reflects, further research is needed to explore the relationship between openness and impact.

Significance This is one of the first studies to analyze TOP Factors across a multidisciplinary set of journals. There are some disciplinary trends, with social sciences having the highest number and percentage of titles with a TOP Factor, and physical sciences having the lowest. Overall, only 5.6% of the Web of Science Core Collection journals have a TOP Factor, and the median TOP Factor is 1 out of a potential 30. This suggests that adoption of the TOP guidelines is not widespread in the publishing community, and those who have pledged to adopt them are not fully embracing them. We found no correlation between the TOP Factor of a journal and its normalized citation impact despite the perception that greater openness leads to greater impact. Further research could explore disciplinary trends, as well as changes over time.

[5623] *Tracing causal mechanisms for the impact of societally targeted funding*

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Abstract

Background

Since the 1970s, there has been a growing emphasis among policymakers and research funders on how to accelerate and augment the societal impact of public research. Increasing constraints on public budgets, a strong belief in the importance of universities as engines of innovation and economic growth, and rising global competition are just some of the factors behind this push for greater relevance and measurable societal impacts. Trends are now moving further, towards greater articulation of the needs and goals of policy to meet societal challenges.

While research so far has added knowledge to some aspects of our understanding of societal impact, the role of research funding in relation to this is still underexplored. Although existing studies have examined the role of funding in promoting changes in researchers' behavior, these studies typically have not probed the nature and intensity of academic and non-academic engagements or to what extent it has been productive in leading towards societal impact.

Given that funding and the design of funding systems are viewed to have a central role in defining the scope, content and direction of public research systems, a detailed understanding of the composition and effects of research funding is vital, both to inform the design of funding that is targeted at societal impacts and to better understand the mechanisms behind research collaborations that are potentially productive in leading to societal goals.

Drawing on two in-depth cases of research projects that have received societally targeted funding and appear to have involved highly intensive academic/non-academic engagements, this study examines processes and mechanisms leading from research funding towards societal impact. One case is within renewable energy research, the other within food science. The two cases have been selected as they have both received societally targeted funding and both have led to new innovations/societally aimed follow-up projects.

We trace causal linkages from the specific research funding to the actual or potential societal impact of the research they fund. We seek to answer the following research question: how does societally targeted funding lead to societal impact? Using process tracing, we aim to explore how funding and its specific characteristics can be linked to impact, with particular focus on collaboration/productive interactions. Interactions among stakeholders are often seen as necessary for research to produce societal impact, but we still lack knowledge on how these interactions can be stimulated and supported in ongoing, meaningfully cumulative ways by funding conditions. Furthermore, we explore how collaboration/interactions between academic and non-academic partners become 'productive', or in other words, what aspects of the collaboration matter for generation of societal impact This includes decisions regarding engagement with non-academic actors and other activities to further develop and exploit research results.

Method and analysis

Process tracing in social science is a method for studying causal mechanisms linking causes with outcomes (Beach and Pedersen 2019). The aim of process tracing is to enable inferences about how a cause (or set of causes) contributes to producing an outcome. Causal mechanisms are traced through the identification of "mechanistic evidence": "the within

case observable manifestations of the operation of activities linking parts of a mechanism together that can act as evidence for how a causal mechanism works in an actual case." (Beach and Pedersen 2019).

In our process tracing study, we seek to explore how societally targeted funding facilitates societal impact of research through inter- and transdisciplinary collaboration, over time periods of 6-7 years. Despite the vast amount of literature tying research collaboration between academic and non-academic partners to societal impact, there are no theories causally connecting societally targeted funding with societal impact which is what we seek to explore. Therefore, we will pursue a theory-building approach to process-tracing.

In this study, societal impact is understood broadly as not only the tangible end-results of research processes, but also as a set of antecedents for the emergence of societal impacts. We seek to trace research development processes both within granted projects and results, outputs and outcomes beyond the projects themselves.

The analysis is part of the PROSECON project (Promoting the Socio-Economic Impact of Research; Aagaard et al. 2021, Ramos-Vielba et al. 2022), which studies cases of societally targeted research funding granted in 2015/2016, with interviews of academic principal investigators (PIs) and non-academics, supplemented by background analysis and detailed mapping of all recent grant projects involving the PI. This study, which is currently in progress, builds on two of these cases, tracing causal mechanisms through additional interviews and analysis of research and innovation outputs. In doing so, we focus in particular on the following:

Tracing the role of research funding in this process. How and to what extent impact mechanisms are connected to the specific design of societally targeted funding

Funding design, including requirements, funding program objectives and proposal assessment criteria, influence project design and consortia formation. Through interviews and document analysis, we examine how the funding shaped the research project and how research was conducted, and subsequently how the project design promoted the development of societally relevant research results.

Tracing the role of collaboration across academic and non-academic partners for the societal impact of research.

Key elements that can drive societal impact are societal orientation and collaboration. Collaborative relationships may have been formed prior to the project under consideration, but in terms of the project itself, collaboration begins with the formation of ideas and objectives and the alignment of expectations among the different project partners. We study how these initial plans and goals influence the course of research and potential further development. The nature and intensity of collaborations themselves have an important influence on the progress and direction of research, including key decision-making processes over the project.

The strengths of this approach are the detailed characterizations of the causal mechanisms leading from funding towards societal impact and how these mechanisms work. The results of this study should thus be useful both towards understanding how inter- and transdisciplinary collaborations function and how funding design influences research. Both are valuable for funding policy design. Research funding often has specific aims, such as excellence, originality, or in this case societal impact. Both the results of this study and the process tracing approach that we use will provide detailed knowledge on how societally targeted funding works.

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[6646] *Identifying and Characterizing Translational Research Strategies*

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Abstract

Rationale: How might one identify translational pathways and evaluate translational research strategies? A translational research strategy is, in essence, a story about how one plans to commit resources over time, and across many related research problems, with a specific goal in mind. Translation, from the Latin trans (across) and latus (to carry or bear), simply means to carry or bear something from one place to another. Translation is generally defined as the process by which initial observations are turned into tangible interventions and applications. Central to this definition is the concept of 'process'. Translation is not about where something is carried from or where it is being carried to. Neither research topics, communities, nor problems are translational in and of themselves. Rather, translation is about the connections between topics, communities, and problems. Translational research is about the carrying across of (micro)solutions from one problem to another—from one community of researchers to another. A translational research strategy is therefore an exercise in pathfinding. From the perspective of strategy, a 'good' translational strategy is one where the organization

has expertise in specific research problems and the micro-solutions that link these problems. In other words, the path is navigable. A 'bad' translational strategy is one where the problems are stated vaguely and/or there is no way to evaluate whether one has expertise in the relevant set of micro-solutions. This study proposes a systematic method by which translational pathways can be identified using a large-scale detailed model of the scientific literature. It also focuses on storytelling based on linkages as a means of evaluating potential translational pathways from a strategic perspective.

Background: Most bibliometric analyses focus on characterizing research areas. This is often done by identifying a (small) set of papers, clustering those papers, and characterizing the actors and content of the clusters. Relatively little work has focused on the linkages between clusters even though translation is inherently an inter-cluster phenomenon. Moreover, most of these studies have little chance of accurately characterizing translation simply because their data do not cover the entire potential translational pathway.

We overcome these difficulties by using a global model of science, one in which 19 million documents from PubMed have been grouped into 29,013 clusters. Each cluster represents a research problem to which a group of researchers is contributing micro-solutions. (No single study solves the research problem, but each study contributes a piece of the solution—a 'micro-solution.') The clusters represent intellectually distinct problems along the basic-to-applied spectrum. For instance, one cluster may represent a problem in understanding the role of R-loops in DNA damage while another addresses the role of silica exposure in lung cancer among coal workers. When a paper from one cluster cites papers in another cluster it represents the potential exchange of a 'micro-solution' between clusters. This is an example of what is 'carried from one place to another'. When considered in bulk, we refer to this phenomenon as the importing and exporting of micro-solutions between sets of research problems.

Consider, for example, significant events in the history of the COVID-19 mRNA vaccine. Between the initial observation that started it all—the discovery of mRNA in 1961—and the emergency authorization of the mRNA vaccine in 2020, many different groups of researchers with many different backgrounds and goals contributed over many years. But while the story of the mRNA vaccine would not exist without them, it isn't solely about them. It's about those discoveries and micro-solutions carried from one community of researchers to another. Thousands of pathways or stories like this one have occurred across the research landscape. More importantly, many currently incomplete potential pathways exist. Progress in translational science can be accelerated and improved by identifying these potential pathways in a strategic manner.

Method and Results: We have identified one translational pathway of strategic importance to the University of Michigan Medical School (UMMS) by exploring the PubMed model of science manually. UMMS has a specific competency in the general topic of chronic pain. We started by identifying a cluster in the PubMed model on pain-related aversion – a basic science cluster in which UMMS has noted expertise. We then identified other clusters that heavily cite the pain-related aversion cluster, finding that the strongest linkage was to a cluster focused on the problem of pain anticipation. This cluster is also one in which UMMS has a strong presence. We then carried on this process for three additional steps, leading to a five-node pathway.

While we were able to easily ascertain the particular focus of each cluster, to tell the story of translation one must have a more detailed understanding of the topical focus of the links between clusters. We thus identified the subset of papers that comprise these citing pathways and summarized their content. For instance, the link from pain anticipation to pain-related aversion is based on 320 citing instances and can be summarized as "the anticipation of pain prioritizes awareness and attribution of somatosensory sensations as painful…"

From a strategic standpoint, this pathway—which has been validated by administrators at UMMS—is important because, while the institution currently has faculty expertise in the first four nodes in the pathway, it has almost no activity in the final (bedside) node. In other words, UMMS discoveries are being translated to tangible patient health impacts by other institutions, potentially depriving UMMS researchers of valuable insights into the clinical applications of their work and precluding them from the clinical collaborations that could make their future work more impactful. If UMMS wants to develop expertise along a complete pathway, it will need to add research in that area to its portfolio, either through recruitment or collaboration. This is key information for UMMS.

While this translational pathway was identified manually, our next step is to develop methods to reproduce these results algorithmically. Once done, we will apply the method to other areas, to identify additional translational pathways relevant to the UMMS strategic vision. These will be validated by experts in-house. The algorithmic method and additional results will be presented at the conference in May.

Significance: In summary, we argue that these intellectual links, which we can quantify through citations, represent dependency relationships. Research communities are formed around difficult to solve problems and these problems cannot be solved in intellectual isolation. These research communities therefore rely on the continuous exchange of micro-solutions, the record of which can be found in article references. These exchanges represent literal instances of translation: the carrying across of information from one community to another. Ensembles of these exchanges become translational pathways—a directed process network of dependency relationships that we call "translation".

Significantly, by examining the papers that comprise these dependency relationships between communities, we can summarize and understand them, effectively describing the way in which solutions from one community are used by

another. The entire translational network, if visualized with all the edges, would look like an impenetrable hairball. We would, in effect, be attempting to describe all of science. The methodological solution is therefore to distill the narrative by screening out nodes and links, both simplifying and strengthening it, so that effective translational strategies can be identified and characterized.

[6203] *Disentangling the societal discourse on covid-19 in Belgium: scientists communicating in the written press during the recent public health crisis*

Hans Jonker (Vrije Universiteit Brussel) and Olivier Delmarcelle (Vrije Universiteit Brussel).

Abstract

Introduction Scientists were omnipresent in the media during the covid-19 pandemic. More than ever, the recent public health crisis required health scientists to become public spokespersons. In Flanders, the northern Dutch speaking region of Belgium, a few academics became known as “the virologists” in a very short period of time, and could count on various media bringing their up-to-date knowledge to the wider public. But not only academics from the medical sector were featured. The covid-19 pandemic became the new issue of choice for academics from various non-medical disciplines as well, with a number of them using the written press to voice their critique of the predominant medical discourse to the general public. While counting media coverage provides valuable insights into the "amount" of media coverage, the question of what discourses both medical scientists and non-medical scientists employed remains underexplored. That the public debate is also an arena where knowledge, ideas and interpretations from different scientific disciplines compete for attention – alongside “scholarly” circuits of communication – is often overlooked. This gap is likely informed by the persistent methodological problems we face when studying scientific communication beyond the academic sphere. The recently developed neural language processing tool at Sentometrics however, allows for a close analysis of the scientific discourse of academics in the written press regarding the covid-19 pandemic. Advanced textual indicators provide insight into the nature and relevance of these interactions, and improve understanding of the lexicon, sentiment, sequence and timing of scientists communicating during the recent public health crisis. Methods Researchers active at the five universities funded by the Flemish Community in Belgium were the focus of this study. Using data from Flanders Research Information Space (FRIS), an open source database operated by the Flemish government, active researchers (n = 35277) were used for analysis, supplemented with additional data on gender, career position, number of publications, sector and discipline. The names of active researchers were queried in the Belgian media database GoPress, collecting the occurrence of their names, after correction of namesakes (false positives). We excluded academics with a political mandate. We focused on Dutch speaking newspapers and magazines in Belgium, because of the highly concentrated Flemish media ecosystem. The time period of the newspaper articles was from Jan. 1, 2019 to Dec. 31, 2020. The year 2019 functioned as a control year, to analyze the distribution of media attention of academics in the written press before the covid-19 pandemic. In the near future, the analysis will be supplemented with data from the year 2021. The covid-19 pandemic was the overriding theme of 2020 and 2021 news in Belgium. First messages on covid-19 began to appear in January 2020 in Belgium, followed by a proliferation brought by the first casualties in March 2020. Quickly, the federal government sought assistance from several expert consortia, which included several academics. These quickly became the public face of the collective response to the pandemic. They consulted regularly to assess the public health crisis, advising the federal government to tighten, maintain or ease the measures, communicating publicly about them in written media. Preliminary results A first question presents itself as to which individual academics appeared in the written press. Only 7.6% of academics (2640 of 34669) appeared once or more in the Flemish written press of 2020. Moreover, five professors (four medical professors and one biostatistician) got 30.34% (6817 of 22467) of all media mentions that year for all academics at Flemish universities, pointing to high skewedness in the data. These “Big Five" became known as “the virologists” and took the lead in providing the public with actual information on the virus and its societal consequences. Their daily presence in several media rendered them “celebrity scientists” almost instantaneously, with initial praise and adulation from the public but, over time, also hatred and sometimes even death threats. In terms of sector - and disciplinary differences, academics from the medical sector evidently received relatively the most media attention in 2020 (49,92%; 11212 of 22462 articles). Whereas in 2019 it was social scientists who received the most media attention (41.0%; 5800 of 14130 articles), in absolute terms they surprisingly remained almost as prominent in 2020 (26,73%; 6004 of 22462), but lost media attention in relative terms. In relative terms, almost all non-medical disciplines lost media attention in 2020 compared to 2019, apart from academics from Psychology and cognitive sciences, who saw a very slight increase in relative popular attention (from 3,6% of articles in 2019 to 3,7% of articles in 2020). The covid-19 pandemic was therefore not just a medical affair; all kinds of academics brought their expertise into the public arena, interpreting, explaining, advocating, promoting the impact of the public health crisis on their area of expertise, some criticizing or expressing their dissatisfaction with the "purely medical" discourse of the virologists. A few academics took the lead in this, representing the “critical” opposing voice in the debate. Significance Results show how the written press provided an immediate opportunity for academics to publicly assert the policy relevance of their field and discipline, not “organically” from the traditional scientific publication cycle, but more directly from the stage they were

given in mainstream media. While counting media coverage provides valuable insights into the "amount" of media coverage, the question of what discourses both medical scientists and non-medical scientists employed remains unanswered. Future analysis aim to unravel which context-specific lexicon academics from both medical and non-medical employed during the covid-19 pandemic, improving our understanding of the impact of proactive and reactive science communication of academics in the written press.

[6801] *Artificial intelligence for COVID-19 research: What makes scientific collaborations successful?*

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Abstract

In this study:

Interdisciplinarity has become a much-appreciated buzzword in science policy. And for excellent reasons. Disciplines have for decades -in some cases centuries- facilitated the development of science by providing scholars with the framework of a coherent paradigm and with the possibility to stand on the shoulder of their predecessors. At the same time, however, disciplinary boundaries can constrain the progress of science, as the growing specialization makes it ever harder (yet ever more necessary) for scientists to venture into unexplored territories and mix practical and intellectual tools coming from different traditions. These drawbacks are particularly problematic when faced with unprecedented research challenges that require fresh ideas and unrestrained experimentation. This circumstance has occurred recently with the outbreak of the COVID-19 pandemic. The urgency and severity of the crisis encouraged researchers in epidemiology and medical sciences to mobilize all available resources within their disciplines, but also to look beyond them for new ideas and external collaborations. Among these, the alliance with Artificial Intelligence (AI) appeared as one of the most promising.

AI is not something new. Yet, the field has recently been revived by the growing power of computational technologies and the growing availability of data on social and natural phenomena. The recent development of new approaches to machine learning has brought about remarkable accomplishments within and beyond data science. An emerging literature has shown that AI techniques are influencing the entire scientific pipeline, from agenda setting, hypothesis formulation, to experimentation, knowledge sharing, and public engagement. According to its advocates, AI is spreading rapidly in all areas of science, increasing the productivity of researchers, and making a major impact on scientific discovery.

The coronavirus pandemic struck at the height of this AI hype, and it is not surprising that many scholars rushed to the idea of using AI tools to address the many challenges posed by COVID-19. If AI is as powerful as claimed, this would be the perfect opportunity to demonstrate its epistemic value. However, not all collaborations inspired by the idea of combining two of the most in vogue keywords in the scientific and societal debate - AI and COVID-19 - were equally productive. While some have made substantial contributions in the fight against the pandemic, others have remained only "on paper". Why have some collaborations been more successful than others? This is the overarching question we address in this work.

Previous research on team science provides us with some conceptual background. We know that, on average, teams produce more cited research and exceptionally high-impact papers. We also know that diversity - e.g., epistemic and institutional diversity - is beneficial for producing novel and valuable ideas. Indeed, larger and more diverse teams are likely to include researchers with different background, methodological approaches and experience, and thus have access to a broader pool of knowledge that allows them to produce more creative outputs in traditional and collaborative science. However, team diversity can also increase the chances of failure in early research stages. Teams that are too large and heterogeneous suffer from lower consensus-building, cognitive diversity, higher coordination costs, and emotional conflict. As diversity increases, it becomes difficult to convert specialized expertise into scientific outputs. Some research, for example, has shown that the most successful collaborations are achieved through interdisciplinary research efforts, but across a proximal range of fields; and that a team's ability to achieve good performance depends more on how the team interacts and coordinates, rather than on the characteristics of individual members.

It is clear that the multidisciplinary nature of AI-COVID-19 research requires the creation of diverse and complementary teams gathering researchers from different communities. Funding initiatives have emerged all over the world to encourage these collaborations and bring the AI community closer to the health care system. Little research, however, have investigated the actual results of these collaborations. To fill in this gap, in this study we analyze the adoption of AI techniques in COVID-19 research, identifying its different trends and application areas; we measure different types of impact of AI--COVID-19 publications (visibility, scientific and media outreach); and, finally, we explore the association between these forms of impact and different features of the scientific papers and their author teams.

Main findings:

Our analysis combines data from three different databases -CORD-19, Semantic Scholar, and Altmetric- and is based on a extensive pre-processing protocol [details not provided here].

We investigate what factors make successful collaborations between domain and AI experts, and we do so by conducting a set of bibliometric analyses on more than 16,000 scientific articles. More specifically, we design and implement a set of metrics to account for interdisciplinarity with respect to AI, at two different levels: team diversity, which measures, among other things, the participation of AI experts in COVID-19 research; and epistemological diversity, which measures the actual knowledge mobilized by each article.

Our research allows us to qualify three main findings. First, both forms of diversity (team and epistemological) are overall positively associated with different forms of impact, namely: number of citations, media attention and outreach to other disciplines. Second, the involvement of researchers with strong AI expertise is negatively associated with impact, suggesting that domain experts and AI experts still struggle to collaborate and produce impactful science. Third, it seems that epistemological diversity is most important for impact outside the academic community.

Mapping the diffusion of AI in science and its impact we hope to contribute to a better understanding of how computational technologies can be of value in addressing current and future societal challenges. Taken together, our results provide a sharp take-away message for academic decision-makers: what breeds impact and interdisciplinarity is neither the use of the trendiest technologies or the "on paper" diversity of a project proponents, but the actual efforts that they make to mobilized ideas, tools and knowledge from different scientific fields.

[9221] *Voluntary Human Capital Mobility, Involuntary Mobility, and Innovation; Evidence from the Collapse of Nortel Networks*

Ruth Samson (University of Luxembourg), Laurent Bergé (University of Bordeaux) and Nicolas Jonard (University of Luxembourg).

Abstract

Researchers on innovation and human capital mobility have considered mobility as a voluntary event where employees choose to enter the job market. However, mobility can be involuntary (forced), and it is often the case. By exploiting the fall of Nortel Networks as a natural experiment, we distinguish voluntary mobility from forced mobility and examine the consequences on innovation performance at the individual level. We find that the two aspects of mobility have different consequences on employees' innovation performance when studied separately from the perspective of the source and destination firms. We contribute to the literature on human capital mobility as a driver for knowledge creation and diffusion, particularly forced mobility which has so far received very little attention. Also, we underline a better understanding of the mobility mechanism on knowledge creation and diffusion patterns by showing how forced mobility compares to voluntary and no mobility.

[9839] *Analysis of the Impact of Sovereign Wealth Funds on Defense Policy : The Case of South Korea's Cluster Munition Industry*

Moonyul Yang (KAIST(Korea Advanced Institute of Science and Technology) Graduate School of Science and Technology Policy) and So Young Kim (KAIST(Korea Advanced Institute of Science and Technology) Graduate School of Science and Technology Policy).

Abstract

This study explores the unique case on how sovereign wealth funds (SWF) impact defense policies. Lately, SWFs have emerged as a critical actor in defense policy, as they are breaking the strong links between the government and the defense industry. SWFs directly affect defense companies, whose industries have mainly been determined by the requirements of their own military. As a result, SWFs are changing the business ecosystem and thereby influencing future domestic defense policies. This study examines the decision of Hanwha, the largest defense industry of South Korea to separate the unit producing cluster munition due to the ESG considerations of European SWFs, which provides an interesting case for the research on increasing influence of non-state actors on defense innovation policy.

"Cluster munition" is considered inhumane because it can attack large area targets and have a high rate of failure, which may cause civilian damage. Nevertheless, it is difficult to ignore their technical effects in terms of war capability. Under the security situation of South Korea, which is to confront North Korea, cluster munition is an important asset in South Korea's defense policy and a high priority of their weapon system acquisition program.

In this situation, the European SWFs have excluded investments in companies that violate the criteria of responsible investment. The criteria include environmental destruction, opaque management governance, and inhumane weapons manufacturers. Korea's largest defense industry Hanwha, which is a Korean cluster munition weapon system

manufacturer, has also violated this criterion. Hanwha accounts for 46 percent of Korea's defense industry's revenue. As SWF's investment in Hanwha as a whole continued to be excluded because Hanwha manufactures inhumane weapons, Hanwha stopped manufacturing cluster munitions. This is because the defense sector, which accounts for only 13% of the corporation's total revenue, could not cause the group as a whole to be stigmatized. Instead, the defense sector established a separate company that could manufacture the already developed cluster munition weapons and supply them to the Korean military.

This study is based on the signaling theory of third-party intermediaries. This theory argues that a signal presented by a third party can more easily gain the trust of other actors than the signals from the stakeholders. This is because the third party has a low possibility of information distortion. The third-party actor SWF invests according to its own standard, but this behavior can impact the investment standards of other investment funds.

This study will be conducted through interviews and archive surveys. We plan to interview government and government-funded research institutes such as the Ministry of Defense, Defense Acquisition Program Administration, Agency for Defense Development, and Defense Agency for Technology and Quality. In addition, military organizations such as the Joint Chiefs of Staff and Army Headquarters, and defense industries such as Hanwha, KDI (which is separate from Hanwha), the Korea Defense Industry Association, and SWF affiliates in Korea. Hanwha's corporate disclosure and investment data will also be analyzed in time series, and the government and public military data will be examined.

Weapon systems exhibit capabilities by integrating several subsystems, and system integration is easier for companies that have large internal capabilities. Hanwha is the representative SI corporation in Korea. The withdrawal of Hanwha from Korea's cluster munition means that the point centrality of the domestic cluster munition will be dismantled in the future, making it difficult to continue research and development and mass production.

This study is expected to provide insights into how foreign actors influence domestic defense innovation policies. Existing defense policies were decided in a top-down manner among limited internal actors. In particular, it is not common to be cross-bordered by actors other than internal actors in the subsequent mass production stage of the weapon system already deployed in the field after domestic R&D was completed. We believe the results of this study can be applied as a reference point when establishing defense policies for various countries in the future.

[3008] *The Economic Logic of Open Science in Fusion Energy Research: A Systemic Approach to Policymaking*

Marco Vincenzi (University of New Hampshire) and Elias Carayannis (George Washington University).

Abstract

1. Background and Rationale

Climate change is a grand challenge of our era. From an economic point of view, government intervention is justified to address two market failures: one environmental and one technological. The former results from an overprovision of electricity from fossil fuels, while the latter from an underprovision of research to develop greener technologies. Environmental technological policy must jointly address both market failures due to their interconnections. On the one hand, the standard approach to climate policy has been to limit the emission of greenhouse gases (GHG). On the other hand, the adoption of greener technologies can reduce or eliminate GHG emissions.

This paper focuses on the development of one of such greener technologies: nuclear fusion, which is the reaction that occurs within the stars, including the Sun, to generate their own energy. A technological breakthrough in nuclear fusion energy can help to decarbonize the power system because it can provide clean, safe, and affordable energy without the amount of nuclear waste resulting from fission reactions, which currently occur in fission power plants around the world. However, fusion energy research is still on the edge between science and technology because it still requires large investment in basic research before developing technological applications.

Despite the infantry stage of fusion energy research, this industry is experiencing a transition from publicly to privately funded research. The influx of private funds is changing the objectives of fusion energy research from an approach based on open science, where the scientific results are shared within the global fusion community, to an approach based on proprietary technologies, where each company protects its technological applications with Intellectual Property Rights (IPRs).

Whereas the enforcement of IPRs can create economic incentives for private companies to generate even more technological applications in the field of nuclear fusion and will eventually lead to the commercialization of fusion power plants, stricter IPRs are often associated with high social costs that result from restricting the access to the knowledge that was previously shared within the global fusion community and thus limit the effectiveness of nuclear fusion in climate-change mitigation policies.

2. Methodology

Building on the new Economics of Science, this paper develops a systemic approach to science and innovation policy in fusion energy research as it transitions from public to private funding. The overall objective of this systemic approach to policymaking is to strike a productive balance between the publicly funded community of scientists, who tend to favor full disclosure of their results, and the community of privately funded technologists, who tend to favor disclosure only after receiving a patent. This productive balance between the two communities can be achieved when policies fund open science and check against excessive incursions of claims to IPRs. To achieve this objective, the methodology employed by this paper is to interview key players in both communities to gather information on how they view open science in fusion energy research. Interviews allow to gather rich information on this topic and they are a qualitative research method that can be used as a foundation for future quantitative research on this topic. To the best of our knowledge, no other authors have outlined a systemic approach to policymaking in this industry. Despite its limitations, the qualitative method employed in this paper has the ability to assist policymakers who seek a regulatory framework to guide the future of this industry.

3. Anticipated Results

Some of these interviews have already been collected by Michel Claessens, who was the spokesperson from 2011 to 2016 for the International Thermonuclear Experimental Reactor (ITER) project, which is currently the largest publicly funded project in fusion energy research. These interviews provide preliminary evidence that scientists who are working in the ITER project follow the Mertonian norms of Communalism, Universalism, Disinterestedness, Originality, and Skepticism (CUDOS).

These preliminary results support a systemic approach to policymaking in fusion energy research that stresses the benefits of openness in science because all the intellectual property developed in the project is shared equally by all the global members of ITER.

Claessens also interviewed some of the private companies that are supplying equipment to ITER. These managers also confirmed that openness in science allows the communal, universal, and original approach required to supply hi-tech components that meet the stringent specifications of a first-of-a-kind project, such as ITER, whose consortia of suppliers span across the world.

4. Significance

Climate change is a complex problem that requires multiple solutions from multiple disciplines. Science and innovation policy in greener technologies can help to mitigate this complex problem by fostering the development and adoption of technologies that can reduce GHG emissions. Although not a panacea, nuclear fusion can provide clean, safe, and affordable energy in the future.

However, fusion energy research is undergoing two paradigm shifts that will jointly shape its future. First, it is transitioning from science to technology as more and more technological applications are providing different approaches to the future commercialization of electricity generated from fusion power. Second, it is transitioning from public to private funding as more and more private companies are entering the newborn fusion industry. This large influx of private funding is shifting the focus of fusion energy research from full disclosure of scientific results within the global fusion community to stricter enforcement of intellectual property rights that could have a negative impact on future research.

Now more than ever fusion energy research needs a regulatory framework to guide this transition. This paper plans to build a systemic approach to policymaking in fusion energy research to show that science and innovation policies that favor openness in science can provide greater economic and social utility to both the publicly and privately funded research communities in nuclear fusion. The main policy recommendation derived from this paper urges the governments that are currently sponsoring private endeavors in fusion energy to keep science open in exchange of public funding.

The systemic approach to policymaking derived from this paper can also provide a policy toolkit for managing complex and dynamic technologies in several other sectors, such as aerospace. Moreover, the implications for sustainability derived from this paper can assist the policymaking system with a multicriteria approach to assist the formulation and implementation of climate-change mitigation policies in other technologies of public interest, such as transportation.

[5299] *Innovation intermediaries in the new bioeconomy: Integrating translation, responsibility, and sustainable transitions*

Claire Holland (University of Manchester), Adam Mccarthy Mccarthy (University of Manchester), Priscila Ferri (University of Manchester) and Philip Shapira (University of Manchester; Georgia Institute of Technology).

Abstract

Background and rationale In the scaling and transfer of emerging technologies to address economic and societal challenges in ways that foster sustainable bioeconomies, applications, there are critical roles for innovation

intermediaries. These comprise governmental, private, or non-profit organizations that support knowledge transfer and the development of innovation. The role of intermediaries is typically presented in a linear way, with intermediaries spanning gaps in the technology transfer process that arise between upstream research and close-to-market product and process development. More recently, innovation intermediaries have been positioned as key nodes in stimulating innovation networks and innovation ecosystems. We posit the need for further evolution in the roles of innovation intermediaries as catalysts for embedding public values in innovation design and scaling to address rising challenges of sustainable bioeconomy transitions.

Performing new functions to actively anticipate implications and address societal and sustainability public values (alongside economic ones) represents a transformative mission for innovation intermediaries. This rescoped mission brings with it key challenges that intermediaries must explicitly recognize and attempt to navigate. We focus on three of those challenges: (1) translation, which encompasses problems of generalization of emerging bioeconomy technologies including viable product and process development, funding, absorptive capacity, and overcoming incumbent technology lock-ins; (2) sustainable development, which encompasses the problem of reconciling promissory claims about how an emerging technology will address sustainability objectives when confronted with realities associated with trade-offs (environmental, economic, or societal) that arise in scaling; and (3) responsibility and governance, comprising issues associated with coordinating diverse governance approaches, understandings, and responsibilities, problems of knowledge uncertainty about the implications of emerging technologies and who should be involved in decision-making, and how to address inequitable distributions of benefits and costs. about applications and scaling of technologies.

These challenges are not mutually exclusive: they are embedded across research and innovation, and in broader governance processes, but particularly present in the processes of innovation intermediation of emerging bioeconomy technologies. Such competing demands have been predominantly presented in organizational theory as “trade-offs” to be overcome through choice of one option over another. However, we suggest it is more appropriate to view these challenges in terms of organizational paradoxes that are persistent, dynamic, and iterative. The implication is that innovation intermediaries need to identify and engage with these challenges and find ways to navigate through them.

By considering these challenges in the context of the strategies and operations of innovation intermediaries engaged with emerging bioeconomy technologies, we seek to: (1) advance understanding of evolving intermediary roles and functions; (2) explore challenges associated with responsible and sustainable development; (3) identify insights, for theory and practice, about the roles that intermediaries can perform in navigating these quandaries, and; (4) identify pathways and strategies for intermediaries and other innovation system and policy actors.

Methods The target emerging technology for empirical analysis is engineering biology. The convergence of biology with advanced digital technologies, big data, and increased automation, has positioned engineering biology as a promising driver for bioeconomic development and sustainable transition. Engineering biology promises to address multiple societal challenges, including climate change, sustainability, secure food and energy sources, global health, and biomanufacturing. In the engineering biology domain, over recent years, there has been growth (mainly in advanced economies but also in some emerging economies) in the scale and scope of intermediaries, including bio-refineries, biofoundries, bio-manufacturing hubs, smart centers, and transition projects.

Our empirical work is being undertaken in the UK, which is an early mover in engineering biology research, has established policies to decarbonize its economic sectors, and set a 2050 goal for net zero greenhouse gas emissions. We will undertake studies of selected UK innovation biointermediaries and interview managers, researchers, users, sponsors, and other stakeholders. We anticipate completing about 20 interviews and will develop 3-6 intermediary case studies. We will probe the current functions of intermediaries; the materialization of the three challenges (i.e., of translation, sustainable development, and responsibility and governance); and how the intermediaries understand these challenges, how they navigate them, and how future navigation might be pursued, given anticipated convergent technology developments. We will pursue these questions for three types of bio-intermediaries: transition projects, where research discovery is focused at engineering biology/AI/automation interfaces with intent for commercialization; bio-refineries that employ advanced automation and computational analytics to significantly improve translational speed of bioengineering applications; and bio-manufacturing hubs, where companies are explicitly involved in translating research to potential commercial processes and products. Qualitative methods will be used for analysis, including content and narrative analysis complemented by analyses of secondary materials (including online sources and public reports).

Anticipated results and significance We expect that this work will advancing understandings of the emerging roles of innovation intermediaries at the intersections of innovation, sustainability, society, and governance. Specific results will consider how innovation intermediaries in emerging bioeconomy technologies operate today in addressing translation, sustainability, and responsibility challenges, and how those roles are expected to evolve. Findings will also help in assessing how innovation bio-intermediaries navigate translation, sustainability, and responsibility challenges, and how changes in organizational design, operation, incentives capabilities, and relationships could advance the speed and directions of travel towards broader and inclusive interpretations of sustainability and responsible governance. The framings of the three conceptualized challenges will be tested and either validated or potentially modified. Insights and

recommendations will be derived for management and strategies of innovation intermediaries and for policies for innovation and bioeconomy transition.

By probing how innovation intermediaries in emerging bioeconomy technologies navigate the challenges not only of translation but also sustainability and responsible governance, we expect to generate fruitful insights and offer a proactive approach to the design of private and public policy responses to these challenges.

[146] *Policy perspectives regarding benefits and challenges of connecting with citizen science initiatives. A case study on environmental justice*

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Abstract

The rationale

Citizen science (CS) is a research approach with potential to build policy-society bridges. On the one hand, citizens can draw the attention of scientific research to understudied topics that could then been addressed by policy making. On the other hand, CS opens opportunities to democratise the policy processes (Cohen & Doubleday, 2021) which makes it particularly promising in the case of environmental policy.

The Rio Declaration developed in the context of 1992 United Nations "Conference on Environment and Development" established the basic principles for environmental democracy, which included access to information, public participation and access to justice. Similarly, the Escazú Regional Agreement (2018) on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean, seeks to strengthen citizen rights to participate in environmental decision-making through specific forms of policy governance.

Although the potential exists, CS literature has highlighted several challenges faced by CS initiatives when engaging to the policy-making sphere. They range from issues regarding data quality to power imbalances and institutional resistance (e.g. Nascimento et. al. 2018; Haklay, 2021). The EU has created an inventory of selected practices from CS projects that attempted to link with environmental policy-making sphere (EC 2018). But there is no empirical research analysing the perspectives of policy makers regarding their connection to CS projects. This paper aims to fill this gap in the context of environmental justice in the Matanza-Riachuelo basin.

The context

The basin is a heavily polluted area in Buenos Aires, Argentina. There are almost 14,000 industries, many of them dumping their waste into the river, while 18% of the population is not connected to the drinking water network. The area is ruled by different government jurisdictions (Municipalities, Province, and Nation) normally governed by different political parties, which has made it very difficult to advance with comprehensive solutions.

We are involved since 2020 in a CS project, which co-designed along with 59 community actors from the basin, a digital platform for citizens to share experiences on key areas for environmental justice. These data open several opportunities for sanitation policy making (e.g. cost effective monitoring of water quality, democratic approaches to natural areas conservations, etc.), including the possibility of broadening participation, as it is legally requested. The early stage of the project (2020) through interviews and workshops we created a knowledge coalition of researchers (12), policy actors (13) and community actors (47). As a result of this process, we understood that policy makers believe in the potential of CS related to a better identification of community priorities and in trust-building for policy actions, but there are several challenges and reservations that need to be addressed (e.g. on data quality, the politics of participation, etc.).

Thus, in 2022 during the last stage of the project we aimed systematising the perspectives of policy actors regarding the potential uptake of CS in sanitation policy. These are the entry point to identify policy options that can contribute to strengthen the CS-policy link, because they shed light over different dimensions where CS initiatives could contribute to decision-making processes, from their standing points. This paper describes the result of this exercise. The method

We used Q-method to identify policy makers' perspectives regarding the uptake of CS knowledge in policy formulation. It is a research technique to identify underlying patterns of meaning and discerning people's perceptions of their world (Webler et. al., 2009, McKeown & Thomas, 2013). People participate in interviews where they are provide with a set of statements expressing ideas on a given topic to order them in a normally distributed grid. Participants are invited to explain the reasons justifying their way of organising statements in the grid. The statistical analysis then proceeds by correlating participants' sorting of statements, which take the place of variables in factor analysis (McKeown and Thomas, 2013). Factors are interpreted with inputs from the interviews.

We presented 52 statements to 14 policy actors. Statements were developed through an iterative process by both co-authors using, primarily, inputs from the review of 36 international papers reporting evidence of CS projects that intended to establish some type of relationship with environmental policy spheres. In addition, some few statements

were built using transcriptions of the public events in which policy actors in Argentina made affirmations regarding CS potential. We codified statements in three dimensions

• Linking mechanism: three forms of citizen intervention through CS initiatives that may connect to public policy: i) citizen-driven-data, ii) citizen participation in agenda-setting and iii) citizen participation in the governance of common goods or public services. • Policy-making phases: three phases of the policymaking processes to link with CS initiatives: i) problem identification, ii) policy implementation, iii) policy-change (e.g. creation of new programs). • Valorisation of CS-policy link: positive or negative.

Two factors were extracted using principal component analysis and rotated using varimax methods.

Results

We found two non-confrontational perspectives regarding the potential contribution of CS in policy-making processes. We confirmed our findings of the knowledge coalition building process that there is a generally optimistic opinion regarding the potential contribution of CS to socio-environmental issues. Stakeholders believe that CS promotes empowerment, inclusion, and more responsive policies since they benefit from situated knowledge. The highest valued mechanism explaining optimism in the CS-policy link is the participatory nature of CS -rather than the capacity to produce and make available citizen-driven data. This is not surprising in the context under analysis that has participation as a formal mandate for sanitation policy.

Although they have some common background in the way they value participation, the two perspectives differ regarding what specific contribution to the policy making process CS could enhance, or, in other words, in what aspects of policy making there are more prospective links with a CS approach. One of them (Perspective A) finds the potential mostly relate to the initial phase -problem identification- and in creating opportunities to change policy, while the other (Perspective B) believes that the highest contribution is in the implementation phase. Remarkably, policy actors more directly involved on environmental issues load more heavily on perspective B.

By combining this quantitative analysis with qualitative material from interview transcripts, we spell out the perspective as following

Perspective A: "CS produces ideas to create new policies or policy programs. These initiatives are particularly useful in the context where there is a lack of policy actions, to fill a vacant area, thus complementing the available policy knowledge. Citizen participation makes visible concrete socio-environmental problems".

Perspective B: “Synergies can be created between public policy agencies and CS initiatives, contributing to the improvement of existing policymaking processes. Participation increases trust in policy actions, which is necessary to enhance policy effectiveness”.

Conclusions

We contribute to the scarce empirical literature addressing the potential of linking CS with policy making using evidence from a highly complex context of Argentina.

Our approach is different to empirical papers providing information on the CS-policy link because while they share insights obtained from the experience of CS, we explore the nuances of the other side of the CS-policy link analysing the perspective of policy actors.

We confirmed that the potential contribution exists also in the minds of policy actors. However, depending on the specific policy context, the contribution could be more complementary or more synergetic with existing policy actions

[3070] *Steering research towards sustainability: the role and determinants of international collaboration in research on Chagas disease*

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Abstract

Background and rationale

Chagas is an infectious disease which affects 6 million people and causes over 14,000 deaths each year worldwide (WHO, 2015) with a DALYs (Disability Adjusted Life Years) of 275k in 2019 (Global Burden of Disease Study, 2019) (similar to Yellow Fever). It is caused by a parasite (t-cruzi) which is transmitted by a vector, from mother to foetus or by blood transfusion.

More than 100 years have passed since Chagas disease was first discovered and there is not any appropriate solution yet. There are several development challenges that interact with the disease and, therefore, Chagas is considered a socio-environmental problem (Sanmartino, 2015) which impinges on various sustainable development goals (SDGs). In a related research, we identified the most prominent needs for scientific knowledge to embrace Chagas complexity and

related them to the SDGs. Besides health related issues (SDG 3 -Health and Wellbeing), many stakeholders identify the need to improve the design and implementation of public policies to embrace Chagas problems in an integrated fashion (SDG 16 – Policy governance). There is also a need to know more about how to control the vector in areas where people live (SDG 11 - Sustainable cities), especially because the vector has been moving to urban areas (SDG 15 – Life on earth). Research is needed also in education (SDG 4) to learn to better disseminate information about Chagas which may improve early diagnosis and treatment.

This paper investigates how scientific production address multiple dimensions of the Chagas problem, contributing, therefore, to the literature on research prioritization (Cassi et al., 2017; Ciarli & Ràfols, 2019; Confraria & Wang, 2020; Evans et al., 2014; Fonseca et al., 2018; Rafols & Yegros, 2017; Wallace & Ràfols, 2018; Yegros-Yegros et al., 2020) We ask: What research topics are prioritized by in scientific production? How do they relate to different dimensions of the problem as expressed by the SDGs? To what extent does collaboration, across disciplines and international borders, drive research towards SDGs?

International research collaboration is intrinsically associated to agenda-setting. Not only because international collaboration may be enhanced as a reaction to the complexity involved in global challenges (Chen et al., 2019), but also because the agenda setting becomes disputed by different partners participating in the research (Adams, 2012). Some authors argued that power dynamics may drive research away from the priorities of less developed countries (e.g. Kreimer & Zabala, 2006). Others, from an open science perspective, claimed that collaboration across diverse partners could contribute to opening-up new lines of enquires, with higher probability of becoming responsive to the needs of participants in the research endeavour (Arza & Fressoli, 2018). Thus, the effect of international collaboration in agenda-setting and its relation to aligning (or not) research towards societal goals deserves empirical investigation.

Methods

We built a bibliographic dataset from the Web of Science produced by Thomson Reuters on Chagas research based on a keyword search containing Chagas related terms. The dataset holds information about Title, Abstract, Keywords, Authors, Affiliations, Citations and WoS Disciplines of 15552 publications from 1990-2019. In terms of the global distribution of Chagas research, Brazil is at the top followed by the United States and Argentina. Other important countries are Spain, France, England and Mexico.

We used topic modelling to discover common topics across Chagas publications. In particular, we used Latent Dirichlet allocation (LDA) and divide research into 12 and 5 topics. This method allows documents to relate to several topics with different levels of intensity, rather than being separated into discrete groups (Robinson & Silge, 2017). We interviewed six experts in Chagas research to help us in the process of labelling the topics. During interviews, we used the interactive visualization provided by LDAvis program (Sievert & Shirley, 2014) (which shows term's frequency within a topic and its exclusivity) complemented with additional bibliographic information, The list of five topics are 1. Preclinical studies; 2.Vector studies – Ecology; 3. Biology of t-cruzi; 4. Drug discovery – Biochemistry and 5. Clinical studies

We also characterised Chagas research in relation to the SDGs. We used the SDG query produced by Strings project to classify Chagas publications in terms of SDGs. In the period 1990-2019, only 12% of Chagas research was directly related to any SDG, while an additional 46% was research cited by those papers. SDG-related research contributes mostly to SDG 3 (Health and Well-being), but also to SDG 15 (Life on earth), SDG 13 (Climate action), SDG 11 (Sustainable cities), SDG 1 (Zero poverty) and much less to others. This means that there is little Chagas research related to SDGs in general and, particularly, to some needs identified as important to address Chagas complexity (e.g. SDG 16 -Policy governance and SDG 4 -Quality education).

Results

Collaboration in Chagas research increased significantly. In 1990, around 45% of the publications were done collaboratively; by 2019 this proportion rose to more than 89%. The national and international collaboration grew between two and three times. National collaboration increased from 26% in 1990 to 51% in 2019, and international collaboration did it from 18% to 38% in the same period. We analyse in particular international collaboration across countries in different income-groups, which grew from 13% to 28% in the period.

We aim at identifying patterns for collaboration driving different research priorities, as Fonseca et al (2018) did analysing HIV/AIDS research, and how they relate to the SDGs. We use an econometric approach to evaluate how different variables characterising research correlate with the probability of being an SDG-related publication. We run separate regressions for different SDGs. Independent variables were the research topics previously identified, citations and the collaboration patterns, across disciplines and countries.

In line with the open science arguments, collaboration is found as an important driver of research towards the SDGs. Inter-disciplinary research is associated to SDG related research. In addition, collaboration among research institutions is also an important driver towards SDGs. Interestingly, international collaboration seems particularly important. More specifically, we find that researcher carried out in international collaboration involving partners where the disease is endemic is key to steer research to relevant SDGs (3, 15 and 11). Thus, we may argue that promoting collaboration from

funders between partners that had contextual experience on societal challenges may contribute to alignment between the research priorities and the SDG.

Conclusions

Our results suggest that promoting collaboration may contribute to align the research agenda towards societal priorities. First of all, collaboration across disciplines. When comparing societal needs for Chagas and actual research, there are clear mismatches in areas such as education and governance. Although research carried out in areas like biology or medicine may have implications for education (SDG 4) and governance (SDG 16), the challenge is how to interconnect those research disciplines when the research evaluation system does not reward such interactions.

Secondly, international collaboration is another important driver that orientates research towards SDG priorities: particularly collaboration between partners in countries in which the disease is endemic -and may have contextual experience of what is needed- and those in which it is not. Unequal research capabilities and opportunities may of course be a constraint. However, by promoting this collaboration funders and policy bodies can better understand what research capabilities are present and which ones need to be further supported and developed.

[4168] *Meta-evaluation of Science, Technology and Innovation Policy: evidence from an emerging economy*

Juan Pablo Centeno (Universidad Externado de Colombia and Technopolis Group) and Gonzalo Ordonez-Matamoros (Universidad Externado de Colombia and University of Twente).

Abstract

The growing institutionalization of innovation systems in emerging economies has led to a more prominent role of the State in policy design and implementation to foster knowledge and innovation production, diffusion and use in different realms of society. In this context, Science, Technology and Innovation Policies (STIP) and instruments require the constant evaluation of its performance and results, in order to better inform the role of governments therein.

In emerging economies, the increasing number of policy documents contrasts with the limited capacity for the implementation of national STIPs, which is often related to the lack of use of policy evaluation results and its derived lessons and recommendations (Kuhlmann & Ordóñez-Matamoros, 2017). One of the reasons for that is the single-intervention approach of policy evaluations, which do not often reflect their implications for broader innovation systems. In that regard, translating policy learning into effective policy change demands more comprehensive lessons on the strengths and challenges of STIP with the use of STIP evaluations. In other words, the body of knowledge produced by evaluations may clarify what we know and do not know about STIP, in order to enhance STI policymaking and governance.

Meta-evaluation frameworks help us to systematically assess the results of evaluations in order to learn more about how STIPs perform within systems (Edler, Ebersberger, & Lo, 2008). Rather than focusing on the intrinsic technical merit of single interventions, these approaches emphasize the broader contribution of STIPs to innovation systems (Arnold, 2004). While such approaches are frequently used in mature innovation systems (Edler, Cunningham, Gök, & Shapira, 2016; Collin, Sandström, & Wennberg, 2022), these could be further operationalized in emerging economies, for instance in Latin America (Bin, Andrade, Vasconcellos, & Salles-Filho, 2019), where more knowledge is needed on the systemic role of STIPs.

With that in mind, this research presents a meta-evaluation of STIP in the context of Colombia, as a relevant and illustrative case of an emerging economy. It assesses the design of and results produced by the STIP evaluations conducted in the country. Specifically, this work has a three-fold purpose: first, to derive lessons learned from the STIP evaluations performed in Colombia; second, to understand and explain the factors that facilitate or hinder the conduct of successful evaluations, where success depends on a) whether the evaluations achieved their objectives and b) whether the evaluation achieved any impact; and third, explore the value or merit of different types of approaches and methods that are used to evaluate. In this regard, some key research questions are:

• Did the purposes of the STIP evaluations clear and achieved? What lessons can be derived from evaluating the effectiveness of STIPs? • Have the evaluation approaches been useful or not in understanding the underlying rationale of STIPs? • What methods have been used to understand the interventions? • What factors are determinants in the impact and use of evaluations?

This paper follows a meta-evaluation approach, i.e. “an evaluation of evaluations” or a systematic analysis of a series of public policy evaluations with the purpose of informing the scope and quality of the ways that the merit of public interventions is assessed (Scriven, 1991, p. 95).

To that aim, empirically we examine different public repositories of evaluations of the Colombian national government, including the Ministry of Science, Technology and Innovation, the National Planning Department and its evaluation system, and the Colombian Observatory of Science and Technology.

A total of 36 evaluations have been identified so far, conducted between 1997 and 2021. The basic relevant information of each evaluation report is extracted and systematized in a table, including categories such as the type of evaluation, the type of STIP evaluated, the date of publication, the time frame observed by the evaluation, the authors and its institutional affiliation, the purpose of the analysis, the evaluation methodology and the type of methods, the main results and conclusions, among others. Furthermore, a grounded literature-based framework is being developed to derive additional categories that allow a better assessment of the evaluations. The main themes of evaluation reports will be codified under these categories by using traditional content analysis software (e.g. Atlas.ti, NVivo).

The expected results include a complete data base with systematized and processed information on STIP evaluations in Colombia. This will allow to eventually build a STIP Evidence Gap Map (EGM) that graphically shows what we currently know and ignore about the STIP process and performance in the country. According to Snilstveit et al. EGMs provide thematic collections of evidence structured around a framework which schematically represents the types of interventions and outcomes of relevance to a particular sector. By mapping the existing evidence using this framework, EGMs provide a visual overview of what we know and do not know about the effects of different programs (2016, p. 120).

Preliminary findings show an evolution on evaluation approaches in the Colombian National STI System, beginning in the 1970's with mechanisms such as expert panels to assess the merit of STI projects and instruments ex ante. During the 1980's and 90's peer-review is the main mechanism to evaluate STI policy, and by 1997 results and impact evaluations are put in place to assess the socioeconomic effects of STI programs. During the 2000's the previous mechanisms are further institutionalized, along with institutional evaluations of actors in the National STI System, and by the 2010's decade more evaluations are conducted using more standardized criteria, professionalizing the role of the evaluator, and complementing measurement mechanism of scientific capacity, performance and output.

The evolution of STIP in Colombia reflects what the body of literature on STIP evaluation stresses regarding the ever growing and changing nature of evaluations: as general STIP frames change (Chaminade & Edquist, 2010; Vehlo, 2011; Schot & Steinmueller, 2018; Kuhlmann & Rip, 2018), so are STIP evaluation approaches, which seem to reflect on the former, offering at least four broad streams on evaluation practice.

A first approach is inspired by the scientific tradition of peer review in which the value of policies lies in their intrinsic (scientific and technical) quality. Second, there is an approach derived from new public management thinking interested in the broader socioeconomic impact of research and innovation programs. Third, a systemic perspective concerned with the performance or 'state of health' of innovation systems, considering the multiple variables that compose them (Georghiou, 1999; Arnold, 2004; Edler, et al., 2016).

Fourth, with recent innovation policy approaches such as Mission-Oriented Innovation Policies (MOIP) (Mazzucato & Semieniuk, 2017) or Transformative Innovation Policy (TIP) (Schot & Steinmueller, 2018), there is a renewed interest in formative evaluation (Magro & Wilson, 2013; Molas-Gallart, Boni, Giachi, & Schot, 2021), oriented towards learning and reflexivity in experimental processes for transition to sustainability (Luederitz, et al., 2017; Mickwitz, Neij, Johansson, Benner, & Sandin, 2021).

This research intends to produce relevant evidence aimed at STI policymakers, program managers and evaluators to inform STIP process and its phases of design, implementation and evaluation, while contributing to the broader debate on the effectiveness of STIP in Colombia. Results can also be relevant for regional projects interested in STIP governance and evaluation, where there may be lessons for cross-learning between Latin American countries (Bin, Andrade, Vasconcellos, & Salles-Filho, 2019), while dialoguing with STIP meta-evaluations conducted in developed countries (Collin, Sandström, & Wennberg, 2022).

[3572] *The multilevel roles of the State in transformative innovation policy: analyzing the implications for emerging economies in the case of Uruguay and Colombia*

Mario Pinzón-Camargo (Universidad Externado de Colombia), Isabel Bortagaray (Universidad de la República), Juan Pablo Centeno (Universidad Externado de Colombia and Technopolis Group), Alejandro Balanzo (Universidad Externado de Colombia), Gonzalo Ordonez-Matamoros (Universidad Externado de Colombia and University of Twente) and Stefan Kuhlmann (University of Twente).

Abstract

Literature on Transformative Innovation Policy (TIP) is growing fast (Haddad, et al., 2022; Diercks, et al., 2019) and, although it has received some attention in Latin America, the role of the State in TIP in the context of emerging economies can be further explored (Ordóñez-Matamoros, et al., 2021). The context of Latin American emerging economies represents differentiated implications for the role of the State in TIP. For instance, gaps in governmental capacity for policy design and implementation, the differentiated types of challenges and priorities for Latin American countries in contrast to more developed economies in the Global North (e.g. socioeconomic inequality, violence, high

levels of poverty, biodiversity loss, among others), the central role of politics that shape innovation policies in line with contested democracies, among other factors that define the role of the State in this context.

In order to better understand the implications of TIP in emerging economies we need to further inquire on how these specific features redefine the conceptualizations of the State in shaping innovation policies. We argue that a 'performative' perspective on the role of the State is needed, instead of the prevailing 'monolithic' approach that overlooks the interplay between different agents at multiple levels of TIP, which might lead to variegated outcomes in terms of transformative change.

In this research we inquire on what are the multilevel roles of States in TIP in Latin American emerging economies. In line with Borrás & Edler (2020), here we argue that TIP is a complex process in which the State plays diverse roles -even contradicting ones- depending on de facto governance settings. Therefore, we unpack these roles at three governance levels in the case of energy policy in Uruguay and the policy for social appropriation of knowledge in Colombia. We aim at disentangling the way in which the strategies of different actors shape the ultimate capacity of the State to design and implement (or fail) innovation policies with transformative potential at different governance levels.

Here we define transformative innovation policy (TIP) as "a set of public actions and instruments, through which governments mediate and mobilize resources towards more sustainable and inclusive sociotechnical systems via the promotion of knowledge and innovation production, diffusion and use with a long-term perspective" (Ordóñez-Matamoros, et al., 2021, p. 119). Considering the comprehensive ambitions of this policy approach, governments deploy differentiated forms of action and roles. While it can often be an active promoter of meta-governance for transitions (Kuhlmann & Rip, 2018), literature usually portrays this role as a reaction to failures in markets (Nelson, 1959), systems (Woolthuis, et al., 2005), or transformation processes (Weber & Rohracher, 2012). Despite its explanatory value, the failures approaches assume the role of the State as linear, reactive and limited to problem-solving (Turnbull, 2018).

As a response to that, we draw on Borrás & Edler's (2020) typology of roles of the State, according to the drivers of sociotechnical change (State or non-State actors) and the modes of governance involved (hierarchical or heterarchical). Furthermore, we use these initial typologies in a multilevel heuristic, in order to grasp the complex interactions that take place in TIP implementation processes. We ground our reflection on the analysis of two cases: Uruguay and Colombia. First, we analyse Uruguay's 'Energy Policy 2005-2030' approved between 2008 and 2010. This is generally regarded as a successful State-level policy for energy sovereignty, with successful results in a short period of time in terms of reducing energy costs and strengthening national energy industry. This is related to the scope of this transformation, the time span in which it took place, and the political consensus on which it was built. We explore this transformative process by focusing on the underlying institutional arrangements that shaped the State's capacity in this case and the role of innovation policy therein.

Second, we analyse the Colombian Social Appropriation of Science, Technology and Innovation (SASTI) Policy, in place since the early 1990s. Here we observe an emerging direct approach to development that challenges the path-dependence dynamics that drive innovation policy exclusively towards increasing productivity and economic growth. In contrast to the Uruguayan experience, this case shows how governments do not necessarily have a purposeful approach on transformative innovation, but their role is rather shaped by the bottom-up agency efforts of institutional entrepreneurs, who nest transformative initiatives in spite of overarching business-as-usual policy environments.

These cases follow the case study research method (Yin, 2018). The data studied considered legal regulations, policy documents, academic and technical documents, and interviews with actors involved in the cases. It is worth mentioning that the two cases took a different scope and focusing unit of analysis. Thus, while the Uruguay case considered the transformative policy, the Colombia case was focused on the institutional entrepreneurs. Such differences do not affect the case analysis. Instead, it contributes to discussing from different viewpoints the state's roles in the Global South, enriching the study.

Early findings suggest at least three possible sets of roles of the State. The first set depicts an optimistic or supportive role of the state. This category is constituted by the roles described so far by literature, as illustrated in section two. The second set is shaped by those roles that describe a neutral position of the State towards transformative processes. This neutrality means an indifferent position of the State towards transformative challenges. In other words, the State does not support nor block transformative processes if there are any in development. Finally, the State can perform a negative set of roles to interrupt or erode the transformative processes. At this point, the question of what are the conditions that explain the deployment of any of these three sets of roles by the State emerges.

This research contributes to a more critical understanding the governance challenges that the Latin American context represents for policies aimed at sustainability transitions and social inclusion, for in such settings it is not possible to assume that the State plays a specific and distinguishable role in addressing transformative governance demands.

[688] *Advancing University, Industry, and Government Collaboration in Bibliometrics Building a network infrastructure for data infrastructure*

Eric Heuser (German Center for Higher Education Research and Science Studies).

Abstract

Background and Rationale Applying an ethnographic approach to the research and application of bibliometrics, this paper synthesizes the scope and relevance of scientometric work with actor-network centered approaches from qualitative social sciences. In doing so, I draw on data collected within the Competence Network for Bibliometrics (Kompetenznetzwerk Bibliometrie, KB) in Germany. The KB is funded by the federal ministry for research and education and is the leader for the development of bibliometric tools in Germany. As a network with 22 high-profile member organizations including Fraunhofer and Max-Planck institutes, KB follows the research output from every field of study, reveals its impact, provides metadata, and makes research visible across disciplinary boundaries. It links partner research institutions and stipulates new disciplinary dynamics in the field of bibliometrics and scientometrics. Recently, the center has initiated an organizational transformation process from a center structure towards an agile network. Reasons for this are manifold, but predominantly rooted in the need for pooling bibliometric skills and making them available to the wider public including universities, government agencies and the industry. Design, control, and implementation of this transformation process is a complex organizational challenge given that the center now comprises of 22 consortium partners. This paper critically examines 1) this transformation process and elaborates on the scientific benefits it has produced so far and 2) the potential this restructuring hold for the fields of skills transfer and science communication with the goal of strengthening exchange between science and government agencies as well as industry. The study and application of bibliometrics is by definition concerned with quantitative measures. This paper promotes an innovative mix of applying ethnographic methods to a field that is shaped by quantitative approaches in order to uncover, and later utilize interpretations, analyzes and attitudes from network partners. Such feedback will be instrumental in structuring later stages of the transformation process.

Methods The aim of the on-going research presented here is to shed light on the benefits and functioning of the KB transformation process towards a network. Methods applied draw from ethnographic and related qualitative methods in order to gain a deep understanding on the 1) transformation process towards an agile network structure, 2) how the implementation procedures applied are viewed by network members and 3) how network members evaluate the changes made so for a) their work, b) their own productivity, c) the overall benefits for the whole network. Applied methods are participant observation in the virtual network meetings, different forms of interviews (online: open, theme-focused, structured) as well as in situ research in selected partner institutes in Germany.

Anticipated Results Anticipated results provide insights into how the transformation process is perceived by selected members of the network. Collected data consists of internal voices from the network and will inform the future implementation process of the organizational transformation of the KB. It also acts as quality assurance as it helps to evaluate and, if necessary, adjust strategy. Furthermore, data will also shed light onto how an agile network structure for a science consortium shapes and improves communication and general interaction between the sciences as well as government bodies and industry.

[8544] *Varieties of Regional Innovation Systems around the World and Catch-up by Latecomers*

Keun Lee (Seoul National University) and Jinhee Kim (Seoul National University).

Abstract

This study identifies the characteristics and types of the regional innovation systems (RIS) of regions and cities in emerging economies in comparison to those in advanced economies. It uses the citation data of the US patents filed by 30 regions. Some RIS variables are newly developed, and they include intra-regional, inter-regional, and inter-national sourcing of knowledge and local ownership of innovation. The cluster analysis of these variables enables us to identify four major types of RIS around the world and link them to regional economic performance. The four types are, in the descending order of their per capita income levels, as follows: large, mature RIS characterized by a combination of long cycle technology specialization and high local ownership (Group 1), mixed RIS characterized by a long cycle and low local ownership (Group 2), “strong catch-up” characterized by short cycle and high local ownership (Group 3), and “weak catch-up” characterized by short cycle and low local ownership (Group 4). Groups 3 and 4 include only the regions in emerging world. They similarly specialize in the same short cycle time of technologies (CTT)-based sectors but show different records of economic performance. The key differentiating variable is the degree of local ownership of knowledge, which can be a basis for increasing domestic sourcing of knowledge and sustained catching up. Another important variable is decentralization, of which the level is lower in the strong catch-up group than in the weak catch-up group. In this Group 3, catching up is led by big businesses. Several cities experiencing upgrading, like Moscow, Beijing, and Shanghai, also show an increasing trend of local ownership and centralization.

[3841] *Federal Laboratories as Anchor Tenants: The Role of Geography in the NASA SBIR Program*

Jenna Rodrigues (University of Southern California), Andrea Belz (University of Southern California), Alexandra Graddy-Reed (University of Southern California) and Richard Terrile (California Institute of Technology Jet Propulsion Laboratory).

Abstract

We examine how a federal laboratory (FL) can serve as an anchor tenant in the context of the United States National Aeronautics and Space Administration (NASA), a federal agency with a mission of advancing the science and technologies of space exploration. The agency manages ten laboratories (Centers) around the country and technology development is distributed throughout the system, with each Center leading specific technical areas. These laboratories are placed in regions with high variation in population, industrial diversity, and research capacity. In this study we examine the capability of the FL to perform two distinct functions of the anchor tenant as a source of: (1) absorptive capacity for locally developed technologies; and (2) spillovers for local firms to succeed in non-contiguous markets of larger scales.

The NASA budget reserves a small fraction for the Small Business Innovation Research (SBIR) program for small firms to become nontraditional vendors to satisfy the agency's needs. We use the NASA SBIR proposal database to determine the impact of the FL in proposal evaluation and selection. Using a weighting procedure to address intrinsic regional and firm-specific differences, we analyze the impact of the distance between a proposing firm and a receiving Center on the evaluation procedure. In so doing, we find that firms located within approximately five miles earn higher scores on their proposals. FLs can, in fact, fund and adopt locally developed technologies like a large firm in the anchor tenant position.

In our second analysis, we consider the core-based statistical area (CBSA) or census tract as the regional unit of analysis and define "co-location" for firms located in the same CBSA as a NASA Center. With this framing, we can ask if the FL's presence helps proposals submitted to a different Center. Our analysis indicates that, surprisingly, co-location has a negative effect on firms applying to distant Centers. This effect is moderated by firm size: Proposals from the smallest (1-10 employees) firms co-located with another Center are poorly evaluated. Together, our results suggest that an FL can act as an anchor tenant, but that the benefits are narrow both spatially and technologically. The complex role that we find for the FL places this study at the intersection of research streams on clustering and spillovers, enabling us to make several contributions to economic geography.

We provide rare insight into regional dynamics in the aerospace sector which is typically examined on a global scale (Caliari, Ribeiro, Pietrobelli, & Vezzani, 2023; Romero, 2011). Our results suggest that FLs can offer absorptive capacity for local technology development and that public entities can function as anchor tenants - namely, customers of locally generated technologies (Agrawal & Cockburn, 2003). Our measured effective proximity of five miles corroborates the scales of dynamic cluster identification methods (Buzard, Carlino, Hunt, Carr, & Smith, 2019, 2017, 2020) but diverges with studies finding spillover effects at the levels of neighborhoods (Rosenthal & Strange, 2001; Wallsten, 2001) or larger areas of tens to hundreds of miles (Adams, 2002; Anselin, Varga, & Acs, 1997; Onken, Aragon, & Calcagno, 2019).

[7772] *STI policies for sustainable transitions: new approaches to stimulating and assessing change*

Rainer Walz (Fraunhofer ISI and Karlsruhe Institute of Technology) and Philip Shapira (University of Manchester and Georgia Tech).

Abstract

STI policies for sustainable transitions: new approaches to stimulating and assessing change Public funding of research and research institutions is under increasing pressure to justify its legitimacy and to increase effectiveness. This is leading to heightened attention to research impact. At the same time, there is a move towards mission-oriented innovation policy directed to address global challenges. STI policies, institutions, instruments, and measurement and evaluation approaches need to evolve to address such challenges. In this context, there is a change in the debate about policies to foster innovations in the energy, environmental, and bioeconomy domain towards the transition of systems. STI policies for research and technological development in these areas are well established. But sustainability transitions involve a move from policies for specific technologies towards system change – and system changes involves not only technical but also organizational and institutional innovations which co-evolve. This is also related to debate on new needs and opportunities for innovation system actors such as intermediaries. STI policies also involve a broad mix of policy instruments, with demand side policies especially important due to the double externality problems. This also leads to a high importance of sectoral policies also for the innovation process, and calls to rethink governance arrangements to facility policy integration between departments. With transition of systems becoming an explicit goal, we need also to rethink our approaches to policy and organizational, intermediaries, and to assessment and evaluation as part of design-build-learning approaches. The session aims at fostering exchange between U.S. and European perspectives on these pressing issues of STI policies to foster transition. In the context of exploring STI strategies for sustainable transitions, we will explore questions related to policy mix, program implementation, governance, and new intermediary roles. We will

seek to identify lessons learned through operations and evaluations of STI policies and organizational approaches that target sustainability transitions. Policy and programmatic insights will be highlighted, compared, and discussed. Papers in this session will include: Specificities of energy and environmental transitions and resulting challenges for innovation policies to support them: a view from Germany. Rainer Walz^,#, Jakob Edler^,+ (^Fraunhofer Institute Systems and Innovation Research; #Karlsruhe Institute of Technology; +University of Manchester) Innovation intermediaries in the new bioeconomy: Integrating translation, responsibility, and sustainable transitions. Claire Holland^, Adam McCarthy^, Priscila Ferri de Oliveira^, Philip Shapira^,+,* (^University of Manchester; +Georgia Institute of Technology; *presenter History-friendly modelling of energy transitions in an enlarged TIS-MLP framework: the case of wind turbines. Christian Lerch^,* Jonathan Köhler^, Wolfgang Eichhammer^,+ Rainer Walz^,# (^Fraunhofer Institute Systems and Innovation Research; +Utrecht University (Copernicus Institute); #Karlsruhe Institute of Technology; *presenter) Policy innovations spawned by the advance of rooftop and community solar systems. Marylyn Brown (Georgia Institute of Technology) plus co-authors. Session organizer: Rainer Walz (Rainer.Walz@isi.fraunhofer.de); Co-organizer: Philip Shapira (pshapira@manchester.ac.uk)

[6284] *Knowledge spillovers from HIV research-funding*

Ohid Yaqub (Science Policy Research Unit (SPRU), University of Sussex), Josie Coburn (Science Policy Research Unit (SPRU), University of Sussex) and Duncan A.Q. Moore (Science Policy Research Unit (SPRU), University of Sussex).

Abstract

HIV/AIDS has been a major focus for research funders. The US National Institutes of Health (NIH) alone has spent over $70bn on HIV/AIDS. Such investments ushered in antiviral drugs, helping to reverse a rapidly growing HIV/AIDS pandemic. However, the idea that research can deliver unexpected benefits beyond its targeted field, in fact, predates HIV/AIDS to at least Vannevar Bush's influential 1945 report. Cross-disease spillovers – research investments that yield benefits beyond the target disease – remains unexplored, even though it could inform both priority-setting and calculations of returns on research investments. To this end, we took a sample of NIH's HIV grants and examined their publications. We analyzed 118,493 publications and found that 62% of these were spillovers. We used Medical Subject Headings (MeSH) terms assigned to publications to explore the content of these spillovers, as well as to corroborate non-spillovers. We located spillovers on a network of MeSH co-occurrence, drawn from the broader universe of medical publications, for comparison. We found that HIV spillovers were unevenly distributed across disease-space, and often in close proximity to HIV, which, when discounted, reduced our spillovers estimate to 40%. We further reviewed 1,000 grant–publication pairs from a local sample and 1,000 pairs from a remote sample. For local spillovers, a quarter seemed to be unexpected, on the basis of on their grant description; for remote spillovers, that proportion increased to one third. We also found that the NIH funding institutes whose remits were most closely related to HIV/AIDS were less likely to produce spillovers than others. We discuss implications for theory and policy.

[1793] *Specificities of energy and environmental transitions and resulting challenges for innovation policies to support them: a view from Germany*

Rainer Walz (Fraunhofer ISI and Karlsruhe Institute of Technology) and Jakob Edler (Fraunhofer Institute Systems and Innovation Research and University of Manchester).

Abstract

Specificities of energy and environmental transitions and resulting challenges for innovation policies to support them: a view from Germany

Rainer Walz^,# and Jakob Edler^,+ (^Fraunhofer Institute Systems and Innovation Research; #Karlsruhe Institute of Technology; +University of Manchester) Background and rationale Innovation policies have been predominantly driven by the goal of enhancing competitiveness and economic well-being in the past. In particular in Europe and Germany, a paradigmatic shift in innovation policy towards a mission oriented approach has been taking place, with programs such as the German High Tech Strategy or the EU-Missions program being implemented. At the same time, energy and environmental policy making has been taking up the need to achieve transitions, focusing on carbon pricing and other regulatory measures. Within European innovation research, conceptual research has been taking up the notion of changing innovation systems and achieving energy and environmental transitions. However, it still remains unclear what the implications for directing innovation policies towards energy and environmental transitions are. The presentation will therefore address specificities of energy and environmental transitions, which form particular challenges for designing and implementing innovation policies to support the transitions: i) an increased role of normativity in innovation policy; ii) a changing role of the state; iii) a need for a more sophisticated methods of evaluation of programs and assessment of societal impacts. Methods The analysis of changing normativity is conceptual and based on desk research. It will look at

the normative content involved with the directionality of innovations, and additional normative decisions to be taken because transitions interact more strongly with economic and societal subsystems. The part on the role of the state draws conceptually on the double externality concept of environmental innovations by Rennings, the concept of Borras and Edler on the role of the state in transitions, and the concept of societal resilience to deal with uncertainties and disruptions inherent in transformation processes. These conceptual analysis will be backed up with empirical evidence from a major study on the policy instrument use in energy and environmental innovation policies in Germany. The part on evaluation and impact assessment will also draw on the methodological debate in the literature, but also on the experience in evaluation the large German FONA program (Research program on sustainability) which funded about 8000 single research projects with about 6 billion $. Results The analysis of energy and environmental transitions makes particular use of the heuristics of technological innovation systems or the MLP approach. In the course of putting these approaches in the contexts of transitions, the system elements included are being expanded, with more and more interactions with further societal subsystems being considered. This is accompanied by increased complexity, which makes it increasingly difficult to adhere to the requirements of consistent argumentation in qualitative case studies. Policies to foster energy and environmental innovations and "normal" innovation policies both start from basic normative assumptions: Innovations are per se helpful for economic success on the one hand, and energy and environmental innovations are needed to achieve environmental targets. However, in the case of energy and environmental transitions the case of normativity is more obvious due to the required directionality of innovation. It is foreseeable that the normative content of policies to foster transition processes will increase in the policy debate to foster transitions. In the European debate, transitions are also linked to institutional and social innovations, which are more controversial and require more normative judgements. In addition, the magnitude of necessary changes lead to increasing economic and social challenges, and even disruptions, with increasing need to make normative decisions on trade-offs. Compared with "normal" innovation systems, the spectrum in supporting energy and environmental innovation systems is shifted more toward a higher intensity of government activities. Demand-side innovation policy plays a much more important role, because demand per se is too low due to existence of external effects of environmental problems. The empirical evidence of the German environmental innovation policy shows that this is associated with an increase in the importance of policy instruments that are considered demand-side innovation policy from the perspective of innovation research, but are classified as typical environmental or energy policy. At the same time, this also increases the importance of the sector-specific ministries such as the ministries in charge of energy and environmental policy in innovation policy making as well. This further exacerbates the challenges of integrating the different departments that already exist even in "normal" innovation systems. With policies to foster energy and environmental transitions, the range of tasks for the state increases once again. The empirical evidence in Germany points towards soft policy measures becoming more important, which create platforms for actor coordination. Furthermore, with transitions also requiring that some sectors such as coal are phased out, policies to soften such changes are becoming more important. On the other hand, the limitations of the state's ability to steer become more obvious. Under these conditions, additional tasks of the state will be fulfilled by taking on additional roles, which, however, will not be geared toward micro-control, but will come to foster in particular discourses with stakeholders from business and society. At the structural level of state action, improvements in the science-policy interface, adjustments in governance, in particular with regard to integrating the policies of different ministries, different enhancement of the state's discourse capacity through the creation of discourse narratives, and the strategic inclusion of political economy conditions in strategy formation are all required. The nature of directionality of energy and environmentally transitions requires that assessments are necessary whether or not the transitions triggered by innovation policy actually meet the envisioned ecological goals. However, since these impacts only occur with considerable time lags, more prospective analyses are required here (ex-ante problem of impact assessment). The methodological requirements for assessment of societal impacts increase furthermore, since the repercussions of interactions of transitions with other societal subsystems must also be examined (attribution problem of impact assessment). The latest development in the envisioned impact methodology in Germany will be presented, in which the methodological experience from monitoring and evaluating research will be combined with the experience from foresight processes and the methodological tools of strategic sustainability impact assessment. Significance Germany and Europe have already some history in both strong policies to foster energy and environmental policies and an academic innovation research community discussion transitions. The U.S has recently decided to push energy and environmental transitions with large programs. This opens up the perspective for international exchange of experience to foster learning in policy making and innovation policy design on an international level.

[3892] *How does artificial intelligence contribute to public values? A large-scale analysis of AI patents*

Philip Shapira (University of Manchester / Georgia Tech), Sergio Pelaez (Georgia Institute of Technology), Barbara Ribeiro (Skema Business School, Université Côte D'Azur, France) and Gaurav Verma (Georgia Institute of Technology).

Abstract

Background

New technologies, as they are applied and scaled-up, especially if they represent disruptive developments, invariably raise concerns about broader public implications, distributional effects, and governance. In recent years, attention has turned not just to the societal consequences of new technology deployment but also to the anticipation (and mitigation) of potential consequences in research, design, and early emergence phases. In parallel, frameworks for considering the implications of new technologies have evolved from expert technology assessment to more diverse (and arguably more encompassing) constructions such as public values mapping and responsible research and innovation.

Advances in analyzing scientific literature outputs and patent documents can now shed light on the emergence, significance, networks, and trajectories of rising topics in research, invention, and innovation. Building on this work, we add a new dimension by identifying and analyzing the public values expressed in patent documentation. We put forward an approach to recognize early signals as to the public values expressed in patents as a new technology emerges and scales. Resulting insights can contribute towards assessing the societal implications of technological development.

For empirical exploration, we focus on artificial intelligence (AI) - a domain that has received growing investment from the private and public sectors and has substantially increased its patenting activity in recent years. Science, technology, and innovation (STI) scholarship has drawn attention to ethical, privacy, bias, control, and distributional consequences of AI applications, as implemented by private sector organizations and governments. AI patenting studies have also examined relationships with business development, economic growth, regional innovation clusters or global innovation dynamics. However, the social sciences have yet to comprehensively probe the relationships between AI patenting and public values and how AI patents express public value claims.

Given this knowledge development opportunity, the paper addresses three research questions. First, what kinds of public values are embedded in AI-related patents? This involves delineation of the AI patenting domain, the conceptualization of public values, and the operationalization of an approach that can identify and contextualize public values within a patent text corpus. Second, how are public values expressed in patents distributed across time, geographies, and areas of AI applications? AI patenting has developed extensively over recent decades, spreading across countries, sectors, applications, and assignees. There is rising public debate about AI's societal implications, with – varying by country and sector – policy interventions and the introduction of good practice codes. Public debate has also grown on sustainable development goals and global challenges. We anticipate that the public value rationales for AI inventions may in some ways evolve to reflect these public debates. Third, how do public values expressed in AI patenting speak to different dimensions of AI governance and policy? Here, we seek to distill insights and recommendations that can inform AI governance and policy, including implications for early anticipation and responsible innovation.

Methods

We use a peer-reviewed method combining a systematic keyword-based search with patent classification codes to select AI-related patents. The method is comprehensive in that it captures a range of approaches relevant to the domain, including deep learning, machine learning, supervised leaning, and other advanced techniques. We also conceptualize and operationalize an ontology of public values, building on available literature and prior work by research team members. To address the core research questions, we iteratively tune a BERT (Bidirectional Encoder Representations from Transformers) language model. This a machine learning method for natural language processing developed by Google and now in widespread use. We use BERT to classify USTPO AI patents (comprising patent applications and grants filed by US-based and non-US entities) according to whether and how public values are expressed. Text expressing public values can be found in patent background text, although it is also in other patent parts. An AI patent may express more than one set of public values, while not all AI patents express identifiable public values. A topic model identifies AI patents' main public value themes (e.g., healthcare, privacy, discrimination, environment, etc.). Model performance is tested and iterated.

Results and significance

Research is advanced in identifying and classifying public values in US AI patents, drawing on patent records contained in PatentsView. We have developed a database of more than 100,000 US AI full-text patents records with application filing dates between 2005 and 2021. We have identified more than 4.6 million patent text sentences which potentially contain expressions of patent values. We anticipate completing the testing and refinement of the model by the end of 2022, with analysis of results in early 2023. The resulting consolidated database of public values expressed in US AI patents, along with other associated patent information (including filing year, award status, patent class, inventors and assignees, address information, forward and backward citations, and whether public funding is attributed) opens multiple opportunities for investigation. This includes addressing our core research questions related to what kinds of public values are expressed in AI patents and variations by time, sector, and inventor/assignee geographies, and policy implications. We will probe factors or motivations that might lead inventors to express or address public values in their inventions or to recognize social, legal, and ethical implications. One of these might be the presence of public funding; another could be the continuous v. discontinuous characteristics of the patent (using methods related to emergent word combinations), where we might expect the latter to be more associated with attention to public values.

While we anticipate that the approach presented in the paper will present a methodological advance, a key goal of the paper is also to advance frameworks for conceptualizing and operationalizing public values that may have broad applicability. While social scientific analysis of patents and patenting practices began to emerge in the 19th century, and began to significantly increase in the 1950s, much of the social sciences literature on patents is focused on their legal and organizational aspects, complemented by management and economics of innovation scholarship on business strategy and private economic value considerations. Nonetheless, the early 1970s did see the growth of articles looking at the implications of patents to society, with a focus on developing countries. It was argued that, until then, not enough was known regarding the distribution of benefits of patent systems. Critical concerns were raised about the benefits of patenting to the economies of developing countries. Social sciences scholarship on patenting grew more rapidly and diversified in focus from the 1990s, with recent increased interest in overlooked topics, such as the impacts of patents on human rights or gender inclusion. Scholarship more generally on public values in science and technology has also grown, although there has been only limited work on public values in AI patents. As well as providing responsible innovation and policy insights about how AI patents are expressing public values, we hope that the concepts and approach elaborated in the paper will stimulate debate and open new pathways for further work on the relationships between innovation in emerging technologies and public values.

[3597] *Applied research to develop cancer drugs, basic research to succeed*

Sihan Li (Universitat Politècnica de València) and Joaquín M. Azagra-Caro (INGENIO (CSIC-UPV), Universitat Politècnica de València).

Abstract

1.Background and rationale Turning scientific research into innovation is a considerable challenge in the medical field (O'Connell & Roblin). Current developments in scientific research have not been mirrored by the same level of progress in drug development (Pammolli et al., 2011), especially with regard to cancer diseases, the most dangerous type of non-communicable disease (World Health Organisation, 2017). Even though research on genetic alterations in human cancers has led to a better understanding of molecular drivers of cancer diseases, and this knowledge should provide more useful drugs, the effectiveness and success rate of cancer drug developments are remarkably low (Hutchinson & Kirk, 2011; Begley & Ellis, 2012). Previous investigations have also confirmed that most medical research organisations focus on publishing novel scientific research instead of developing new drugs (Venditto & Szoka, 2013). This state of affairs is the motivation for the present research to explore the knowledge transfer from scientific research to drug development in cancer diseases. In academia and industry, all parties support the idea that new drug developments rely on the improvement of scientific research. However, how scientific research can be transferred into drug development is still being discussed. Some scholars support that scientific organisations should participate in drug development directly, as their scientific research helps them better understand pre-clinical results and match the patient conditions with in vitro tests (Van Dongen et al., 2017; Haeussler & Assmus, 2021). However, others believe publishing scientific research and developing drugs both require a great deal of effort, and that organisations do not have enough resources to cover both areas well (Du et al., 2021). Thus, this investigation will explore to what degree the basicness and the scientific impact of research influence organisations to engage in drug development and their effect on its success. Given the limitations of knowledge and resources, some organisations prefer to co-operate with others to develop drugs jointly rather than in isolation. Knowledge spillovers can be generated via co-operation activities (Hájek & Stejskal, 2018; De Noni et al., 2018). According to Smith (1994), the definition of knowledge spillover is the process of knowledge transfers from producers (knowledge sources) to users (knowledge receivers) through sharing, interaction, and the exchange of knowledge. In a co-operation network, knowledge spillover is always produced as a phenomenon in which the existing research efforts of co-operators may allow a given organisation to achieve results involving less research effort on their part than they would otherwise require (Jaffe, 1986). In this paper, research co-operation networks are built to observe and analyse the knowledge spillover through co-operative relationships. However, the efficiency of knowledge spillover is different with regard to basic and to applied knowledge, and it is still not clear whether the scientific impact of research can effectively spill over through the co-operation network. Thus, this paper also explore the spillover effects of basicness and the scientific impact of research on the success of drug development in the co-operation network 2. Method Since cancer diseases are very dangerous and the efficiency and success rate of cancer drug development are remarkably low, it was decided to choose two typical cancer drugs for the sample: alkylating and immunological cancer drugs. Variables were built with reference to the process of drug development through information from publications, clinical trials and FDA-approved drug products in oncology. Publications data was collected from PubMed, since it is the optimal publications database in the biomedical field (Falagas et al., 2007). The U.S. Clinical Trials Registry was chosen due to collect clinical trials data. For the purposes of this study, only the clinical trials from 2005 to 2018 were considered. The final database contains 104 drugs, with 250,257 publications and 14,345 clinical trials. After matching publications and clinical trials, there were 29,723 organisations with publications, of whom 832 had develop clinical trials in alkylating cancer drugs and (or) immunological cancer drugs. The co-operation networks were built according to the records of

"Sponsor/Collaborators" in ClinicalTrials.gov. There are 591 organisations in clinical trials co-operation networks. There are two dependent variables, Engagement of drug development and Success of drug development. For a given publishing organisation, Engagement of drug development means the organisations decide to develop clinical trials. This takes a value of 1 if that organisation develops clinical trials, and 0 otherwise. The second dependent variable is Success of drug development, which is calculated by the number of FDA approved drugs or Phase IV clinical trials drugs. The first independent variable is Basicness. This is calculated according to the Triangle of Biomedicine, which maps PubMed papers onto a graph to determine the basicness of the organisations' scientific research (Weber, 2013). The basicness of a given organisation is measured by the average of the basic scores of their publications. A higher score means it is more basic. The second independent variable is Impact. The scientific impact of an given organisation is calculated by the average of the Relative Citation Ratio (RCR) of publications. Other factors which influence the engagement and success of drug development are monitored: Publications are used to reflect the number of scientific research articles; Organisation Type to reflect the types of organisations; Country to reflect the location of organisations; Drug, Clinical Trials, Participants and Biomedical Percent to reflect the factors of clinical trials; Degree Centrality and Betweenness Centrality to reflect the characteristics of co-operation network; and NIH, Other U.S. Fed, Industry and Other Funding to reflect the funding sources of organisations in clinical trials development. Since the dependent variable, Engagement of drug development, is a dummy variable and there are only a few values equal to 1, rare events logistic regression was run to test the effect of basicness and scientific impact on the engagement of drug development. The zero-inflated negative binomial regression and spatial Durbin model were used to test the direct and spillover effect of basicness and scientific impact on the success of drug development. 3. Results The results show that although engagement in drug development is an important concern, only a few medical research organisations (less than 3%) actually engage in drug development. The lack of applied research is the reason behind this lack of engagement. Applied research fosters organisational engagement in drug development. In drug development process, basic research increases the success rate of drug development. The scientific impact of research not only stimulates the organisation into engaging in drug development, but also provides novel solutions to increase the success rate. In the co-operation network, applied research is easier to transfer and is more successfully exploited than basic research, thus the spillover effect of the basicness of scientific research is negative on the success of drug development. An efficient way to obtain frontier research from co-operators is through co-operation; thus, the spillover effect of the scientific impact of research is positive on the success of drug development. This investigation improves understanding about which scientific research — basic or applied — leads to engagement and the success of drug development in cancer diseases, and whether high-impact organisations also develop drugs. Methodologically, this study offers a new approach that overcomes the huge computational effort to empirically test these links, exploiting the spatial Durbin model to test the spillover effect in the co-operation network.

[4145] *Experiences of Foreign Born/Foreign Trained US STEM Faculty: A Qualitative Metasynthesis of the Literature through the Intersectional Lenses of Gender and Race/Ethnicity*

Sue Rosser (SVR).

Abstract

Limited research has focused on the experiences of foreign born/foreign trained (FB/FT) faculty compared to the U.S. born/U.S. trained (USB/UST faculty), and even fewer have used the intersectional lens of gender to explore issues faced by FB/FT women faculty compared to either FB/FT men faculty or USB/UST women faculty in STEM departments. This systematic review and meta-synthesis of extant qualitative literature on FB/FT faculty using intersectional lenses should provide valuable information to develop policies and practices tailored to better enhance inclusion, career success and retention of both FB/FT and USB/UST faculty of all genders and race/ethnicities. Since the U.S. academic STEM workforce is highly dependent upon FB/FT faculty, understanding their experiences and how their retention might be enhanced is crucial for innovation and science.

[4978] *Averting Obsolescence: Knowledge Spillovers from Junior to Senior Inventors*

Christopher Esposito (University of Chicago).

Abstract

Introduction Wisdom may come with age, but for inventors that work in rapidly advancing fields of knowledge, age may also bring knowledge obsolescence. Jones (2010) estimates that the likelihood that a scientist or inventor will create a great contribution to science and technology declines after age 40, the same age at which inventor productivity peaks (Kaltenberg, Jaffe, and Lachman, 2021). Esposito and van der Wouden (2022) show that the decline in the inventiveness of late-career scientists and inventors is linked to the difficulty for inventors to learn new ideas late into their careers –

and the ability of their fields to move on without them: at the end of the 20th century, incumbent inventors adopted new ideas into their patents half as quickly as their fields did.

The incidence of knowledge obsolescence falls not just on private actors, but also on the economy and society at-large. Knowledge obsolescence produces economic hardship and unemployment (Aubert, Caroli, and Roger, 2006), impoverishment and political disillusionment in "left behind" regions (Kemeny and Storper, 2019; Rodriguez-Pose, 2018), and may contribute to the R&D productivity decline (Bloom et al. 2021). Policies to resolve knowledge obsolescence are thus urgently needed, but before such policies can be developed, mechanisms that stimulate dynamic learning in senior inventors need to be identified.

One way for inventors to learn new ideas late into their careers is by interacting with junior inventors who are trained in the latest methods and theories. To test the viability of this mechanism, I examine how the age structure of inventors' organizational, geographical, and collaborative environments affects their propensity to learn frontier ideas throughout their careers. I begin the analysis at the level of the firm, where I analyze how the demographic structure of inventors' firms affect their propensity to develop new inventive capabilities. From there, I zoom out to look at the geographical environment in which inventors are embedded by analyzing how the age structure of inventors' metropolitan areas affects new idea adoption. Finally, I zoom in to the inventors' collaborative network to assess how the age of inventors' immediate collaborators affects new idea adoption. An advantage of this micro level analysis is that it allows for the causal identification of the effect of the age of an inventors' collaborators on new idea adoption, by using the unexpected deaths of collaborators as an exogeneous shock to the surviving inventors' networks.

Data and Methods I use USPTO patent data from PatentsView to track inventors across patents, measure their learning rates, identify migrations between patent assignees (firms) and between Core-Based Statistical Areas (CBSAs). I combine these data with information on the age and deaths of a subset of patent inventors by using a dataset assembled by Kaltenberg, Jaffe, and Lachman (2021) that scraped online demographic and obituary information for inventors. Of the 3.7 million inventors that appear in the PatentsView dataset, 1.5 million appear in the Kaltenberg, Jaffe, and Lachman (2021) dataset.

To measure inventors' learning rates, I calculate the rate at which the mean age of the USPC subclassification codes that the USPTO assigns to each inventors' patents changes over their careers. The USPC subclass codes describe the knowledge elements of each invention, so inventions that are assigned to older subclasses make use of older idea elements. Inventors that continue to combine recently introduced subclasses late in their careers have fast learning rates.

To identify inventor moves between firms and CBSAs, I record the first patent granted to inventors in a new firm or CBSA. To identify the demographic structures of firms and CBSAs, I calculate the average age of their inventors in each year. To ease interpretability, I define firms and CBSAs as having "young age compositions" if their mean value is below the yearly median value; all other assignees and CBSAs are defined as having "old age compositions".

To test if inventors learn new ideas more rapidly from their junior collaborators, I analyze how the age of the knowledge combined in an inventors' patents changes after they lose junior collaborators to unexpected deaths, relative to those who lose senior collaborators. I define junior collaborators as those aged 20-49, and mid-career collaborators as those aged 50-59. I omit all deaths of late-career collaborators (those aged 60+) from this analysis, because their death is more likely anticipated and thus endogenous. Moreover, my method assumes that deaths before age 60 are unexpected.

Results I begin by testing whether inventors adopt and combine new ideas in their inventions at a faster rate after moving to firms and CBSAs with young age compositions. To test these propositions, I estimate a regression model in which the age of the knowledge combined in a patent is a function of the number of years before or after an inventor moves to a new firm or region, interacted with a dummy indicator that equals 1 if the new firm or region has a junior inventor composition. The model also includes inventor*firm or inventor*CBSA fixed effects and technological class*year fixed effects. The show that inventors begin to combine more recently introduced subclasses in their patents 10 years before they move to firms and cities with younger inventor bases. Thus, inventor moves are highly endogenous to their career trajectories. This endogeneity emphasizes the necessity of a causal framework to study how inventors' environments affect their dynamic learning.

To causally test whether the age of inventors' collaborators influences their propensity to learn new ideas, I compare the average change in the age of the knowledge combined by inventors that lose early-year collaborators to premature deaths to the those who lose mid-career collaborators to premature deaths. I estimate a regression model where the age of the knowledge combined in a patent is a function of the number of years before or after a collaborator dies prematurely, interacted with a dummy indicator that equals 1 if the collaborator died before reaching age 50, and 0 if the collaborator died between ages 50-59. All deaths at age 60 and above are omitted. The model also includes inventor*collaborator and technology class*year fixed effects. The results show that, 3 years after losing a collaborator, inventors who lose early-career collaborators patent in subclasses that are 0.5 years older relative to inventors who lose mid-career collaborators to premature deaths. The results also show no pre-trends. Running the model separately for inventors in firms and regions with young and old age compositions shows that the results do not apply for inventors in firms and regions where the inventor age composition is young, suggesting that the demography of inventors' organizations and regions influence the demographics of their networks and their late-career learning opportunities.

Significance By emphasizing how the demographics of inventors' collaborative networks affects their learning, and how inventors' firms and regions affects the networks they develop, this study develops policies that can reduce knowledge obsolescence. Specifically, this study shows how policies that permit the movement between firms (such as the prohibition of non-compete agreements) and between regions (such as allowing for housing construction in innovative regions) can increase the uptake of new ideas by senior inventors.

[8578] *Should universities be Smart about innovation? University technology portfolio and licensing strategies*

Arman Yalvac Aksoy (Polytechnique Montreal), Catherine Beaudry (Polytechnique Montreal) and Davide Pulizzotto (Polytechnique Montreal).

Abstract

Background and rationale

The Smart Specialisation Strategy was first proposed in a 2006 Policy Brief and adopted by the European Commission in 2009. The concept quickly grew in popularity, and today, the strategy is emulated by other nations around the globe.

The place-based approach is characterised by the identification of local competitive advantages to bolster through targeted policies. It aims at developing local economies and coordinating innovation ecosystem actors around common development goals. Policymakers in North America have shown interest in the strategy and Canada has even launched a smart-specialisation-inspired initiative called Innovation Superclusters (now referred to as Global Innovation Clusters).

However, previous studies have shown that diversification is an important factor for innovation. Thus, smart-specialisation could have unforeseen effects on university research commercialisation by reducing the university's and local actors' research diversity.

This paper studies the effect of university-industry research coordination on university research commercialisation for North American universities. The aim is to provide empirical evidence of the effect smart- specialisation type policies could have on university research commercialisation. The study focuses on the relationship between research coordination and licensing to incumbent companies versus launching new startups.

Methods

We used patent and licensing data to analyse how the university and province/state patent portfolios affect university licensing behaviour in Canada and the United States. Patent data was collected from the United States Patent and Trademark Office (USPTO). Licensing data was obtained from the association of university technology manager's (AUTM) Statistics Access for Technology Transfer database (STATT).

We used panel regressions to measure the relationship between university/state patent portfolios characteristics and the number of licenses generating income and university start-ups. Our dependent variables are the number of licenses generating income and the number of startups created. These two variables represent the two strategies that universities can use to license their technology, either generate income with an existing company or create a new company to commercialise the technology.

Our independent variables include the technological diversification of the university and the state, the technological proximity between the university and the state, and the national expertise of the university. We use two different indexes on patent portfolios to calculate the university and state technological diversification and compare the results: the entropy index and the Herfindahl-Hirschman index. These indicators are supplemented with the technological proximity indicator which is the cosine similarity between the university patent portfolio and the state patent portfolio. Finally, the university national expertise is a location quotient of the university patent portfolio. We selected the highest location quotient as it represents the expertise field of the university compared to the nation.

Our control variables are based on prior literature on university research commercialisation. They include the university R&D spending which represents the size of the university, the amount of legal fees per license, the number of patents per disclosure, the proportion of exclusive licenses, the sum of all patents granted to patent holders in the region, and the ratio of industry-sourced R&D expenditures. We also supplement these with two binary variables representing the Canadian status of the university and the presence of a medical school.

Results

We observe strong associations between our dependent and independent variables. Technological diversification is associated with more licenses generating income and more startups being created. However, the effect of proximity is moderated by technological diversification. For diversified universities, technological proximity has a positive association with the number of startups created and a negative association with the number of licenses generating income. For none diversified universities the relationship is inverted, proximity is associated with more licenses generating income and fewer startups. More specifically, results show that universities can be divided into four (4) profiles alongside two axes:

technological diversity and technological proximity to the local patent holders. Hence, our four profiles are: high technological diversification and proximity, low technological diversification and proximity, low technological diversification and high technological proximity, and high technological diversification and low technological proximity.

High technological diversification and proximity are associated with more startups and fewer licenses generating income. This profile shows the highest number of startups created amongst all four (4) profiles. This hints at the importance of local absorptive capacities and spillovers. Companies can not or do not want to integrate every innovation the university can come up with due to cost issues. However, these innovations can still have an economic value which encourages entrepreneurs to launch startups to capture it.

Low technological diversification and proximity are associated with fewer licenses generating income and more startups. This profile exhibits the lowest number of licenses generating income. This is coherent with results from previous studies on regional innovation which highlighted the negative association between local absorptive capacities and startup creation. In the absence of local incumbents with sufficient absorptive capacities to integrate the innovation, the only way to commercialise becomes the launch of a startup. However, none diversified universities launch fewer startups than their diversified counterparts which demonstrates the importance of knowledge diversification for innovation.

Low technological diversification and high technological proximity have the fewest number of startups. These universities grant more licenses generating income than their low-proximity counterparts but are still far behind diversified universities in that regard. We believe that this is due to these universities preferring to work with local incumbent firms to innovate and license instead of launching startups. However, low diversification hinders their innovativeness.

High technological diversification and low technological proximity are characterised by the highest number of licenses generating income. This profile is also associated with fewer startups than their high-proximity counterparts. High diversification is leading to more innovation. However, low proximity to local patent holders ensures that, first, the innovation cannot be easily absorbed without the aid of the university researcher. Second, low technological proximity also ensures that the university technology is not in competition with existing similar technologies and does not threaten sunken costs.

Significance

We contribute to the literature on university research commercialisation in a unique way. This is the first study to look at the relationship between university technology portfolios and licensing. Our results confirm the importance of technological diversification for innovation and highlight its moderating effect between technological proximity and licensing strategy.

These findings can help universities and policymakers in setting up the right R&D programs and incentive structures. These can be aimed to either push the university towards more collaboration with local incumbents to improve existing industries and bolster local R&D efforts, or towards more startups to create new industries and open up new R&D avenues. This is all the more important considering the growing literature on smart-specialisation-type policies aimed at coordinating local economic growth and innovation efforts. The results provide insight into how such policies would impact university research commercialisation. These results show that smart-specialisation could in fact hinder innovation by reducing technological diversification. At the same time, proximity to local patent holders can either help or hinder commercialisation efforts depending on the university's technological diversification.

[8097] *Publication Quality and Publishing Practices: Views from Researchers*

Eriko Fukumoto (University of Tokyo).

Abstract

Researchers and Publishing: Qualitative Dimensions

Researchers publish to share their research findings, and every publication is supposed to add something new to the previously accumulated knowledge. On one hand, we may assume that "more is better" in terms of the number of publications, considering not only the amount of knowledge but also their diversity. On the other hand, we may question whether all these publications are meaningful, and the level and ways of meaningfulness could be diverse. Issues of the possible trade-off between quantity and quality of publications often gain attention, where citation count is often used as the proxy of quality or impact in bibliometric analysis.

This study is about mediocrity in research, which is usually not the main analytical target in social studies of research and researchers. In social studies and policies of research and researchers, themes such as success, excellence, high productivity, breakthrough, creativity, and stars often gain attention. If we define mediocrity as the quality of being average or lower, mediocre publications and researchers may consist the majority. This study transposes the question of scientific productivity into the question of mediocrity. The ratio of mediocre research may vary according to the judging criteria, and the criteria itself is the point of inquiry in studying mediocrity in research. This study aims to investigate why

and how researchers produce mediocre publications, from the standpoint of researchers. The focus is publication-level mediocrity, which could be distinct from mediocrity of research and researchers.

Research Questions

To investigate how researchers perceive the quality of their research and possible reasons they publish mediocre research, this study addresses the following questions:

- How do researchers perceive the quality of their publications, and what criteria they use to judge the quality?
- Why do researchers publish papers that are average and below-average quality?
- What are their perceptions on research and profession of researchers that are underlying their perceptions and behaviors about publishing?

These questions enable us to understand perceptions and practices behind publishing behaviors of researchers. This study starts by exploring how researchers perceive the quality of own publications without providing certain quality criteria in advance.

Interview Data: Sakigake Researchers

The data were collected through interviews with twenty-three researchers who work at universities or research institutes in Japan. The interviewees were selected from the past participants in the Sakigake program (Precursory Research for Embryonic Science and Technology: PRESTO in English), operated by Japan Science and Technology Agency (JST). The Sakigake program sets "research fields" and each field selects dozens of early-career researchers as independent principal investigator (PI), creating a group of researchers who interactively engage in high-risk and creative research across disciplines. For each PI's project, the research period is basically 3.5 years, and research budget is 30-40 million yen. Selection in each field is often competitive, sometimes less than 10% acceptance rate. From 1991 to 2022, 104 fields were established, funding 3,165 PIs.

The interview participants were recruited through email, and the interviews were conducted between August 2021 and March 2022. The interviewees were selected from the participants in six Sakigake research fields. Among the selected fields, the oldest field started in the mid-1990s, and the latest field ended around 2010. The interviewees had diverse disciplinary backgrounds, including biology, chemistry, physics, engineering, and computer science. The interviewees were mostly at senior-level in their careers at the point of interview- twenty professors, two associate professors, and one research fellow. The entire interview was designed to investigate researchers' perceptions, experience, and strategies in their research throughout their career and in the Sakigake program, with focus on challengingness of research. The interviews were conducted as semi-structured interview, using online vide call system. Each interview was around 30 to 60 minutes. The audio data were transcribed for the analysis. With qualitative approach, thematic coding was conducted primarily for three items, corresponding to the research questions.

Findings and Discussion

Findings are presented regarding three points outlined in research questions. The first point is researchers' perceptions of the quality of their research outputs. The interviewer asked researchers to classify their publications into three categories (good, average, and below-average quality publications) and answer in the form of ratio with 10 as the total number. In principle, the interviewer did not provide criteria for the judgment of the ratio, in order to investigate how they describe the publication quality. Some researchers stated that most of their publications are good, while others provided the opposite statement. Respondents mentioned various criteria in judging their publication quality, including the newness of ideas and level of contributions, citation counts, journal prestige, utility, and one's satisfaction.

The second point is why and how they publish what they regard as the average and lower quality papers. The interview results indicate that they have various reasons such as educational reasons as a supervisor of graduate students, own career and CV development, and professionalism. Respondents described situations where they had to "earn the number" for the publication record. Instead of having a sole reason for such publishing throughout their career, respondents had combinations of reasons to publish the average and lower quality research.

The third point is their views on research and researchers. These are foundations of their perceptions and behaviors in publishing. Findings on this point primarily focus on their views about risk-raking research (hit and home run, how they took risk, and risk-taking for early-career researchers), research lifecycle, and metaphors of research. Respondents often used metaphors to describe the nature of research, such as arts, farming, course meal, and sports.

Overall, interview results suggest that the production of mediocre publications is the integral part of the activities for most respondents. Even those who do not prefer to publish such papers still mentioned that each publication has a certain role. This study presents preliminary insights on mediocrity in research, indicating the potential importance of studying mediocrity in research and researchers.

[996] *Governing academic research and publication with public sector logics: recipe for failures?*

Muhammad Hali Aprimadya (The Australian National University).

Abstract

Background and rationale Academic publication is central to higher education as it serves various purposes that affect and determine the life and career of academics. Commonly known as an output of knowledge production, academic publications also play multiple administrative roles in determining individual promotion, funding, and institutional performance (Ramsden, 1994). In addition to its centrality in determining individual academics' accountability, earlier studies have also shown that, to varying degrees, academic publication contributes to knowledge governance through evaluative systems (Geuna & Martin, 2003) and rankings (Marginson, 2014). With such multiple roles, various policies and programs have been designed and established to improve publication performance, such as collaborative research initiatives (Lee & Bozeman, 2005), academic writing interventions (McGrail, Rickard and Jones, 2006), and publication incentives (Andersen & Pallesen, 2008; Xu, 2019). However, it remains unclear how massive incorporations of academic publications as output and administrative means in various policies and programs improve academic research governance, especially with the increasing influences of public sector narratives. Against this background, this study argues that consistent narratives are essential to facilitate the implementation of government policies and programs. Accordingly, this study uses regulatory mapping to uncover official narratives underpinning various laws and regulations in constructing and advancing our understanding of academic publications' roles in academic research governance. More specifically, the study aims to address two objectives: first, to identify and map legal provisions governing academic research and publication. Second, to assess the cohesion of narratives and values of corresponding legal provisions across regulatory mechanisms in understanding implementation approaches. In doing so, the study will assess Indonesia's regulatory mechanisms on higher education and research enacted between 1999 and 2019. Methods This study reviewed 30 authoritative documents governing Indonesia's higher education and research enacted between 1999 and 2019 to generate insights on how academic publication governs and, conversely, being utilized in research governance. Given the complexities and densities of Indonesia's research governance, obtaining the authoritative documents involved accessing various ministries' and agencies' databases. Therefore, the mixture of authoritative documents used in this study arguably represents the broad interests of different ministries and agencies on academic publication while also showcasing the propagation of academic publication in various government policies and programs. The review began with identifying various provisions related to research and academic publication. Keywords used in this study include academic publication, journal articles, scientific publication, and more ambiguous references such as 'research output' to identify relevant regulatory provisions. In making sense of extracted information, the study employed 'horizontal review' (Molinuevo & Saez, 2014) and 'vertical' classification of the authoritative documents. The horizontal review was used to uncover and identify different dimensions and perspectives of academic publication. Meanwhile, 'vertical' categorization was essential to analyze consistency and coherence between narratives, objectives, and provisions between 'high-level' policy and 'lower-level' technical documents (Howlett, 2009). Such an integrated approach provided this study with a comprehensive tool to unpack the dynamics of governance and implementation. Preliminary result This study identified significant proliferations of New Public Management (NPM) logic and values in various provisions governing research and academic publication, confirming public sector narratives' influences on higher education (Ferlie et al., 2006). It is also found that the Government has introduced numerous programs to enable and accelerate academic publications, such as publication incentives. However, as NPM values, like efficiency and effectiveness, arguably do not resonate with higher education traditions and values, this study discovered profound applications of control and audit in various programs, implying a strong sense of distrust. While some might justify such restrictive approaches with accountability reasonings, distrusts are deeply embedded in the administrative and bureaucratic obligations and practices associated with funding and performance assessment, thus, potentially reducing or crowd-out motivations (Frey, 1997) in conducting research and producing academic publications. Research funding Indonesia's research funding has been incrementally increasing controls on the applicants and quality demanded using track records and required outputs that are exercised through frequent revisions of funding guidelines. While applicants' track records and research outputs were arbitrarily defined for years, Guidelines Edition XII, published in 2019, requires the applicant's publication track record as a condition to apply for funding and specifies the type of publication criteria. For some schemes, these arrangements go into more detail, such as the obligation to state Hirsch-index or to publish at top quartile journals indexed by Web of Sciences or Scopus. With such increasing specificities, the funding arguably creates higher barriers to applying, especially among academics whose work is not publication oriented. Lecturers' performance assessment system The performance assessment system audits academic performance by aggregately measuring the outputs of research, teaching, and community services. However, the system sends mixed signals about academic publications. Although the system substantially rewards academic publications, the pre-2013 system required a review process to determine the 'real value' of the academic publication. While such a provisional mechanism no longer exists in the current system, the bureaucratic review of academic publications and other research outputs to assess academics' performance continues. As a result, the system arguably discriminates against academic research with excessive audit and gatekeeping on academic publications. Significance This contribution of this study is trifold. First, it aims to advance behavioural public administration research,

which remains underexplored, especially in the higher education and research policy contexts. Empirically, the study also serves as an empirical contribution to the study of Indonesia's higher education, which is rarely discussed academically despite being one of the largest and most dynamic higher education systems. Lastly, the regulatory mapping performed in this study provides a foundation for further policy developments.

[2791] *Parody, Joke, or Insanity? Retracted Publications Continue to Garner Attention*

Autumn Toney (Georgetown University) and Sara Abdulla (Georgetown University).

Abstract

"I think the article is a parody thing, or a joke, or maybe just [obscenity] insane. Fair warning, you will not be any smarter or better informed after reading it, but you might get a good belly laugh or two [retracted publication]." -Twitter User

Background: Scholarly literature can be retracted for multiple reasons, including faulty analysis, plagiarism, or falsification. Retracted scholarly literature raises questions about the validity and rigor of academic work. In some cases, retracted articles can hinder an academic field's growth by inserting misleading or wrong information into a topic's body of knowledge.

Especially in cases where articles are retracted due to flawed reporting or methods, it is useful to examine the nature of retracted papers. Conversely, it is also important to understand retracted papers because it is arguably worse for a flawed paper (i.e., one with faulty analysis, not reproducible, or another reason that is related to its results) to not be retracted, or take extended periods of time to do so.

Methods: Basic analysis The publicly available RetractionWatch (RW) dataset comprises our base set of data. We only include articles with a DOI in our analysis - this restriction appears to mainly exclude articles affiliated with Russian institutions. To inform our basic analysis, we perform summary statistics on the original dataset, including assessing retractions by year, country, reason for retraction, and subject matter. We also examine these measures on the subject of papers that are technology-related - we measure this by the RW subject (either "computer science" or "technology"), or if the paper is assigned an AI-related label using a SciBERT classifier.

Citations analysis Using a corpus of scholarly literature (containing merged publication data from Web of Science, Digital Science, arXiv, Microsoft Academic Graph, and the Chinese National Knowledge Infrastructure) we assess the number of times each retracted paper was cited, comparing the retracted papers' number of citations to a stratified sample of our corpus. To create the stratified sample, we controlled for paper publication year, publication country, and a binary variable indicating whether or not the paper is technology-related based on the criteria described earlier. For this comparison, we additionally employ "citation percentiles," which indicate the percentage of papers published in the same year and field as a given scholarly article that have fewer citations (e.g., a biology paper published in 2010 in the 95th citation percentile is cited more than 95% of 2010 biology papers). Finally, to examine the practice of citing retracted papers, we measure retracted papers' citations before and after their retraction years, again subsetting technology-related articles against all articles.

Social media impact analysis To gauge social media impact of retracted papers, we connected our papers to Dimensions' Altmetrics database. Altmetrics provides data on tweets, public Facebook posts, and other social sharing data on papers in the Dimensions database. It does not cover the full Retraction Watch database, but does cover most English-language publications. We compare social media metrics on retracted articles to the same stratified sample of scholarly literature that we use for our citation analysis.

Pilot results/expected results: Basic analysis: China has triple the number of total retracted articles than the second-highest country with retracted articles, the United States, with India, the United Kingdom, and Japan in 3rd, 4th, and 5th places respectively. Iran has the 6th highest global retractions despite not placing in the top 20 countries for scholarly paper publication globally. Regarding technology papers, China has ten times as many retracted papers as the United States, with the United States, India, Iran, and Malaysia following with slim margins respectively. Biology and medical papers were by far the most common subject in the general corpus, with triple the number of retractions as the second most common field, technology-related papers (over 12000 versus 4000), followed by business and engineering respectively. More papers over the past decade have been retracted than in previous decades, as other analyses have reported (insert source). On average, it took two calendar years for a technology-related paper to be retracted; in contrast, it took four calendar years for a non-technology related paper to be retracted. This discrepancy drops to 2 years to 3 years when we only consider papers originally published after 2009.

Citations analysis: Retracted papers continue to be cited after retraction. On average, 53% of citations for retracted papers occurred after the retraction year for non-technology-related papers, while 57% of citations occurred after the retraction years for technology-related papers.

The Kolmogorov-Smirnov test shows that retracted and non-retracted papers have different citation-percentile distributions for both technology-related and general research papers. Specifically, retracted publications follow a uniform distribution (i.e., the median percentile is 0.5) more closely, and the sample papers have higher percentiles.

Altmetrics social media analysis: To understand how the public discusses and interacts with retracted research, we used the Altmetrics API to retrieve tweet IDs that mentioned retracted technology-related papers. We retrieved the tweet texts and applied the Valence aware dictionary for sentiment reasoning (VADER) sentiment analyzer on the text. Repeating this process with our sample of non-retracted technology-related papers, we compare the difference in tweet activity of retracted and non-retracted publications.

VADER detects the polarity of text and provides a sentiment score on scale of -1 (negative) to 1 (positive). Retracted papers have a low average sentiment score of 0.03, compared to the non-retracted papers with an average sentiment score of 0.16. For retracted papers, positive tweets reflected sarcasm and negative tweets reflected frustration and disappointment.

For example:

Positive sentiment: "I'm no chemist, but pretty sure this is the greatest paper Big-E has published."

Negative sentiment: "Sadly, misinformation is not only plaguing social media but the scientific community. Here are two bizarre examples of poor peer-review standards and the flourishing of low-standard "scientific" journals."

For non-retracted papers, positive tweets reflected praise of and genuine interest in the research mentioned and negative tweets generally received a low score due to the research topic (e.g., depression or cancer).

For example:

Positive sentiment: "Oooh! Shiny! This was certainly worth waiting for. Also great to see coverage of leading edge research in high profile non-academic press"

Negative sentiment: "New research on breast cancer risk assessment"

Significance/discussion: China, the United States, and India lead the world in the number of retracted papers, both for technology and non-technology-related papers. The top 10 countries with the highest number of retracted papers differ when disaggregated by topic, and differ from the top 10 countries ranked by general scholarly output. Russia, Iran, and other countries with less sophisticated scholarly research infrastructures are overrepresented in the top countries list; this phenomenon may be due to less rigorous research methods, peer review, or research standards on the front-end.

Papers are both more likely to be retracted over the past decade and papers retracted in more recent years have a shorter retraction period (as to be expected, if they exist in this dataset). The higher retraction rate may be due to more rigorous review of papers post-publications and reduced stigma regarding research retraction. Still, papers tend to be cited more often post-retraction than before, which has significant implications for advancing scholarly research in all fields, but particularly nascent ones like technology-related fields.

[1054] *How sectoral differences influence STI policies in catching up by emerging countries: A systematic literature review*

Tung Tran (National Graduate Institute for Policy Studies).

Abstract

Background The relevance of government interventions and the catching up of emerging countries has been the subject of a significant amount of study that has been published in academic circles. However, the majority of articles concentrate on making up ground on a national level. Studies on sectoral catching up, particularly those dealing with distinct industries in different nations at various stages of development, on the other hand, are fairly sparse. Furthermore, research has focused on industrial policies, whereas just a limited number of authors have specifically addressed STI policies. With the presumption that the type of government policies strongly varies based on sectoral characteristics and learning objectives during each phase of catching up, the purpose of this study is to examine the applicability of STI policies that account for variation in stage of development and different sectors. The textile and apparel and the pharmaceutical industry are selected for investigate because of the vast differences between their respective knowledge bases: the former is supplier-dominated and the latter is science-based. The research attempts to answer the following research questions. 1. What are STI policy instruments have been adopted in each stage of sectoral catch-up in textile and apparel and pharmaceutical industry? 2. How the adoption of STI policies varied between the catch-up process of different knowledge sectors: textile and apparel and pharmaceutical industry?

Methods This study conducts a systematically review of academic literature on the STI policies for catch-up of pharmaceuticals and textile and apparel considering two primary criteria: i) papers including a discussion of the government's STI policies for sector catch-up; and ii) the records need to have information indicating the stage of catch-up at which certain measures were implemented. A search of Scopus and Google scholar databases for articles published up to May and 22 to the textile and apparel industry. By utilizing the three stages catching up model of learning objectives, i.e. operational skills & process technology, design technology for existing products, and new product

development technology, those articles were examined to explores relevant STI policies that facilitate catching-up process at each phase of development for textile and apparel and pharmaceutical industry.

Findings The results show that a variety of STI policy instruments have been utilized at each step of the catching-up process in both the textile and apparel industries as well as the pharmaceutical industry. Moreover, although certain policy instruments, such as strategies for developing a public education system or policies that promote quality and standards, are relevant in each phase of the catching-up process, the goals of these policies are fundamentally distinct from one another and depend on different sectors as well as specific learning objectives associated with the stages of development. When compared the textile and apparel and the pharmaceutical industry, despite the fact that the two sectors have distinct sectoral characteristics, catching up strategies for both follow a fairly similar pattern. In the early phase of catching up, education system development was a top priority and contributed significantly to the growth of industries in latecomer nations. During this time period, R&D funding has been limited. Only when nations enter a later phase of catching up do their governments starting to explore more ways to encourage R&D investment as domestic firms have accumulated basic and intermediate R&D capabilities. These strategies may include competitive financing programs, tax incentives, venture capital, and policies that facilitate access to capital for R&D activities. In addition, in last phases of development, policies promoting linkages within the sectors become a crucial tool for fostering the development of sophisticated R&D skills among domestic players. Still, there are differences in which the textile and apparel industry and the pharmaceutical industry diverge from one another in terms of STI policy implementation. For example, intellectual property law plays a vital part in the growth of the pharmaceutical business, but it has played a lesser role in the other sector. On the other hand, one distinguishing feature of nations that have successfully made the transition of their textile and apparel industry into the later phase of catching up is government's efforts to increase awareness about the value of new products and scientific and technological innovation as well as elevating design as a cultural and artistic symbol.

Contributions This research review research on government's initiatives to develop the textile and garment sectors, as well as the pharmaceutical industry of latecomer nations, and discusses the lessons that may be learned from those studies. The objective of this study is to investigate implementation of STI policies for catch-up purposes in a manner that takes into account differences in both the phase of development and sectors. The findings will shed light on when and how and when the government should employ policies on STI to facilitate the growth of the textile and apparel and pharmaceutical industry.

[9656] *Corporate science and IPO*

Federico Bignone (Université de Bordeaux and Swinburne University).

Abstract

IPOs allow companies to raise new capital, but this money comes with strings attached. Disclosure requirements and pressure from the shareholders affect your scientific strategies and consequently your scientific output. I test the causal impact of going public on firms' scientific output, using data on 1,919 US IPO firms, which is the population of IPOs from 1994 to 2010 with at least one patent. My empirical strategy involves a treatment group of firms that successfully completed an IPO and a control group of firms that filed for an IPO but then afterwards decided to withdraw their filing. Identification is achieved instrumenting the IPO decision with stock market average returns in the two months after the filing. Preliminary results show a positive effect of IPOs on scientific output, measured as patents and scientific publications.

[2518] *Risk-Taking in Science*

Sotaro Shibayama (Lund University), Pauline Mattsson (Lund University) and Anders Broström (Gothenburg university).

Abstract

Science is a risky business by nature. Scientists explore and cultivate uncharted space of knowledge through trials and errors, in which their original ideas are often rejected and expected goals are not fulfilled for various reasons (Franzoni and Stephan, 2021; Machado, 2021; OECD, 2021; Reinhilde et al., 2022; Wang et al., 2019). Such risk and uncertainty tend to be especially high when scientists aim at novel discoveries, which have the potential to open up new avenues and make substantial advancement (Bourdieu, 1975; Hagstrom, 1974; Kuhn, 1970; Merton, 1973). Thus, there is a growing concern over scientists' risk-averse behavioral patterns, and science communities and policymakers emphasize that efforts should be made to facilitate high-risk-high-return research (Franzoni and Stephan, 2021; Gewin, 2012; Machado, 2021; OECD, 2021). Despite its fundamental role, risk and uncertainty in science have been poorly understood (Althaus, 2005; Aven, 2011; Franzoni and Stephan, 2021; Hansson, 2018). Thus, this study aims to contribute to advancing our understanding in scientists' risk-taking behavior. In particular, we investigate (1) how risk-taking is socialized in the

academic training context, being transferred from a generation to the next generation, and (2) how risk-taking behavior is translated into research output.

To achieve the goal, we carried out a questionnaire survey with a sample of PhD students in life sciences in Sweden. We collected responses from 1,200 current PhD students concerning their research experiences, lab environment, risk attitudes, and their supervisors. We also collected information as to their supervisors based on secondary data. Finally, we collected bibliometric data for students and their supervisors. With the bibliometric information, we computed several features of research output from both generations. Among others, we developed a bibliometric measure for "riskiness", which we validated against a self-reported perceived risk. This is to quantify the risk-taking behaviors of both students and supervisors. We also highlight the novelty of research output (Wang et al. 2017; Shibayama et al. 2021) to investigate whether novel discoveries are facilitated by risk-taking behavior.

With the data complied, we first analyze how the risk attitudes of the younger generation (i.e., students) is shaped. We test the impact of various explanatory variables concerning the research training environment, including their supervisor's risk attitudes. In particular, we investigate in what situation supervisors' risk attitudes are likely to be transferred to their students. Second, we investigate how student's risk attitudes are associated with the nature of their research output. In particular, we examine whether risk-taking is associated with an increasing chance of novel discoveries. Based on the empirical findings, we discuss policy implications concerning funding, career development, etc.

[3589] *Are researchers in national research institutes in China satisfied with the block grant funding policy ?-evidence from Fundamental Research Funds policy implementation*

Cong Wu (University of Chinese Academy; Institutes of Science and Development, Chinese Academy of Sciences) and Ruhan A (Institutes of Science and Development, Chinese Academy of Sciences).

Abstract

Block grants and project funding have been the two major forms of government funding for the science and technology field in the worldwide level. (Wang et al., 2018) Similar cases occur in China.(Aruhan et al., 2019) Ever since the science and technology reform initiated in 1985, the competitive project funding mechanism based on peer review has been the chief funding model in China. This has contributed to a huge breakthrough in national innovation capacity and development in various research fields and disciplines, yet it has also triggered a series of problematic issues, particularly for the individual researcher, i.e. over-competing causing less time in research, insufficient stable funding causing heavy workload from project application, etc. To solve these problems, the Chinese government issued a series of stable funding policies, starting with Fundamental Research Funds (FRD) to national research institutes in 2006. As one key type of block grant in China, FRD is granted to two types of research institutions. national research institutes and research universities. Recently studies have examined the efficiency and performance of block grant funding policy in the national research institutes and universities in China(Chen et al., 2018; Zhang, 2019;Fu et al., 2016; Liang et al., 2017), yet an in-depth investigation based on individual perspective, namely how individual researcher feels about the policy implementation has not been taken into consideration. Based on the two-factor theory（also known as Herzberg's motivation-hygiene theory）， this study first combines the FRD policy intentions and expert opinions and establishes an FRD block grant policy implementation satisfaction evaluation indicator system. The evaluation indicator system is semi-structured, containing one part of closed questionnaire-based survey and one part of open-ended question. The closed questions consist of eight questions, three of which belong to hygienic factors and the rest five belong to motivation factors. The open-ended part consists of one question investigating the researcher individual suggestions to improve FRD policy implementation satisfaction. Next, this study hands out the questionnaire-based survey to various national research institutes in China. Based on the sample of 4,016 questionnaires received, this study then divides the respondents into two groups, namely the high-satisfaction group and the low-satisfaction groups. By adopting research methods of descriptive statistics, multiple linear regression and text analysis, this study shows the following conclusions: a. The satisfaction of FRD block grant policy implementation is positively and significantly associated with the amount of FRD funding the researchers receive. b. For the low-satisfaction group, the satisfaction of FRD block grant policy implementation is negatively and significantly associated with the pressure of receiving the FRD funding. c. The satisfaction of FRD block grant policy implementation is negatively and significantly associated with the age and professional titles of individual researchers. Further, the paper conducts the full-sample and grouped analyses on the individual suggestions for FRF policy implementation, revealing that to improve block grant policy satisfaction, researchers anticipate a larger amount of investment and an improved allocation scheme based on demands and strategic plans. Last, the study puts forward relevant policy implications based on these research findings.

[5762] *Joining evenly while remaining unlike: the influence of balanced inter-sectoral research collaborations on scientific performance*

Fredrik Niclas Piro (NIFU (Nordic Institute for Studies in Innovation, Research and Education)), Alfredo Yegros (CWTS, Leiden University), Siri Brorstad Borlaug (NIFU (Nordic Institute for Studies in Innovation, Research and Education)) and Pablo D'Este (INGENIO (CSIC-UPV), Polytechnic University of Valencia).

Abstract

Joining evenly while remaining unlike: the influence of balanced inter-sectoral research collaborations on scientific performance

Fredrik Niclas Piro (NIFU), Alfredo Yegros (CWTS), Siri Brorstad Borlaug (NIFU) & Pablo D'Este (INGENIO (CSIC-UPV)).

Introduction In the past decades, research funding agencies have increasingly supported research projects involving participants from different sectors (universities, private companies, etc.) hoping that new funding/collaborative mechanisms may increase knowledge transfer between the sectors and enhance research and innovation through formal collaboration.

In this paper we investigate whether such structural aspects affect the research outcome in collaborative projects in an analysis of data from 7,052 collaborative projects in the European Union's 7th framework program for research and innovation (FP7), foremost from calls under FP7-COOPERATION, whose mission was to support transnational collaborative research addressing "European social, economic, environmental, public health and industrial challenges". The aim of this paper is to study how the diversity of FP7 consortia influenced on citation impact of project publications.

Data and Methods We use project data from eCORDA (European Commission), which includes information about project outputs from self-declarations of project coordinators. As dependent variable, we measure project-level scientific performance by the count of highly cited papers (articles among the top 10% most cited worldwide in their respective fields). We only included projects that are collaborative (e.g., not the European Research Council), and may be expected to produce scientific papers (i.e., not aimed at SMEs, Coordination and Support Action, etc.).

Our key independent variables assess features of the collaboration profiles of projects. The independent variables measure the research projects' inter-sectoral nature of collaboration. We classified project partners into five broad categories of institutions: universities (HES), research organisations (REC), companies (PRC), public sector (PUB) and other types of organisations (OTH). This allowed us to build a measure that captures the number of different institutional sectors involved in a particular project: Inter-sectoral Variety. This variable ranges from 1 (projects in which all partners belong to a single institutional sector) to 5 (projects involving partners from all sectors).

We computed the distribution of the overall project budget that corresponds to each institutional sector in a project. The proportion of the overall project budget attributed to a particular institutional sector includes the sum of funding received by the EU and the financial contribution to the project of all project partners that belong to that particular institutional sector. Using this information, we computed a measure that captures the evenness (or skewness) of the funding distribution corresponding to the contributions of the different institutional sectors involved in the project. We use a Shannon diversity indicator to compute this measure: Inter-sectoral Balance. This variable ranges from 0 to 1, where 0 reflects a highly skewed distribution (i.e., a particular institutional sector contributes with most of the overall project budget), and 1 refers to a highly even distribution (i.e., all institutional sectors contribute similarly to the overall project budget).

Control variables include measures to assess the influence of the size/scale of the project: (i) total number of project partners involved, (ii) project duration (in months), and (iii) overall project budget normalized by number of partners (i.e., euros (€) per partner). We also controlled for the sectoral institutional affiliation of the project coordinator and the main thematic area of the project (ICT, health, agriculture, energy, etc,).

Results We use OLS regression analysis to study the relationship between inter-sectoral research collaboration and scientific performance at the project level (using a logarithmic transformation of the count of highly cited papers). The analysis is performed in three steps:

First, we observe that when only including the control variables, the scale of project matters: projects with greater volume of funding per partner, larger number of partners and larger duration exhibit greater scientific performance in terms of number of highly cited papers.

Second, we include the two variables associated with the inter-sectoral collaboration profile: Variety and Balance. The results show that each has a distinct, contrasting effect. The variety of institutional sectors is negatively associated with scientific performance, suggesting that bringing together partners belonging to different institutional settings may represent a significant coordination challenge for the achievement of high impact scientific outputs. However, the influence of inter-sectoral balance goes in the opposite direction: projects in which partners belonging to different institutional sectors contribute evenly (in terms of funding), display greater scientific performance (high impact papers).

Third, we examine whether there is an interplay between these two aspects of inter-sectoral collaboration (variety and balance) on scientific performance. We examine this by including an interaction term between variety and balance, finding that the interaction is positively associated with scientific performance. We interpret this as suggesting a positive

moderation effect of balance on the relationship between inter-sectoral variety and scientific performance. That is, the negative association between inter-sectoral variety and scientific performance is attenuated for greater levels of inter-sectoral balance.

Discussion

In EU collaborative projects, the type of outputs being produced is of different relevance to the partners. In our study it is thus not so much a matter of whether e.g., companies are represented in papers as co-authors, but in what way their project involvement impacts on the publications where the co-created knowledge is distributed. The results indicate that collaborative projects with similar efforts between the partners have greater scientific impact compared to projects where partners contribute unevenly.

After the regression analyses were carried out we conducted interviews with Norwegian coordinators/principal investigators of projects included in our study sample. The purpose of the interviews was to have them commenting on our main findings (are they recognizable, give meaning?) and to ask how they consider inter-sectoral balance and diversity as factors in the publishing process. The coordinators, who were mostly from universities and research institutions, emphasized that whilst academic publishing in a cross-sectoral project is foremost an activity carried out by academic personnel; the other sectors (public, private, NGOs, etc.) are important in developing good research ideas, and may contribute with essential knowledge and infrastructure in order to carry out the projects, thus also enabling the production of (highly cited) papers.

[8834] *Data-driven innovations in Germany: Drivers and determinants of adoption by SMEs*

Denilton Luiz Darold (Fraunhofer ISI) and Rainer Frietsch (Fraunhofer ISI).

Abstract

Studying the dynamics of data-driven innovations (DDI) is becoming increasingly important to map the drivers for developing data-intensive solutions by SMEs. Such an analysis provides substance to an analysis of barriers to the adoption of DDI as well as the impact of policies and legislative acts, like the Data Act, and public-funded data-sharing platforms, on fostering innovation and promoting growth and social well-being. To that end, a combined collection of structured and unstructured data will be used to analyze the adoption and diffusion of DDI in the German industry.

[9018] *The curvilinear effect of economic growth on the quality of business patents*

Manuel Acosta (UNIVERSITY OF CADIZ), Joaquín Azagra (CSIC-UPV), Daniel Coronado (UNIVERSITY OF CADIZ) and Esther Ferrándiz (UNIVERSITY OF CADIZ).

Abstract

We analyse the relation between economic growth, the quality of business patents and their links to university knowledge. For this purpose, we use a sample of 11,318 Spanish firm patents in the period 2000-2014 which includes the Spanish Great Recession (2008-2014). We rely on patent data retrieved from EPO Worldwide Patent Statistical Database (Patstat). Our results show that economic growth improves the quality of business patents, up to a point. Economic growth has another non-linear effect on the quality of business patents: it improves the contribution of university spillovers to technological impact. By contrast, a more engaging knowledge transfer mechanism, technological co-production with universities, is not positive for the quality of business patents neither directly not through interactions with the economic cycle.

[8081] *Changing Directions: Steering science, technology and innovation towards the Sustainable Development Goals*

Tommaso Ciarli (UNU-MERIT, United Nations University).

Abstract

Adopted by the United Nations in 2015, the Sustainable Development Goals (SDGs) offer a globally shared opportunity to change the directions of science, technology and innovation (STI) to contribute to a better and more sustainable future for everyone. STI can help address many SDG challenges, for example, by increasing access to safe and nutritious food, improving per capita economic growth, or enhancing access to trans- port systems. However, in doing so, STI can also undermine progress towards some of the goals, for example, through carbon emissions or the pollution of water basins.

So how can we steer STI activities towards solving, rather than exacerbating, SDG challenges? Just doing more R&D will not contribute to achieving the SDGs. Depending on the directions of the associated STI, it can, in fact, undermine

progress towards them. Determining how to invest in research and development for the SDGs is not a simple task. There is no single definitive perspective or STI direction for addressing any particular SDG. Each SDG challenge can be viewed differently, according to diverse and plural understandings, values, interests and STI priorities.

To help understand and better address the challenges of investing in STI for the SDGs, while embracing the complex relationship between STI and the SDGs, we carried out a major global study to determine how and to what extent the world's STI priorities are aligned with the goals.

We analysed scientific publications and patents data to gather quantitative information about global research and innovation priorities, and how these align with SDG challenges. We conducted a global survey of stakeholders to explore views about what types of STI are needed in the future to help achieve the SDGs. This allowed us to consider the alignment between current and desired STI priorities. We interviewed local STI users, including fishers, farmers and researchers, to explore how different actors, each with their own priorities, are shaping local STI pathways to tackle specific sustainability challenges. We then appraised stakeholders' views about how far each pathway aligns with sustainable development objectives. We produced data, mappings and case studies to gain a better understanding of STI priorities and to illustrate how such evidence and methods could be used in other contexts, according to plural interpretations of SDG challenges and STI pathways.

By combining these analyses, we gained deep insights into the way that particular STI priorities emerge both locally and globally, and how STI can be steered to improve alignment with the SDGs. Our results can help policymakers, research funders, academics, international organizations (INGOs) and aid organizations to make informed decisions about investing in research and innovation that will address the SDGs and ultimately create a positive impact on society.

[8798] *Balancing the Tradeoff between Regulation and Innovation for Artificial Intelligence: An Analysis of Top-down Command and Control and Bottom-up Self-Regulatory Approaches*

Gleb Papyshev (HKUST), Keith Chan (HKUST) and Masaru Yarime (HKUST).

Abstract

The rapid development of AI technologies has propelled various countries to increase their research and development capacities in this domain as part of "the AI arms race." At the same time, the widespread utilization of AI highlights the need for regulatory interventions. Despite the difficulty of the regulatory task and uncertainty associated with AI's impacts, several countries have started "the race to AI regulation" and have come up with unique and innovative approaches to regulating this technology. The spectrum of regulatory proposals spans from hard laws and the prohibition of certain systems to industry self-regulation based on AI ethics. The most detailed hard law on AI is currently undergoing public discussion in the EU, and regulation for recommendation algorithms is already implemented in China. Meanwhile, the governance of this technology elsewhere is mostly conducted through soft law mechanisms, which include governmental strategies and frameworks, alongside private and non-governmental sector guidelines and codes of conduct, often realized in the form of ethics-based industry self-regulation. This spurs the ongoing debate about which of the two approaches better promotes consumer welfare. While strict regulatory requirements may better protect society against the risks of AI technologies, they also tend to hinder the pace of innovation. It is unclear to policymakers and researchers which approach (strict command and control or ethical industry self-regulation) maximizes consumer welfare, and under what conditions. The conceptual difficulty in addressing this dichotomy partly stems from the lack of a common framework that incorporates both sides of the argument. In response to this gap in the literature, this paper has developed a model to address the following interrelated questions: (1) What are the advantages and disadvantages of the two regulatory approaches? (2) What institutional factors influence the outcomes of the two approaches? (3) How should governments optimally balance the tradeoff between AI innovation and consumer protection in general? To empirically ground our conception of different levels of regulatory stringency, we first examine the regulatory proposals from the EU, the UK, the US, Russia, and China. Our document analysis shows that a more stringent approach to AI regulation is taken by China, the EU, and potentially the US (if the Algorithmic Accountability Act is adopted), whereas a more relaxed approach is taken in Russia and the UK. The proposed level of regulatory stringency depends on how much they prioritize stimulating AI innovation in the private sector. Having understood the trade-offs from the policy documents, we zero in on the regulation of AI systems that are developed by the private sector for commercial purposes. Unlike those developed by the state for national security or military purposes, the former

presents a more challenging case for regulators since they do not have direct control over the innovation, exploitation, and usage of such AI systems. We also set aside systems that are outright prohibited since the issue they present is one of legal enforcement rather than economic trade-offs. Thus, our primary interest lies in the grey area – the types of commercial exploitation that are within the legal boundaries, yet may be considered unethical once revealed to the consumers. Examples of such exploitation include the case of Cambridge Analytica, the usage of large language models for clickbait fake news generation, deepfake technologies for generating pornography, or the boosting of Amazon's own products on its website. However, the logic behind regulating consumer-facing AI systems is intricate, not least because

decisions regarding innovation, consumer protection, and frequency of usage are all decentralized among various stakeholders who pursue their own objectives. The understanding of the optimality of various regulatory approaches, therefore, calls for a systematic framework capable of analyzing the strategic interaction between various stakeholder groups. As such, we answer the proposed research questions by constructing a game-theoretical model which examines the complex incentive dynamics between innovation and consumer protection. It is important to acknowledge that our model is not designed to be explanatory for the differences in regulatory approaches chosen by different countries, because the countries' choices could be irrational, affected by path dependence, or be the derivative of the political regimes in power. Instead, our model intends to contribute to the normative discussion on the optimal approach in regulating AI, and clarify the current academic and policy debates by pointing out how the optimal regulatory stringency is conditional on the institutional environments. The regulatory stringency chosen by the government is modelled by the probability that the exploitative practices of local AI companies are revealed to the consumers. This modeling choice is motivated by a unique challenge facing AI regulators. One key aspect of regulating AI is the difficulty of interpreting the workings of the black box systems, particularly what kinds of data are collected and what types of algorithms are used to extract valuable information by the companies. This fundamentally differs from industrial sectors where their social cost of production such as environmental pollution is relatively easily monitored and detected. In that sense, it is important that our model incorporates the possibility of revealing information to consumers, which will affect the behavior of consumers and their welfare in the end. After all, for unethical but lawful exploitation, it is consumers' knowledge of such practices rather than top-down prohibition that acts as a disciplining device. Based on our game-theoretic analysis, we have developed an economic theory of how the welfare-maximizing level of regulatory stringency for AI depends on various institutional

parameters. Under high foreign competition, domestic innovation plays a relatively small role in serving consumers. On the other hand, consumers benefit most when they are not misled to underuse the highly competitive foreign AI systems. As a result, the prioritization of consumer protection should motivate a government to choose a high level of regulatory stringency under high foreign competition. Meanwhile, under low foreign competition (for instance, due to strong protectionist policies), the domestic AI industry can effortlessly win over local consumers from their foreign competitors. This means domestic firms can derive high marginal benefits in terms of market share from improving their algorithms. As a result, the robustness of domestic firms' innovation incentives should motivate a government to also choose a high level of regulatory stringency under low foreign competition. Interestingly, under intermediate foreign competition, the government faces a delicate trade-off between consumer protection and innovation. Too stringent regulation stifles the innovation incentive of the domestic AI industry, whereas minimal regulation subjects the consumers to excessive exploitation. To maximize the actual consumer welfare, the government may strategically lower its regulatory stringency and turn a blind eye on some occasions. Across all institutional environments, however, minimal regulations are never compatible with maximizing actual consumer welfare. As such, the objectives of such regulatory design may be either rationalized by the prioritization of innovation, domestic producer surplus, or the perceived welfare of the consumers. In the latter, the government is primarily concerned with the image that this regulatory intervention produces without worrying too much about the actual protection of consumers – essentially using a loosely designed regulation as a PR tool. This suggests that further empirical studies should pay close attention to cases where governments are proposing very loosely defined regulations for AI.

[8435] *History-friendly modelling of energy transitions in an enlarged TIS-MLP framework: the case of wind turbines*

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Abstract

Background

Meeting the global challenge of climate change requires not only a high level of innovations but also changes in direction of innovations and transformations of socio-technical systems. Building an innovation system, which supports such transitions is a major challenge for society and policy, and a thorough analysis of the dynamics of transition would benefit such an endeavour. The recent literature on sustainable innovations includes both numerous applications of technological innovation systems (TIS) and studies, which look into niche development and regime shift from a multi-level perspective (MLP). Each of these approaches has merits and limitations in contributing to a dynamic analysis of sustainable transitions. Existing case studies show that the development of innovation systems is a complex process. This requires accounting for numerous interdependencies, which take place directly and indirectly, some of them immediately, others with considerable time delay. This complexity puts an additional burden on scientists to keep track of all the repercussions, which might result from changes in a framework condition or a policy design variable. We see a

trend to support applied policy studies with simulation models. Lately there are calls, e.g. in journals such as EIST or TFSC, to employ simulation models for the analysis of sustainable transition processes and the design of innovation policies. This calls for gaining first experience with such a model and a critical reflection of its merits.

Methodology

We develop an empirical system dynamics model for analysing the transition towards a renewable electricity system based on renewable energy, in particular wind. Conceptually, we base the model on three types of dynamics which drive the transition: i) the internal dynamics within a technical innovation system, which results from the interaction of the innovation functions within a TIS; ii) embedding the TIS of wind energy into a MLP approach, which accounts for the interaction of the TIS with the existing regime it is aiming to replace, but also the long-term interactions with the landscape; iii) the dynamics arising by embedding the TIS with other subsystems in order to catch the interactions with the physical, spatial, political and economic context. We build a model of the transition in Germany towards wind energy in form of a history-friendly model, which captures - in stylized form - mechanisms and factors affecting industry evolution. Stylized facts of the development of the industry are developed based on reviewing the numerous case studies on development of German wind industry, and are combined with hard data on industry and innovation. We use system dynamics as modelling approach, which is able to use both quantitative hard data and qualitative insights, and which is in particular suited to account for the feedbacks resulting from various interactions.

Results

The German wind energy development is widely seen as a success story. In 2020, wind power accounted for 26 % of all electricity produced in Germany, replacing coal as the most important energy source for electricity production in Germany. We view the development of wind energy in Germany as characterized by three phases. In the formation phase, R&D subsidies supported technology development. The legitimacy of wind energy was strengthened by the German climate policy, with the share of wind energy in Germany starting to increase continually after introducing feed-in tariffs. Professional firms emerged, entrepreneurial experimentation increased and the technology improved, especially with regard to turbine size and costs. In the second phase, growth was taking up speed after introduction of the Renewable Energy Act. The industry consolidated, and growth in installation continued. Knowledge generation, measured by transnational patents for wind technologies reveals a very strong position in technological competences in Germany. During this phase, the focus of the wind turbine industry changed from an inward looking industry supporting the soaring domestic market only, into a strong exporter of wind turbines. In the 2010's, the German system entered a phase of new challenges. Other countries were developing wind energy more strongly, and new competitors did arise. Rising policy costs led to questioning the supporting policy in Germany. However, the political lobbying power of the wind energy industry also had improved, and the sector was successful in portraying itself as a future growth industry. Thus, the feed-in rates were adjusted, but the system was kept in place. More crucial for a slowing down of installations was resistance against new installations and adjustment of the electricity transmission system, resulting in scarcity of additional on-shore sites and bottlenecks in transporting the electricity produced in the north of Germany to the customers in the south. The system dynamic model links the stylized facts to the innovation TIS-functions, the relationship of the wind energy industry with the regime and the landscape, and the interrelationship with the political, economic and spatial subsystem. The model structures the different interactions in eight feedback loops. Five of them are reinforcing a development. Three of them are balancing loops, which dampen a development. For quantification of the model, we use historical data, such as R&D data, patent data, installation of capacity and development of costs etc. Other variables have to be implemented based on the qualitative insights, which are normalized as specific values between 0 and 1. The calibration of the model is performed in such a way that the model run fits the historical development of the German wind energy system. An analysis of historically divergent scenarios provides insight into drivers of stimulating change, and the respective role of innovation policies on the supply and demand side. The history divergent scenario I underlines the importance of landscape changes and political context factors. Without these factors happening, wind power development in Germany would have been delayed substantially. The history divergent scenario II indicates that getting the system started or accelerated with supply oriented innovation policies only seems to be difficult. The history divergent scenario III, on the other hand, points towards the limit of a demand led innovation policy only, which pushes acceleration too much and too quick, resulting in quickly raising policy costs and sinking legitimacy. Contrasting scenario II with scenario III also points towards the importance of a balanced policy approach. Only looking at the supply side in innovation policy will run into dysfunctionalities, as demand oriented policies will do, which do not take into account the supply side of technology production and regime resistance.

Significance

The analysis demonstrates the potential for using simulation models for innovation policy analysis. The use of system dynamics opens up a perspective of simulating and understanding the system behaviour in sustainable transitions. Analyzing sustainable transitions with system dynamics might be a promising field in which case study based methodologies could be supported by model based analysis. However, this also presumes that the modellers are highly aware of the complexity of the interrelationships showing up in case studies and are able to perform a critical self-reflection about the limitations of modelling in such a heterodox approach.

[3646] *Leveraging technology spillovers to accelerate clean energy innovation*

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Abstract

Background and Rationale Spillovers of knowledge across technology domains are one of the key drivers of technological innovation, as knowledge initially developed in one technology area can be applied in another area to enable discovery and invention, reduce technology costs, and improve technology performance. Contributions of technology spillovers to clean energy innovation are expected to play a major role in the global push towards cost-effective decarbonization of the energy system. Despite the importance of technology spillovers, we have limited understanding of the micro-level processes of how knowledge spillovers across technology domains occur, what factors enable or affect spillovers, or how spillovers can be most effectively spurred and leveraged by public policies targeting the decarbonization of the energy sector.

Methods We have undertaken a multi-year mixed-methods investigation of technology spillovers in three important clean energy technologies: solar photovoltaics (PV), lithium-ion batteries (LIB), and solid-state lighting (SSL) (specifically, white light-emitting diodes (LED)). We use process tracing to combine and integrate quantitative and qualitative empirical evidence from a broad survey of the scholarly literature and primary documents, expert interviews, analysis of citations in patents and scientific publications, and a machine learning-based method of patent text analytics to understand the mechanisms and enablers of technology spillovers. Using these methods, we reconstruct the historical contributions of spillovers to individual innovations in the three technology areas, and then develop an inductive generalized typology of technology spillover mechanisms and enabling factors.

We find evidence of crucial knowledge contributions made by technology spillovers to 15 innovations in solar PV, 12 innovations in LIB, and 9 innovations in white LED-based SSL. In all three domains, identified spillovers were particularly important at the early stages of innovation, as they enabled key components and manufacturing processes that eventually became integral parts of the first commercial LIB and white LED products and the solar cell design that dominated the PV market for several decades. However, the impact of spillovers is not limited only to the stages of early research and development (R&D). We also find evidence of spillovers occurring at later stages of technology demonstration and market formation. Across the three areas, spillovers contributed to innovations in technology components, materials, system architecture, and manufacturing processes. In addition, spillovers drove a majority of improvements in consumer experience characteristics of white LED-based lighting products.

Results Based on the analysis of identified spillover processes in three technologies, we identify four types of "spillover mechanisms," different ways by which a spillover can occur: (1) learning and researching, (2) communication and collaboration, (3) human mobility (both physical and across disciplines or fields), (4) exchange of physical objects that embed knowledge, such as manufacturing equipment. Importantly, these four mechanisms are not mutually exclusive, as a spillover can operate through several simultaneously occurring and supporting mechanisms. Observed spillovers also differ in how intentional they were. In many cases, spillovers occurred as a result of a targeted search for external knowledge needed to solve a local problem or targeted application of available knowledge in a new area or for a new purpose. However, a few notable spillover cases also occurred serendipitously in the process of undirected "blue-sky" research.

We identify many broad categories of enabling factors for technology spillovers, including, but not limited to, external sectoral and market shocks; booms of R&D in external but related technology domains; freedom of search in the laboratory setting, both in academia and industry; multidisciplinary education and training; cross-disciplinary hiring and team composition; multi-sectoral firms; and academic-government-industry partnerships and knowledge exchange events.

Finally, we highlight four categories of public policies that enable spillovers: (1) public R&D funding that stimulates cross-disciplinary knowledge search and collaboration; (2) public funding for technology demonstration projects; (3) deployment policies that create incentives for strategic entrepreneurial knowledge search by incumbent firms in other industries; and (4) cross-cutting policies that support cross-sectoral and systemic coordination, such as government-industry round tables and roadmapping exercises. We also find that "stop-go" funding cycles negatively affect spillovers into clean energy technologies, potentially delaying resulting innovation and technology deployment.

Significance for Policy Based on our findings, we propose a set of five principles that can guide the design of energy and innovation policies and management practices that leverage technology spillovers to accelerate clean energy innovation.

First, for any organization, firm, or funding agency, there is a need to recognize and acknowledge the trade-offs that exist in supporting innovation activities in a focal knowledge domain against supporting a broader multi-disciplinary knowledge base involving multiple knowledge domains. Access to a broad pool of knowledge can accelerate innovation in the focal domain through technology spillovers, but it may not work on its own without a deep understanding of the focal

domain and the ways by which external spillover knowledge can be applied in it. These trade-offs suggest that there is a balance to be found between the depth and breadth of knowledge search in an organization, and that this balance can be proactively pursued and managed.

Second, policies that aim to leverage technology spillovers for innovation should be flexible, both in the choice of particular policy and funding instruments and in policy design, to allow for knowledge search in unexpected directions. Some of the most notable spillovers in our study occurred when researchers were able to pursue "blue-sky" research or worked in public- or industry-funded mission-oriented R&D while still being allowed a certain freedom of search.

Third, we find that continuous knowledge exchange between science, engineering and manufacturing is important for the generation of spillovers, which often requires deliberate management of boundaries within organizations and disciplines to alternatively nurture development of knowledge within an organization or discipline and cross-pollinate with external knowledge across the stages of innovation.

Fourth, cross-disciplinary, cross-sectoral exchange should be supported at all organizational levels: from individuals (e.g., through temporary or extended placements of public sector and university researchers in industry) and events (e.g., conferences mixing scientists, engineers, and industry representatives) to teams (e.g., multidisciplinary team composition), organizations (e.g., through academia-industry collaborations and alliances) and platforms for broad cross-sectoral and cross-disciplinary collaboration (e.g., industry roundtables, roadmapping, and visioning or foresight visioning exercises).

Finally, all instruments and activities supporting technology spillovers should not be restricted only to R&D policy. They should also be included in the policy mix for the support of innovation at all stages, including technology demonstration and market deployment. This principle is particularly relevant for innovation in clean energy technologies, in which deployment policies are known to have played a crucial role in stimulating dramatic cost reductions and technology deployment over time and are expected to continue playing this role in the future.

[5726] *Towards the measurement of epistemic disagreement in science*

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Abstract

Background: Healthy disagreement among scientists drives the creation of new knowledge and is a necessary precursor to consensus. Yet in spite of their prominence in histories and theories of scientific progress, disagreement has received little empirical attention. A rigorous quantitative accounting of disagreement and consensus would have many far-reaching impacts, such as informing better models of science and innovation, supporting tools that improve the accessibility of the scientific literature, and contributing to new consensus-aware approaches to science policy. However the complexities of disagreement have so far made quantification difficult, instead confining its study to time- and effort-intensive historical analyses and surveys which, although rich in detail, cannot generalize across the sheer scale and heterogeneity of science.

This abstract describes results of an ongoing project that aims to address these challenges by providing a rigorous foundation for the study of disagreement in science. First, we aim to provide a measure of disagreement. Leveraging the increasingly-availability of full-text content from scientific publications, we describe a methodological approach to generate and manually-validate cue-phrases that reliably signal that an in-text citation sentence represents valid instances of disagreement. We then use this approach to quantify the extent of disagreement across more than four million publications in the Elsevier ScienceDirect database, and investigate the rate of disagreement across fields of science. Building on this initial study, we also chart a path towards a more thorough and holistic study of disagreement through the curation of an extensive dataset of exemplar scientific disagreements alongside the development of theoretically-grounded and validated indicators of disagreement.

Methods We adopt a holistic notion of disagreement that can occur when one paper references another, characterized by three distinct types:

1. Paper-level disagreement: when one publication offers a finding or perspective that is (at least partly) incompatible with the perspective of another (even though there may be no explicit contradiction). 2. Community-level disagreement: when a citing publication, without explicitly disagreeing with a cited publication, instead mentions controversy or lack of consensus in the larger body of literature

We identify disagreement in a corpus of in-text citation sentences (citances) extracted from English-language research articles published between 1980 and 2016 and indexed in the Elsevier ScienceDirect database. A set of preliminary signal and filter terms were derived through an iterative process of manual labeling, validation, and discussion between all the authors both in-person and virtually. Signal terms were chosen such that citances containing them were likely instances of disagreement; the presence of filter terms further increased the likelihood. Queries were constructed from all signal/filter term pairs.

Two coders manually labeled 50 randomly-selected citances returned by each query as valid or invalid instances of disagreement. Our operationalization of disagreement was robust, with 85.5% agreement between coders. The validity of each query was calculated as the proportion of citances labeled as valid by both coders. Only the 23 most precise queries, with at least 80% validity, were selected to form the disagreement indicator, resulting in about 500,000 citances, the incidence of which in a field forms our novel indicator of disagreement.

Results Disagreement accounts for 0.32% of all citances in our corpus. Examining the rate of disagreement across a high-level categorization of scientific disciplines reveals that rates reflect the "Hierarchy of Sciences" proposed by Auguste Comte. Namely, the lowest rates of disagreement can be found in the physical sciences (0.15%) and math & computer sciences (0.06%), whereas the highest rates of disagreement are in the social sciences & humanities (0.61%)—differences that likely stem from the complexity of the subjects they study and which methods are possible. This interpretation is further supported by examining more fine-grained sub-fields, which reveal that fields such as paleontology have higher rates of disagreement than other subfields in the natural sciences, likely owing to their dependence on contested and incomplete historical records rather than controlled experiments.

We also investigate how disagreement varies across a range of contextual factors. In the interest of brevity, here we provide a high-level summary of some of these findings: The rate of disagreement has steadily declined between the year 2000 and 2016 in physics & engineering, whereas rates in other fields either remain stable or only marginally change.

- Papers are more likely to issue a disagreement against a newer paper rather than an older paper. This effect is especially prominent in the social sciences & humanities. Disagreement is mostly likely to occur at the beginning of a paper, mostly likely in the introduction or literature review.

- Citation to another person's work is 2.4 times more likely to be disagreement than is self-citation (defined as any overlap between the authors of a citing and cited paper), though this difference is lowest in the social sciences & humanities (1.6 times greater).

- We find little difference in the rates of issuing or receiving disagreement between men and women first and last authors. Receiving a disagreement citation has no notable effect on citations in the years following the disagreement. However, papers that issue a disagreement citation tend to receive more citations than papers that do not, suggesting that critically engaging with prior work is associated with higher citation impact.

- Our approach provides a strong first-step in a quantitative understanding of disagreement. There are limits, such as reliance on a non-exhaustive signal and filter terms, yet despite them, we show the approach to be robust, transparent, and act as a strong first step towards more general indicators of disagreement.

Next Steps: This study serves as the foundation for the further development of data and indicators for the study of disagreement and consensus across science. Namely, we aim to develop the largest-ever dataset of scientific disagreements, drawing from the method listed here, alongside identifying disagreements through explicit editorial notices, such as published comments, and identified from social networks like Twitter and PubPeer. Then, we will develop a series of theoretically-validated indicators of disagreement at the level of scientific topics, evaluating each based on their ability to identify topics containing the previously-identified disagreement. These indicators will be wide-ranging, including the cue-word based approach used here, but also analyzing features of article metadata, the complexity of their textual content, and the position of the paper in the broader citation network. To showcase their applications, the best-performing indicators will be applied towards studying the causes, consequences, and trends of disagreement in key topics during the COVID-19 pandemic.

Significance: The significance of this work can be understood across four main dimensions. First, these indicators will facilitate empirical analyses of the temporal evolution of consensus formation and provide vital insights into theories of scientific progress. They will also prove crucial to research in adjacent fields such as the public engagement with science, in which public controversies can be compared against their corresponding scientific consensus. Second, these indicators will also find applications in industry, particularly for scientific search engines and discovery tools. Third, these indicators will contribute to consensus-aware science governance, giving funding agencies, journals, and other institutions the tools to guide scientific fields towards debate or consensus. Fourth, our indicators of consensus mark an important conceptual shift in the science of science—moving beyond measures of performance and instead developing indicators of scientific certainty, a feature of knowledge itself.

[9722] *Engaging learned societies in promotion of open science and responsible research*

Janne Pölönen (Federation of Finnish Learned Societies) and Elina Late (Tampere University).

Abstract

Background and rationale

Since the 17th century, learned societies - voluntary non-profit organizations involving academics - have existed for the advancement of scholarship, research, disciplines, publishing and public understanding of science. Publishing scientific

journals and books has traditionally been an important part of the activities of learned societies but they also take other various activities including arranging conferences, supporting research, and popularizing knowledge.

The most well-known learned societies are the national science academies, in which membership is typically based on invitation and merit. However, there also exists a much broader archipelago of local, national and international societies, whose membership is open to all academics, and often also to interested professionals and citizens. In English-language literature, a learned society can also be referred to as a learned/scholarly/scientific association or scholarly society. Occasionally, the term professional society is also used. We have estimated in a working-paper that there are around 9000 learned societies in Europe (https://doi.org/10.5281/zenodo.5513560).

In historical perspective, learned societies constitute, along with universities and other kinds of research performing organizations, the foundation of contemporary academia. International Survey on Research Integrity (IRIS: https://doi.org/10.17605/OSF.IO/XB9RK) provides the broadest available indication of the continued relevance of learned societies. Over 82% of 60,885 active researchers from Europe, United States and other countries, who in 2021 answered the IRIS survey question concerning professional societies, identified at least “a little bit” with the societies, and 62% identified “moderately”, “a lot” or “a great deal”.

Yet, surprisingly little information and research exists on their current number, forms of organizations and operation, or contributions to scientific and societal impact of research in specific countries, regions or globally. While more attention has been paid to the obstacles and challenges for promoting open access in the landscape of learned society journals, next to nothing is known or said about the (potential) role of learned societies in the area of responsible research, including research integrity and research assessment. However, we argue that these societies create networks of scholars and professionals and have discipline specific expertise on scholarly activities that should be exploited more.

In this paper we address the following questions: 1. What role does open science and responsible research play in societies’ activities? 2. Do the members expect open science and responsible research to be part of the societies’ activities?

To answer these questions, we would need a global review of learned societies, their activities and membership. The scope of our present study is mainly focused on Finland, from which we have a comprehensive report in 2019 (https://doi.org/10.23847/isbn.9789525995190). Besides Finland, one survey study has covered learned societies in Portugal, and another one social science societies in the UK.

Methods and data

We provide data from Finland and from Finnish societies. Currently, almost 300 societies are members of the Federation of Finnish Learned Societies (TSV), and they have more than 250,000 individual members (Finland has a population of 5,5 million). Recently TSV collected two broad datasets from its member societies and the individual members of these societies.The first dataset (N=114 unique societies) concerns the actions related with responsible research of learned societies. The second dataset (N=1540 individual members of learned societies) concern the membership of the societies. By integrating these two datasets we are able to provide insight about the open science and responsible research activities from the viewpoint of the societies and their membership.

Results

Over 94% of 114 learned societies in Finland, who answered the survey in 2021, indicated that the promotion of scientific activities is a major part of their activities, followed by the promotion of general understanding of science and societal impact. Generally speaking, the promotion of responsible research and open science has not yet become a key part of learned societies’ operations. Yet around 70 per cent of the societies participate in developing open science, 60 per cent publish immediately openly available publications. However, activities linked to research integrity, open data, open education and citizen science are rarer.

Nevertheless, the majority of societies were interested in developing their activities in one or more areas of responsible research: identifying and proposing experts to working groups, committees or as evaluators (65 % of societies), promoting open science and organizing events (more than 50 %), evaluating the quality of research (more than 40 %), assessment of social impact, science education and research ethics (approx. 30 %).

The membership of the learned societies regards traditional forms of operation, such as networking, publications, events and the popularization of science as the most important parts of the societies’ operations. Over 90 per cent of the respondents agreed at least partially with the statement that the promotion of the openness of research-based knowledge is important, and more than 80 per cent agreed that this should be free of charge to the readers. Almost 90 percent of the respondents agreed at least partially with the statement that the promotion of research integrity should be an important task of societies, and almost 80% agreed also on the importance of responsible assessment of researchers and research quality. Almost 60% agreed on the promotion of citizen science, while 45% agreed that producing open learning materials is an important task of societies.

Significance

Our case study in Finland shows that societies are active in the most traditional forms of open science, such as open access publishing. Publication activities are indeed one of the learned societies’ key forms of operation, and a significant

proportion of learned societies' publications already complies with the principles of open science. The societies have been important enablers and promoters of open, non-profit and scientific publication activities without author fees (so called Diamond OA) in Finland. Other forms of open science and responsible research are not yet established but highly supported by the members of the societies. The perceptions from the membership should guide the future development of the societies.

Data on society memberships shows that learned societies represent the science community on a broad scale in terms of age, field of education, work organization and place of residence. The networks created by the societies are cross-organizational and often international and provide a unique resource for identifying experts of different domains and creating collaboration between the domains. Thus, societies have a great potential in implementing and developing field-specific open science practices through engagement of researchers at the grass-root level towards a more responsible direction. Policy makers, research performing and funding organizations could develop more strategic collaboration with learned societies as a valued intermediary between science and society.

[4124] *Utilizing the national resources for financing transformation: experiences from four Latin American countries*

Michiko Iizuka (National Graduate Institute for Policy Studies (GRIPS)), Fernado Vargas (Inter-American Development Bank) and Jakob Baumann (Policy lead).

Abstract

Background and Rationale: The sustainable transformation of the economy is increasingly a relevant topic globally, including for the Global South. This topic has particular relevance to natural resource-rich countries because these countries are challenged with distinctive pressures globally and locally. These are 1) market pressure to produce more extractive resources (in particular, mineral resources required for renewables) by the Global North for the energy transformation; and 2) growing local tensions between the extraction of natural resources and local environmental sustainability and society. It is urgent to identify a new pathway toward their own transitions, leveraging natural resources.

The management of revenues from natural resources, in this context, plays a critical role in transforming the economies of resource-rich countries. Traditionally, the revenues--mineral royalties--had been levied and these were used to stabilize the macroeconomic fluctuations (e.g. stabilization fund, sovereign wealth fund, natural resource fund) or economically compensate the people who live in the localities (usually poor communities) where extraction activities take place. These revenues, however, were rarely invested actively for innovation or knowledge for transforming the existing structure of the economy.

In the public policy literature, the importance of the dynamic capability of the public sector had been identified as a critical factor in adapting society to the new context. The management of finance and how to invest in knowledge would also require such dynamic capability of the government, whichever level it is situated either at national or local. The existing literature attempt to classify the types of capabilities and actors necessary for this purpose; however, there are still limited cases from the Global South.

Several Latin American countries, on the other hand, had introduced policy that earmarks certain parts of natural resource revenues for science, technology, and innovation purposes. In this paper, we call these initiatives as Natural Resource for Knowledge Fund(NR4KF). The mechanism, in distinctive ways, is introduced with the purpose to strengthen knowledge and innovation capacities in the country, especially in remote regions. The cases we study in depth are Bolivia's direct tax on hydrocarbons (IDH), Chile's Innovation for Competitiveness Found (FIC), Colombia's Science, Technology and Innovation fund (FCTeI), and Peru's Canon and Mining royalties. These mechanisms are introduced in distinctive moments between 2004-2012, allowing sufficient time to observe the outcomes of these initiatives.

The purpose of examining above mentioned Latin American cases are to identify the types and moments of policy interventions and their design that are needed to avoid various difficulties that are associated with natural resource revenues. We consider that studying the case of NR4KF in the four Latin American countries mentioned above would give some insights into the challenge of transformation in the Global South, especially for those with natural resources, and provide policy suggestions.

Methods: Building upon the literature on the management of natural resources, industrial policy, and public management, we developed a framework for the ideal design criteria for NR4KF. These consist of four static design criteria (clear statement of purpose, rule-based design, multiple stakeholder governance, and transparency), and three dynamic design criteria (monitoring and evaluation system, Institutional ma/managerial capacity building, coordination with external actors). This framework is used to compare four Latin American NR4KFs.

In order to understand the mechanism, procedure, and outcome of NR4KF in each country, the following information is collected and analyzed: 1) gray literature on legal and policy; 2) interviews with policymakers involved in the process, and

3) data on the flow of NR4KF and STI performance indicator. Point 3) was done to identify the short-term outcome of STI activities to indicate some aspects of transformation.

Results or anticipated results, significance:

This study compiled rather a unique set of data, the revenue flow to STI areas, connecting back the natural resources. The observation of complied data on the flow of NR4KF in relation to STI performance indicators (number of scientific publications, exported products) did not show strong relationships. This can be interpreted as the lack of impact in providing finance for transformation, or simply the time span in which the observation was made was not long enough to mark the difference.

As the quantitative measures to assess NR4KF fail to show a clear outcome of NR4KF, the qualitative comparative analysis was conducted to identify differences in mechanism in detail based on the NR4KF design criteria.

While the static design principle of NR4KF ensures consistency, and transparency, and diminishes the possibility of corruption, the rigid rule-based design hampered the effective use of the funds. For example, in Bolivia and Peru, due to the shortfall of capacities in research management, universities appear unable to cope with sudden increases in the inflow of research funds, especially lacking the means to convert them into research output. This problem is compounded by the fact that the funds cannot be used for salaries to hire researchers. The lack of flexibility in management practice and capacity to manage it effectively was especially noteworthy in the regions, where the funds are allocated. As the result, a higher proportion of funds is left unused and even if these are used, funds are used on items that may not effectively lead to knowledge outcomes leading to transformation (such as physical infrastructure on research i.e. ICT equipment and research facilities). This means that the dynamic capability of knowledge institutions needs to be built in tandem with the creation of the static rule-based design of the fund.

In contrast to the above, dynamic design criteria can be used to examine institutional abilities to adapt to the new "evolving "policy goals. Under this category, the striking finding across the cases is their absence. For instance, monitoring and evaluation systems are mentioned in the design but not implemented. Even with the system installed, the political cycle often interrupts projects preventing them from undergoing an adequate evaluation process to ensure policy learning. In other words, nurturing the dynamic capability of the state would require a well-functioning policy setting, a big challenge for the Global South.

This paper illustrated the capability of transformation requires the dynamic capability of public institutions, through a comparative analysis of NR4KF examples in four Latin American countries. The results would have the following implications: one is to show in detail both static and dynamic capabilities are necessary for the resource-rich Global South to develop to enable transformation; second, if transformation were to be implemented effectively, the capacity building at implementing agencies is critical prior to mobilizing large sum of finances and, the third, long term aim for policy should be combined with a short-term policy. This will provide the means to maintain a good balance between flexibility in rule-based design and space for dynamic interaction.

[6618] *Information accessibility and knowledge creation: the impact of Google's withdrawal on Chinese scientific publications*

Katrin Hussinger (University of Luxembourg) and Lorenzo Palladini (University of Luxembourg).

Abstract

Since Google entered mainland China in 2006, its share of the total search engine market of mainland China rapidly increased to 40.08% by the end of 2009. Together with the Chinese firm Baidu, which offers a similar service portfolio and held a market share of 58.47%, Google effectively became part of a duopoly (Kong et al., 2022). Google was, hence, a main source of information in China, especially of information from foreign countries (Kong et al., 2022; Wang et al. 2020). Like any search engine provider operating in China, Google was obliged to follow the strict censorship guidelines imposed by the Chinese government, but, in January 2010, Google decided to discontinue the censoring of search results on its China search page. This decision rapidly escalated in a sudden and unannounced withdrawal of all Google services from China, leaving millions of users without access to the world's top search engine overnight. From the 30th of March 2010 onwards, users in China could not access Google services anymore (The Guardian, 2012; The Official Google Search Blog, 2012; Bloomberg, 2014; Xu et al., 2021; Kong et al., 2022). In this paper, we investigate the effect of Google's sudden exit from China on the scientific research output of Chinese scholars. Access to information in the form of books and research material has been shown to be crucial for the generation of new knowledge (Furman and Stern, 2011; McCabe and Snyder, 2015; Waldinger, 2016; Berkes and Nencka, 2019; Mueller-Langer et al., 2020; Furman et al., 2012; Biasi and Moser, 2021; European Commission, 2012). A lack of access or high accessibility costs can, hence, be a key barrier to new discoveries and knowledge creation. Not surprisingly, information and communication technologies have been shown to enhance science production by increasing the availability of information and, hence, reducing search costs (Agrawal and Goldfarb, 2008; Ding et al., 2010; Winkler et al., 2010; Kim et al., 2009). Google's sudden exit from China, therefore, bears the risk that Chinese researchers lose touch with the research frontier and persistently lag behind their

foreign peers. Using Google's exit from China to assess the effect of barriers to information accessibility has several advantages which address common challenges for causal estimation. First, Google's exit was exogenous to science production and unexpected as it was the result of a rapid escalation of political tensions between the Chinese leadership and Google (Zheng and Wang, 2020; Xu et al., 2021; Kong et al., 2022). Second, Google was, at the time of the sudden withdrawal of its services, one of the main sources of knowledge for China (Kong et al., 2022; Wang et al. 2020) and its scientists (Qiu, 2010). Our empirical analysis focuses on the field of economics following prior studies such as Kim et al. (2009), McCabe and Snyder (2015), Liang et al. (2022), and Piracha et al. (2022). Economics is a research field with a simple knowledge production function as it does not rely on material and expensive equipment (Stephan and Levin, 1992). New insights are published almost exclusively in scientific journals rather than in books and conference proceedings which are often not well covered in bibliometric databases (e.g. Michels and Fu, 2014). Hence, an estimated effect of the sudden decrease of information accessibility on scientific output is less likely to be confounded by other effects resulting from the knowledge-generating process or publication strategy of the field. To derive causal results, we use a Difference-in-Difference (DiD) approach employing a control group of researchers located in Taiwan and Hong Kong following Zheng and Wang (2020) who argue for a control group that is culturally, economically, and geographically closely related to China. Our results show that researchers affiliated with Chinese institutions experience a significant decline in both their research output quantity and impact as measured by citations received by the future literature. The magnitude is about 28% for co-author-weighted publications and 30% for co-author-weighted citations. We explore the proposed underlying mechanism of information accessibility further and show that the productivity and impact of those Chinese scholars that work with foreign co-authors are less affected by Google's exit. These scholars can use their interpersonal networks as a channel for knowledge access (Singh, 2005; Mohnen, 2022). The publication output and impact of these scholars decreases by smaller shares of 20% and 22%, respectively, supporting that the mechanism of knowledge accessibility is responsible for the decline in publication output after Google's withdrawal. In further analysis, we find that the effect in terms of quantity and impact is stronger for those scholars with the highest impact as measured by their citation stock over publication stock before Google's exit. The publication output and impact of the top 25% scholars decrease by 39.5% and 37.5%, respectively, while the publication output of the scholars at the bottom of the impact distribution decreases by 20%. There is no significant effect for the scholars at the bottom of the impact distribution in terms of impact. The large effects on the top scholars raise concerns about the ability of China to stay in touch with the research frontier in the medium and long run with potentially harmful implications for economic growth (Griliches, 1992; Jaffe, 1989). We make several contributions to the literature. First, our work adds to our understanding of the determinants of knowledge creation (Stephan and Levin, 1992; Stephan, 1996, for an overview) and more specifically of the role of information and communication technology in knowledge creation (Agrawal and Goldfarb, 2008; Ding et al., 2010). Prior studies have shown that access to network technology (Agrawal and Goldfarb, 2008; Ding et al., 2010, for the case of BITNET) eases information accessibility and facilitates the knowledge production of scientists. Here, we focus on Google as a general search engine and complement prior findings for different technologies. Second, we contribute to recent literature that focuses on positive information shocks such as the availability of access to libraries (Berkes and Nencka, 2019; Furman et al., 2012; Biasi and Moser, 2021), of research resources (Furman and Stern, 2011) and of online access to scientific journals (McCabe and Snyder, 2015; Mueller-Langer et al., 2020) and their impact on knowledge creation. We differ from these studies in two ways. First, these studies focus on the access to prior scientific knowledge available in form of books, journals, and research resources while we focus on the access to a search engine that covers a much broader scope of information. Second, we explore a negative shock of information availability to assess the effects on science production while prior studies focus on positive shocks of information availability. Third, we add to the developing literature that focuses on the implications of Google's China exit. These include a higher stock crash risk for firms (Xu et al., 2021) and a decrease in corporate innovation (Kong et al., 2022; Zheng and Wang, 2020). Other than these prior studies, our focus is on the scientific rather than on the corporate sector.

[3100] *How do firms overcome barriers to innovations?: the mediating roles of external and internal funding of Korean Green firms*

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Abstract

Background: Over the last several years, growing international interest in environmental protection has led to the promotion of low-carbon industries and pursuit of sustainable development on a global scale (Mensah et al., 2019). For research and development (R&D), which is essential for strengthening a firm's innovation capability, the most important element is funding. This also applies to green firms, for whom financial investment into R&D is crucial (Noailly & Smeets, 2021; Yuan et al., 2020). Researchers using a resource-based view of the firm have four categories: physical, financial, organizational, and human capital (Barney, 1997). We analyze R&D funding based on resource-based view theory. Arrow (1962) argued that if R&D is funded from the outside, a moral hazard and adverse selection due to asymmetric information are possible. Gertler (1988) explained that external funding may be difficult and more expensive than

internal funding if elements of market imperfection are present, such as transaction cost, agency cost, and asymmetric information. Some scholars have argued that firms tend to invest their internal R&D funds because of this risk. In other hands, Noailly and Smeets (2021) argued that the green firms, like clean energy technology sector, are capital-intensive and large investments are a prerequisite. We address the following research question: Does the innovation barrier of green firms affect innovation performance? and what are the effects of external and internal funding-based innovation strategies, respectively, on this relationship?

Purpose: This study examines whether green firms can overcome barriers to innovation and improve innovation performance through research and development(R&D) funding. We analyzed innovation performance with internal and external R&D funding for firms facing barriers to conducting green technology innovation activities.

Data: This research utilized the data on the Korean Green industry from the 2015 Green Industry Innovation Survey (GIIS), which was conducted by the Green Technology Center, Korea. As the data contains overall innovation, including the objectives of green innovation, resources used for green innovation (input of innovation), and green innovation performance, GIIS data is believed to be appropriate for this research.

Result: The analysis results indicated that internal R&D funding was more influential than external R&D funding. The results showed significant innovation performance for firms using internal, rather than external, R&D funding to overcome barriers; internal R&D funding mediated the relationship between innovation barrier and performance.

Contribution: First, This study demonstrates the need for green firms to recognize barriers they face and conduct R&D despite these barriers. Further, we add to the academic discussion on the importance of R&D investment in technological innovation when overcoming barriers to innovation. Second, the findings emphasize the importance of green firms using internal resources to fund R&D to improve innovation performance, rather than injecting external R&D resource, despite the recognized barriers. This study indicates that, despite recognized barriers, entrepreneurs need to invest in R&D for innovation, and it is more important to invest internal resources than to take on the many risks associated with external funding.

Limitation and Further study: First, it did not take time lags into account. This study was conducted by analyzing only the 2015 data. Innovation performance includes sales growth rate and patents, which may have time lags. Second, knowledge exploration and external cooperation can be used as strategies, in addition to R&D funding, to overcome barriers. Third, barriers to innovation may vary depending on a firm's characteristics and industrial environment.

[6195] *Discovery patterns in the concepts entropy network and their impact on scientific research*

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Abstract

The massive growth of global research activity in recent years has spurred an exponential increase in the amount of related scientific literature. Successful research in the face of the increasing complexity of modern scientific knowledge together with the diversity and depth of the studied problems requires an understanding of the related scientific landscape - the structure and interrelation of trends in science. The situation gets even more pronounced for the granting organizations on their way to developing efficient granting policies since they have to deal with many areas of science at the same time. Professional expertise remains the unique option to address the mentioned problem but it is often subject to personal opinion which, as consequence, requires a pool of experts engaged to perform single expertise. Seeking for appropriate experts willing to participate in the expertise becomes a challenging problem considering applied time limits. Therefore future scientific information management should belong to systems that will play the role of "virtual experts", helping researchers and scientific foundations cope with the massive amount of research data and the high speed of scientific progress by facilitating manipulation, filtering, and combination of information. One of the features of such systems should be the ability to generalize scientific knowledge to identify scientific research trends and possibly even predict ones.

To satisfy mentioned requirements it is necessary to develop methods of data manipulation and processing that will accurately analyze the current state of scientific knowledge and have the potential to predict its future states as an intrinsic feature of such an analytic system. Available digital records open wide possibilities for statistical analysis of scientific documents and related metadata for topic modeling and evolution, knowledge mapping, citation indexing, etc. We have a lot of statistical tools to evaluate and measure the scientific outcome by calculating different scientometric indices. But while such measuring is efficient for evaluating the current scientific progress it is an open question of how to model future scientific discovery.

Recent studies by Wang at. al. use historical data on paper citations to predict later citations based on early patterns. It was shown that citations accrue to articles published in scientific journals over time according to a well-behaved log-normal distribution, with a rise in citations at the point of publication followed by gradual decay. The proposed model can

be used to predict an article's success and its development may lead to the methods of effective detection of promising research directions. But even in this approach selected articles needed a human expert to analyze their content to extract promising new hypotheses.

We propose to combine mentioned approach with a full-text analysis of scientific documents to identify promising research directions. The central element in our approach is a field-specific ontology based on a conceptualization of scientific knowledge. We use data collected by Science-WISE (SW) platform (http://sciencewise.info/) about frequencies of scientific concepts - the unique phrases that comprise one or more words and reflect certain basic notions of the scientific ontology. Investigating the dynamics of the entropic proximity measure of concepts we plan to find common patterns in the corresponding ontology graph at the moments preceding the appearance of new concepts as indicators for possible discovery.

The SW platform appeared as a result of a collaboration between physicists and computer scientists from EPFL and CERN. The SW uses modern methods of information retrieval, text analysis, and statistical data analysis to process large corpora of research publications and offers semantic recommendation systems, semantic bookmarking capabilities, and paper annotation. It is essential that the SW system excludes subjective statements about scientific ontology and provides evaluation and reflection made by the scientific community. In this study, we use an SW collection of concepts of high energy physics, derived with unique algorithms by processing and parsing the texts of scientific documents from ArXiv (https://arxiv.org/) preprint server.

Technically, scientific concepts are the keywords and a few of them are usually added to the article metadata to describe the main directions of the study. The collection of concepts commonly related to a particular scientific area forms the specific scientific ontology used to encode scientific knowledge in the texts of the documents. Information about the occurrence of the concepts in a particular text may identify the topic of the article. Statistics on the usage of concepts in various documents can be used to calculate the proximity between concepts. To evaluate such proximity we propose to calculate the amount of mutual information between concepts. For the collection of concepts, their mutual proximity is stored as a symmetric matrix of normalized distances between each pair of concepts. Scaling of the matrix on 2D or 3D plane can produce the so-called entropic map of concepts. By calculating the matrix for a particular time interval and then gradually increasing it with a certain time step we can investigate the dynamics of the underlying complex network of concepts. We explain the algorithm in more details in our previous study, where we use information about the dynamics of a such network of concepts to identify the hot topic trends.

The collection of concepts that can be related to a certain topic is changed over time. New concepts may be introduced by the scientific society to identify a new method, solution, or discovery. If the idea behind the concept is successful, later it can be used in many scientific documents on the corresponding topic so the amount of its associated Shannon entropy will grow. This also will lead to stronger connections with other concepts and eventually, this new concept may become a center of a new topic.

Detecting the patterns in the concepts network before and after the moment the new concept was introduced we plan to identify the necessary conditions preceding the creation of the concept. As a possible features to identify a successful concept we use the evolution of its Shannon entropy and citation history of the document(s) where it was introduced first.

We anticipate that detected patterns in the concepts network associated with successful new concepts can be used to predict future discovery. The detailed analysis of the parameters of the concepts network at a time preceding the moment of discovery may serve as a source of information for future prediction mechanisms that would augment scientific ability, increase productivity, and multiply returns from science for society.

[9605] *Joining the dots between government, funders and academia: are Areas of Research Interest the missing cog in the system?*

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Abstract

Background: With the aim of making it easier for researchers to produce policy-relevant research, the UK Government now requires all departments and arms-length bodies to publish annually-updated statements of their evidence needs, called 'Areas of Research Interest' (ARIs). We describe how ARIs are produced, and how they are used to support this aim.

Aims and objectives: In this paper we offer a description of ARIs and their development by UK governmental departments, and an assessment of how different stakeholders have responded to or otherwise used the ARIs.In the UK, the Government Office for Science (GOS) supports the Government Chief Scientific Adviser (GCSA), and holds a cross-government remit to support science capability across departments. It relies on 'soft power' networking and influencing

rather than mandating. It also holds the policy for Areas of Research Interest. As part of this remit, Giulia Cuccato led a team of civil servants in the Government Office for Science (GOS) to develop guidance for departments in developing their ARIs, and supporting and tracking their ARI-related activities. Alongside this work, Kathryn Oliver and Annette Boaz have been embedded in GOS to explore and support better production of ARIs, and more effective engagement with them by funders, researchers and intermediaries. We have been involved in supporting the development of ARIs across the UK government, in helping departments use ARIs to access relevant evidence and expertise, and in researching how ARIs could be optimised to support the research-policy system.

Methods: We draw on 25 interviews, approx 50 hours of observations of meetings and roundtables, and our 3 years' embedded researcher experience to describe the ARIs, their different functions across settings, institutions and audiences. We describe how ARIs are produced, what ARI-related engagement occurs, and how they function as a systems level intervention.

Findings: ARIs were intended to identify strategic research priorities for departments, but in practice we have found that they have a much broader set of uses. We found that departments use them to improve internal working and relationships, to implement the agenda of the Chief Scientist, to support other governmental processes such as spending reviews, the Integrated Review, and the Science Capability review. For some they are a reflection of their policy priorities; for others an articulation of the activities and structures of their internal science system; a statement of likely research commissioning priorities; and/or a statement of research areas around which they would welcome collaboration or input. However, the end products appeared to be mostly appropriate for the departments in question. By and large, they were seen as useful internal tools to negotiate and communicate with policy colleagues around budgets and priorities, and useful external tools to solicit help.

Universities and academics find them useful to plan engagement activities such as workshops and fellowships, but often tend to view them as poorly-written research questions. ARIs can help the research community to understand what government departments want from them. This happens most effectively when there are opportunities for dialogue or a clear narrative about the policy history behind each ARI.

Identifying relevant expertise and research is a real challenge for government departments, particularly where resources are limited. Framing problems is an important step for departments, because it dictates what research and which experts are considered relevant and appropriate. We found that officials in government departments were committed to addressing the challenge of diversity and inclusion in academic-policy engagement, but we unsure how best to go about improving practice in this area.

Strengths of ARIs: ARIs work well as an external articulation of research and evidence needs for departments. They offer funders, intermediaries and researchers insights into what departmental research agendas. Universities and intermediaries in particular have used ARIs to develop their own strategic engagement plans (see, e.g Heckels, 2020). Most departmental ARI documents now contain contact details as well as ‘asks’ and ‘offers’ for each ARI. This makes it easier for funders, intermediaries and researchers to know how to respond (e.g. by getting in touch for a conversation, arranging a research collaboration or responding to a research tender).

ARIs as a systems intervention: The ARIs were proposed to encourage the production of more policy-relevant research. This has been describe as a ‘deficit model’, suggesting that if decision-makers had better evidence, their decisions would improve. This model has been widely criticised as being based on some fundamentally flawed assumptions about how decision-making works (Jones and Crow, 2017) and on how evidence informs that process (Locke, 2002). The ARIs may have been planned to address this illusory ‘deficit’, but in practice perform a far greater range of functions which help to connect the policy research system in complex ways.

The true value of ARIs may be in illuminating the ways in which the research-policy system is connected, and how we can intervene most effectively to support this system.

Weaknesses of the ARIs: systems challenges

Not everything can be or is articulated as an ARI: ARIs are not able to articulate the totality of departmental research needs. For some departments, this is due to political or operational sensitivity, and for others, they prefer to only publish ARIs on topics where they are currently seeking external input. It would be a mistake, therefore, to think of ARIs as a complete and exhaustive list of the topics on which government is seeking input.

ARIs are not research questions: Academics frequently describe ARIs as poorly written research questions. An alternative, more useful phrase might be “research needs”, which helps to give the impression that there is a process attached to them, that they are valued, and broader than research questions. They are more usefully thought of as topics for conversation.

ARIs are difficult to access and analyse: By 2018, most departments had published at least one version of their ARIs, which then sat on the government website in pdf or html formats. There is as yet no easy way to search for ARIs by topic, department or year, which makes it difficult for researchers to identify relevant topics or potential collaborators This also means that departments are not easily able to identify shared cross departmental areas of interest.

Finding relevant evidence and expertise takes time and work: While some departments had resources dedicated to engagement around the ARIs, others did not. While relevant research often exists (as bodies of primary research, in research and practice communities, or in ongoing funding investments), this knowledge is often inaccessible, being behind paywalls or requiring time and skill to find and absorb.

Key conclusions: The ARIs have great potential to enable funders, government, research organisations, researchers, and intermediaries to work together in a more effective way. We have observed that merely producing ARIs is not a sufficient intervention; instead, it requires skilled mobilisation work by people within all these organisations to be able to optimise their production and use.ARIs are a mechanism for organisations to share their research interests with external audiences in the form of a published document,. They also have a much broader set of uses, including connecting departments with each other and helping intermediaries shape engagement plans. All groups would benefit from more robust evidence to choose effective engagement mechanisms, and more can be done to make the ARIs discoverable and useable. Overall, the ARIs are a useful tool to illuminate, and begin to connect different parts of the research-policy system.

[3472] *The Smart City as a Field of Innovation: Effects of Public-Private Data Collaboration on Innovation Performance of Small- and Medium-sized Enterprises in China*

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Abstract

Data is increasingly considered to be a key component in stimulating innovation. Numerous promising possibilities have been opened up by rapidly emerging, data-intensive technologies, including the Internet of Things (IoT) and artificial intelligence (AI). The analysis and interpretation of big data are critical in the growth of technology firms in terms of AI training and computing capabilities. Small and medium-sized enterprises (SMEs), with their limited resources internally, particularly face a serious challenge of implementing innovation, which increasingly requires the effective processing and use of various kinds of data. The smart city provides an important opportunity for creating data-driven innovation. Significant amounts of data are increasingly available from various sources through sophisticated devices and equipment scattered in smart cities. Many smart city projects across the globe provide rich opportunities for SMEs to explore data-driven innovation. China, in particular, has recently been active in collecting and utilizing various kinds of data in smart cities. The availability of and access to data help to improve the software development of private enterprises in China, where massive amounts of data resources are collected and maintained by the public sector. In the process of smart city development, there are also many tasks that are complementary to each other, including connecting databases, building online platforms that connect different data coming from various data sources, operating and maintaining these online platforms, and providing products and services to citizens. These diverse kinds of tasks involved in smart city projects initiated by local governments have brought about new business opportunities for innovative SMEs in China. To implement the policies of encouraging the development of SMEs by the central government, municipal governments have introduced policies that give priority to SMEs in participating in smart city projects. Those companies that have access to the data collected in smart cities and held by government agencies are expected to benefit from utilizing the rich data for creating innovative products and services. There were few empirical studies conducted, however, to examine how data are actually managed and provided in smart cities and how they affect companies' innovative activities. It remains unclear how public agencies and private enterprises collaborate on data and how that influences the innovation performance of SMEs in China. In smart cities, different types of public-private collaboration are involved, including hardware purchase, platform building, platform operation, and data analysis. It is not yet well understood how these different types of collaboration influence the availability and accessibility of data and consequently the innovative performance of SMEs. In mainland China, smart city development has been promoted actively to tackle severe urban issues, including air pollution, traffic congestion, and public safety. The Ministry of Industry and Information Technology (MIIT) established the China Smart City Industry Alliance in 2013 to implement smart city projects, and a policy paper, Guidance on Promoting the Healthy Development of Smart City, was published in 2014 by eight government departments. In 2015, the development of smart cities was promoted by the Prime Minister as the future development direction for cities in China. Encouraged by these policy measures, nearly 300 smart city projects have been approved so far. Smart city development in China has particularly emphasized the linkage and synergy with big data through advanced information and communication technologies, including IoT and cloud computing. Very few empirical studies have been conducted so far to investigate what kinds of data are collected in smart cities, how these data are available, who has access to the data, how these data are managed, what incentives are provided to encourage data sharing, and what impacts are made on stimulating innovation. In this study, we examine how data are managed through collaboration between the government and companies in smart cities and how the mode of data collaboration influences firms' performance on innovation in China. By focusing on the case of SMEs in the Guangdong province, this research aims to shed light on what kinds of data are available and used in smart cities and how the government and enterprises collaborate on data to facilitate innovation. The analysis of this study utilizes data on more than eight million contracts

extracted from the Government Procurement Database managed by the Ministry of Finance. The database contains rich information on government procurements, including the goods and services procured, the date of the contracts, and the monetary size of the contracts. Data on companies are assembled with regard to the registered capital, industry, software products, and patents in 1990-2021 from the database of Tianyancha. The applications of patents are also analyzed by using the patent database maintained by the State Intellectual Property Office (SIPO) of China. The SIPO patent database provides complete information on all patent applications and grants in China, including the application and publication number of the patent, the application and grant years, the classification number, the type of patent, and the assignee of the patent. The knowledge and technological domains are identified by analyzing the patent classification numbers and the content of the descriptions of the inventions. By using these data sources, panel data is established with key characteristics of SMEs, software and patents outputs, and their record on government contracts. The contracts are divided into three categories, namely, data analysis, platform building, and hardware purchase, based on keyword identifications. To deal with the unbalance between the treatment group (the companies that obtained government contracts) and the control group, we use propensity score matching (one-to-one nearest neighbor matching) to narrow down the sample size of the control group to that of the treatment group. Then we apply the event study methodology to examine whether there are significant differences in innovative outputs of software products and patents before and after the companies receive government contracts. We also compare how the innovation performance of companies differs based on the types of contracts these companies obtain. That makes it possible to identify what kinds of data collaboration would be effective in improving the innovative performance of SMEs. Our preliminary analysis suggests that many of the government contracts obtained by SMEs that have innovation outputs would be concerning platform building. After receiving government contracts, firms that conduct data analysis for smart city projects would tend to have more patent outputs compared with companies with similar characteristics. On the other hand, firms that implement platform building and platform operation for smart cities would be likely to have more software products. That difference in innovative performance would be considered to be influenced by the quantity and quality of data available and accessible to companies. While government contracts for buying hardware devices and equipment for smart city development would encourage innovation in technological products and services in SMEs, they would not have a significant impact on the innovative performance of these firms. Government purchases of hardware that contains data-intensive technologies would promote the use of these products in smart cities. That, however, would not involve any substantive exchange or transfer of data possessed by the government and would not significantly contribute to stimulating innovation at firms. Policy implications will be explored for various modes of data governance, including government-led, industry-led, and public-private partnership approaches, with their impacts on facilitating innovation and addressing societal concerns about data security and privacy.

[597] *The involvement of non-academic partners in societally targeted funded research*

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Abstract

Background and aim The focus of research policy has progressively expanded into broader variegated societal goals, resulting in an increased orientation of public research funding to contribute relevant outputs to society. Subsequently, additional funding expectations have highlighted the possibility of wider uses and benefits of research for society, e.g. for the public sector, in health research, or in tackling grand societal challenges.

Embedded in mission-oriented contexts of application, contemporary research and innovation ecosystems also involve multiple interdependencies with society that permeate the way knowledge is conceived, generated, communicated, and used. Expectations regarding the utility of the knowledge produced by scientific research are thus significantly demand-driven. In consonance, contemporary policies advocate collective knowledge production and translation processes based on multi-actor networks that stretch across social sectors. Accordingly, societally targeted research may develop through diverse knowledge flows among varying stakeholders that generate multidirectional contributions to society.

Against this background, funding policy designs to enhance the societal relevance of research have promoted the inclusion of non-academics in societally targeted research. The rationale for such involvement is based on three main assumptions we address in our study.

1. Involving a wider range of society stakeholders It is believed that the complexity of real-world challenges requires going beyond academic disciplinary research to incorporate a larger spectrum of stakeholders from policy, private, and

social realms. More societally inclusive approaches in research would allow the integration of cultural values and expertise from different practitioners. The involvement of non-scientific domains is thus expected to facilitate more socially robust knowledge. This argument is in line with prior systemic diagnoses that had pointed out how the dynamics of knowledge production and innovation co-evolve within a framework of socially distributed knowledge, the validity of which rests on its effectiveness and legitimacy within broad communities of producers, disseminators, and users of knowledge. Literature to date has essentially centred on private firms and the determinants of university-industry interactions. Therefore, the nature of non-academic actors engaged in societally targeted funded research remains unclear.

2. Contributing to Knowledge co-creation A second assumption considers that the integration of external insights, tacit knowledge and practical skills may also contribute to the generation of more effective responses to actual societal problems and needs. Knowledge co-creation with stakeholders in society then follows a logic of expanding the perspective of approaches throughout the research process to enhance research results. Co-creation appears in this context as a joint synergetic combination of diverse capabilities that are synthesized through the active participation of partners for a mutual functional interest. Previous studies have pointed out that various individual and organizational factors may influence collaboration dynamics involving a series of interrelated research activities, from problem formulation to problem-solving. Furthermore, the high value placed on academic knowledge and preconceived beliefs of both academics and industry partners regarding project roles and responsibilities have been considered to set a ceiling to the co-production of knowledge. There is, however, limited scholarly understanding of how non-academics contribute to the development of societally targeted research in practice.

3. For societally broader use and beneficial outputs A third intertwined argument in favour of non-academic involvement in research is linked to the expectation of generating wider knowledge dissemination and further utilisation of research outputs. Supporting funding requirements for practitioners' engagement are also aimed at improving the translation, absorption and use of the knowledge created. Following this reasoning, the integration of more collective perspectives emphasizes the societal role of research, since stakeholders may help to create valuable outputs for their respective contexts of application and oriented towards extensive practical use. Literature has differentiated between first and second order users of knowledge, depending on whether they add, reshape, create new applications or are self-conscious end users. Nevertheless, how partners in societally targeted funding are promoting research use and collective benefits is still largely unknown.

Method The study design is based on a purposeful selection of twelve cases of societally targeted funded projects that are most similar on specified funding variables, which made them suitable for comparison. In line with this, the cases were identified using a series of criteria regarding funders (three main national public funding agencies), research areas (renewable energy and food science), time period (funded 3-5-year research projects that started in 2015-16) and funding programmes (societally oriented) in three well-resourced European countries: Denmark, Netherlands and Norway.

Complementarily, we considered characteristics of principal investigators (PIs), such as type of academic organisation, female/male, and academic position. Through desk research, we identified the non-academic participants in the studied funded projects, who were confirmed and selected based on interviews with PIs. We then collected background information on these participants' key features, including type of non-academic organisation, location, size, stated mission, and R&D/other core activities. The analysis is centred on semi-structured interviews we conducted with the non-academic partners during first semester of 2022. This empirical approach also provided variation across research networks and practices for our exploration.

Expected contribution In our paper, we qualitatively investigate the abovementioned three assumptions about the involvement of non-academics in societally targeted funded research. First, we examine the profile, characteristics and backgrounds of a set of non-academic participants in societally oriented funded research projects to contrast their similarities and differences. This allows us to observe whether there is a predominance of certain types of entities — such as large companies working on knowledge intensive environments — and regular or new participants in collaborative research, mobilised through interpersonal networks. In addition, the analysis of their past experiences, as well as their motivations and expectations to become involved in these particular projects, reflect their understanding of engagement according to how familiar they are with research processes and what is valuable to them to partner with academics. We also explore to what extent societally targeted funding, in comparison to other funding, act as an enabler of their participation or affect their decision to participate, including the possibility of co-funding research.

Second, we analyse the role of stakeholders in the selected research projects, acting either as direct suppliers (e.g. of data, materials, equipment or field experiments), co-participants along the research process (e.g. in proposal design, knowledge production, project management, publications and patents creation), or recipients of research results. We check how diverse involvement materialises to explore differences in significance of non-academic partners' contribution associated with each of these roles (separated or mixed) for project development. We also take into account the challenges participants face and the level of flexibility they have to foster changes in project decisions.

Finally, our work addresses how non-academics value the corresponding project user-orientation and further societal utilisation, including the consideration of specific end users. We also contemplate the relevance of individual and organisational gains from the studied research projects for participants, and their first/second order use of research outputs in relation to their initial expectations and needs. The engagement in further research projects with academics is also indicative of how beneficial this type of collaboration resulted for involved stakeholders.

In sum, this paper will provide new insights on the types of participating non-academics in societally targeted funded research, the role they play for research development and knowledge co-creation, and how they facilitate broader uses and benefits for society. Therefore, this study is expected to contribute to science, practice and policy.

[5184] *Are Digital Innovation Policies Effective in Promoting the Development of Digital Economy in China?*

Siqi Xie (The Hong Kong University of Science and Technology) and Masaru Yarime (The Hong Kong University of Science and Technology).

Abstract

Title: Are Digital Innovation Policies Effective in Promoting the Development of Digital Economy in China?

How latecomers of emerging countries catch up with the incumbents on technological innovation is always an important topic (Guo et al., 2021). China is also facing challenges in upgrading its manufacturing value-added in the global market and transferring to a more sustainable economic growth model. Digital technology has become the driving force of Chinese economic growth and transition (Li, Hsu, Mao, & Zhang, 2022). In 2013, the size of the digital economy was about 9.5 trillion, accounting for 20.3% of China's GDP. In 2020, the size already increased to around 39.2 trillion, taking a share of 38.6% of GDP. China is also a leading digital economy in the global market. According to CGTN (Empowering digital transformation for china's economy. 2022), the size of China's digital economy is ranking second in the world in 2020.

Three elements shape the development of China's digital innovation: a large consumer market, a well-developed supply network of digital products, and a unique societal and regulatory structure (Li et al., 2022). On the one hand, in the past ten years, the rise of the middle classes has stimulated consumer demand for high-end products. It has brought a large group of users to digital innovation enterprises in China. On the other hand, the "deep supplier networks, a large skilled workforce, and a developed logistics infrastructure" have enabled China to develop a completed digital innovation ecosystem. As the Chinese government plays a predominant role in economic development, China's institutional system has significantly affected demand and digital supply-side innovation. China has pointed out to develop a national strategy for the digital economy in its Medium to Long-term Planning for Scientific and Technological Development plans. For example, in the Thirteenth Five-Year Plan Outline of National Economic and Social Development of the People's Republic of China, the Chinese government proposed implementing a national big data strategy and promoting the open sharing of data resources (Xinhuanet, 2016). Furthermore, in Fourteenth Five-Year Plan Outline, the Chinese government has proposed accelerating digital development and building a Digital China (Xinhuanet, 2022). In response to the government's national strategy, Chinese governments at all levels have introduced policies for digital economy development and digital transformation. The data from the Chinese policy database shows that in 2013, the Chinese government introduced 342 digital innovation policies, and in 2021, the Chinese government introduced 1242 digital innovation policies. The figures have tripled in the past eight years. Although the Chinese government has implemented a series of innovation policies to stimulate digital innovation in different regions of China, existing digital innovation studies may not systematically evaluate and compare the effectiveness of these policies in fostering digitalization in China. The government may waste many valuable resources on policies that are not very effective. Therefore, it is incredibly intriguing and helpful to find out how the Chinese government uses policy instrument mix to promote the development of the digital economy and comprehensively evaluate the policy effectiveness of digital innovation. Thus, the research questions of this paper are as follows:

Research Question 1: "What kind of policy instruments are frequently used by the Chinese government to promote the digital economy?"

Research Question 2: "Is every type of policy instrument effective in boosting the digital economy?"

Research Question 3: "Among all applied policy instruments, which policy instruments are more effective in facilitating the digital economy?"

The unit of analysis is a province (excluding Hong Kong, Macaw, and Taiwan). This study will collect two kinds of data. The first is the 2013-2021 digital innovation policy document at the province level, collected from Bailu Zhiku (http://www.bailuzhiku.com/) by a web's crawler. The second is the 2020 digital economy index by provinces, collected from the microdatas.cn database. The approach of Natural Language Processing will be used to clean and process the collected policy documents. In this process, some Chinese keywords (“税收减免 Tax deduction,” “孵化器 Incubators,” “政府采⊠ Procurement” and “⊠⊠ Subsidy” etc.) will be used to identify the policy instruments in the policy text. Based

on the innovation policy instrument framework proposed by Elder et al. (2016), we define thirteen types of instruments in this study, including "R&D tax credits," "Direct R&D support," "Training and skills," "Entrepreneurship," "Technical services and advice," "Cluster," "Collaboration," "Innovation network," "Procurement," "Innovation prizes," "Standard," "Regulations," "Technology foresight." This study will also construct a multivariate regression model to test if a certain innovation policy instrument significantly impacts the digital economy development of provinces in China and to compare the effectiveness of different types of innovation policies.

The preliminary results show a huge regional heterogeneity of digital innovation development in China. Coastal regions like "Guangdong" (N=302), "Zhejiang" (N=193), "Jiangsu" (N=188), "Fujian" (N=165), "Shandong" (N=128), "Beijing" (N=100), "Tianjin" (N=85) and "Shanghai" (N=73) have launched more digital innovation policies. Southern provinces pay more attention to digital innovation than northern provinces (Guangdong, Zhejiang, Jiangsu, and Fujian compares to Shandong, Beijing, and Tianjin). Besides, Chinese governments frequently use direct support for R&D and innovation, training and skills, and cluster policy when developing a digital economy. Lastly, from the multivariate regression results, we observe that both demand (⍰=12.57, $p<0.05$) and supply policies (⍰=2.62, $p<0.05$) can significantly improve the development of the digital economy development and the demand-side policy is more effective than the supply-side policy.

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[3883] *Failure in Science: How organizational and institutional factors shape early career experience*

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Abstract

This project aims to theorise and empirically investigate the role of failures in science, thereby offering a new understanding of the mechanism behind progress in scientific research. Failure is ubiquitous in science, yet the underlying significance and repercussions of failure remains scarcely understood. We thus explore scientists' failure experiences and learning from failure with a particular focus on the research activities and achievements of early-career scientists. Through a multi-method research approach, the project generates novel insights on how scientific progress is stimulated by failures with direct implications for relevant stakeholders.

[2584] *Global research governance and its adaptation to research 'shocks': COVID disruption, response and recovery*

Gemma Derrick (University of Bristol), James Robson (University of Oxford), Xin Xu (University of Oxford) and Alis Oancea (University of Oxford).

Abstract

Crises present the scientific community with unusual demands, including the need for rapid solutions. Research as an interaction between the practice of producing knowledge, and the various governing stakeholders that fund and ensure the reliability and translation of such knowledge, is not immune to withstanding a variety of endogenous and exogenous shocks. However, rarely has there been a global shock to systems, institutions and their structures and processes equivalent to COVID-19. Whereas crises within national contexts: the Syrian war (Greenland & Fabiani, 2021), the Fukushima disaster (Kaur et al, 2019); and or natural disasters (Rotolo & Frickel, 2019), may influence one context of an otherwise global knowledge endeavor, the COVID-19 crises were experienced globally, regardless of the different responses exercised by different nations. There has been little research focusing on a systems-level approach to COVID-19 research disruption. Suh an approach includes exploring how research institutions that take a governing role (hereon stakeholders) in the production, utilization and otherwise monitoring of research practice. In addition, there has been

little research that takes a global perspective, acknowledging that COVID-19 disruptions may be operationalized differently in different country contexts, and at different times during the 2020- 2022 period of the pandemic. Using interviews with n=66 research stakeholders from the UK, Australia, Norway, New Zealand, Hong Kong and Italy, this research explores the way in which research governance organizations responded and reasoned the realities of disruption caused by the COVID-19 pandemic, and how they positioned procedural changes to their governance mechanisms towards ach research culture change in the wake of the pandemic. Methods This paper uses this section of interviews with stakeholders conducted as part of the first phase of a multi-scale study of six research systems. As of Oct 2022, 66 research and higher education stakeholders across six systems (England, Norway, Italy, Hong Kong, Australia and New Zealand) were interviewed. Participants were identified via a combination of initial purposive sampling snowballing based on participant recommendations. Participants included senior representatives of ministries and other government agencies, politicians, major research funders, research assessment agencies and assessment panels, data and publishing industries, library bodies, academies and learned societies, unions, other research providers, associations, and networks (including regional), advisory bodies, research on research institutes. In-depth semi-structured interviews have been conducted online, each lasting over an hour and complemented by follow-up interviews to explore additional topics. The interviews were transcribed in full, sense-checked and pseudonymized before analyzed thematically along three levels (eco/systems, organizations and people, including comparative analysis across countries and group of stakeholders). Inter-coder checks are conducted between primary and secondary coders. Results From the interviews, close attention was paid to how governance stakeholders acknowledge (disruption) the nature of the problem to research caused by the pandemic; place immediate remediating actions to support and/or promote crisis science during the term of disruption (response); and, finally, how they envision or reason a long-term response to the experiences learned from the COVID pandemic, towards re-building a stronger future for research (recovery). Acknowledgement but no experience of research disruption Stakeholders expressed awareness of the effects of COVID-19 on 'normal' research practice that had impacted individual researchers. This included how participants imagined the long-term challenges faced by these groups, however this was solely problematized, but not translated into meaningful actions or else the impetus to address these disparities in the future. In the responses there was an expression of otherness and empathy to the problems experienced by the research workforce, but there is a lack of a plan of how to address this in the short term. Indeed, the participant's interest in "watching(ing) how that plays out" betrays a sense of immobile inevitability of the outcome that requires no intervention now as a preventative measure but is something to be addressed in the future when the extent of the problem is known. In addition, this 'otherness' was also expressed by participants when reflecting on the effect that the pandemic would have on wellbeing; or else to disruptions caused by restrictions to certain lab-based scientists. For other participants, there was a caution against over generalizing the impact of disruption on research practice due to the "…highly variable [disruption] across the community and across our sector, depending on people's personal circumstances, depending on even which state they lived in." AU-SAK-20220426. This type of differential is likely to apply to the consideration of effects of disruption on research, where the extent and timing of disruption will result in differential effects. This reinforces the context- and country-specific comparison employed by this study. Initial reactions to the immediate challenge of COVID The ability for organizations to develop 'adaptive resilience' characterizes how they initially respond to a disaster, recover and then renew themselves within a post-disaster environment Nilakant et al (2016). For research as a globally, organized practice, how 'lifeline organizations' that provide essential infrastructure services for research (funders, government and other governing stakeholders) responded in the immediate aftermath and during the prolonged period of COVID-19 disruption, contributes to organizational resilience. In the interviews, country comparisons showed represent the differing needs of a country from science during a crisis, as well as dependent on the type, and timing of COVID-19 restrictions and disruption. Considering the acknowledged difficulties examined above, there were two common options available to governing stakeholders in response to the restrictions imposed by the pandemic: (1) make research work easier; or (2) promote and push research towards translation. From our sample, the immediate response was to protect the institution, and to sustain research throughout the pandemic. In addition, these measures to protect the institution of science concentrated on protecting the reliability of knowledge produced; and to "keep things running as normally as possible, rather than to divert our funding into extending existing grants or doing something very different because of COVID" AU-S-AK20220426, or else mobilizing (reliable) knowledge towards translation through, for example, increased need for OA knowledge. Here there was a conflict in how the institution that, on one hand wanted to protect the reliability and robust nature of research but was faced with a research workforce that was temporally unable to conform to bureaucratic measures normally needed to govern this reliability. However, despite an acknowledgment of increasing EDI disparities in the research workforce exacerbated by the pandemic, less attention was paid to implementing changes to address these research practice concerns. Lessons from COVID-19 and impetus for change How organizations learn from experience, is an important characteristic in how they develop resilience against the possibility of future, exogenous shocks (Nilakant et al, 2016). There was a lack of longterm vision for the participants about how to utilize the shock of COVID-19 towards long term change in research because it was acknowledged that "…the recovery is harder to talk about." AU-S-AK20220426. Instead, when participants were queried as to their institutional plans for long-term recovery, there was a tendency to confound talk of the long-term recovery to come, with notions of institutional response (above). Participants also implicitly referred to recovery as a process running parallel to the pandemic response: "…we haven't got time to think about a it. We have to, you know, we're managing a

pandemic…its like what particular apocalypse is coming today?" AU-S-GB-20220322. In here, research policies necessary for long term recovery were acknowledged to be necessary, but their development at this stage was premature. Discussion Although, the need for a long-term research recovery was acknowledged, there was little impetus shown by institutional stakeholders to alter their own practices, responsibilities, or else position in the governance framework beyond reinstating the 'status quo'. Moreover, the results indicated the perceived inability research institutional stakeholders sow to sustain meaningful, long-lasting change in the science system. Instead, their role remains as guardians/monitors of research, rather than of governors of responsible scientific practice. For these groups, their responsibility does not extend to these micro level interactions in knowledge production but is focused on maintaining the strategic and financial future of the institution, and by mobilizing research translation focused on crisis-related scientific benefits, ensuring future public and political support of publicly funded research practice. References Greenland, F., & Fabiani, M. D. (2021). Collaborative Practices in Crisis Science: Interdisciplinary research challenges and the Syrian War. Sociological Science, 8, 455-479. Kaur, K., Ng, K. H., Kemp, R., Ong, Y. Y., Ramly, Z., & Koh, A. P. (2019). Knowledge generation in the wake of the Fukushima Daiichi nuclear power plant disaster. Scientometrics, 119(1), 149-169. Nilakant, V., Walker, B., Kuntz, J., de Vries, H. P., Malinen, S., Näswall, K., & van Heugten, K. (2016). Dynamics of organisational response to a disaster: A study of organisations impacted by earthquakes. In Business and Post-disaster Management (pp. 35-47). Routledge. Rotolo, T., & Frickel, S. (2019). When disasters strike environmental science: a case–control study of changes in scientific collaboration networks. Scientometrics, 120(1), 301-317.

[3131] *Examining Firms' Engagement with Different Forms of Knowledge Disclosure: Website, Publication and Patent data*

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Abstract

Background and rationale Firms engage with a variety of practices to disclose knowledge resulting from their R&D efforts. Although these disclosures can lead to unintended knowledge spillovers and hinder a firm from fully capturing the benefits of R&D, they also enable the firm to accrue a range of benefits – e.g. reputation building, gaining access to external knowledge and financial resources, establishing intellectual property rights – that contribute to the firm's innovative performance. Scholars have extensively examined patenting and publishing as forms of knowledge disclosure and their impact on innovation (e.g. Alexy et al., 2013; Arora et al., 2018; Hicks, 1995; Rotolo et al., 2022), and more recently, the extent to which these forms of disclosures are substitutes (Blind et al., 2022). Yet, our understanding of how firms disclose knowledge through their websites and how this channel of disclosure relate to other channels of disclosure remains scant.

In line with recent efforts aimed at expanding our understanding of the innovation process on the basis of novel text-based indicators (Bellstam e tal., 2021; Gatchev et al., 2022), in the paper, we examine firms' behaviour in disclosing and signalling their R&D activities and strategies on their websites, and compare these disclosures with disclosures firms make in patents and publications. To do so, we build a large-scale textual dataset derived from the website pages of a sample of firms. We employ Natural Language Processing (NLP) and topic modelling to map firms' knowledge activities in term of topics as reported on their websites.

Methods We piloted the study on a dataset that combines publication and patents data related to a sample of 9000 UK firms with textual data extracted from the websites of these firms in the year 2020. We employed a text mining-based approach that uses firms' textual data at scale to delineate topics from website data and to match these with the well-established Microsoft Academic Graph (MAG) Field of Study (FOS) model. The MAG is the largest publicly available dataset of scholarly publications and the largest dataset of open citation data (Shen, Ma, & Wang, 2018). MAG data models scholarly communication activities which consist of six types of entities – publications, authors, institutions (affiliations), venues (journals and conferences), fields of study and events (specific conference instances) ¬– and the relations between these entities – e.g. citations, co-authorship. The relations between the entities are described in more detail in (Sinha et al., 2015). The FOS classification can be conceived as one of the broadest classification systems for knowledge transparently available for use. FOS are the results of a hierarchical topic model run on the entire MAG data corpus. More precisely, the hierarchical topic model produces unique FOS identifiers (ids) by creating a hierarchy of five levels (about 700,000 topics).

Extant research has shown the potential of website data in creating valuable information on innovative activity at a firm-level (Bellstam e tal., 2021; Gatchev et al., 2022). For example, website data can be used to better understand innovation outcomes, strategies, and relationships (Gök et al., 2015). Running the analysis at scale also allows drawing industry-wide structures from the data. Ashouri et al. (2021) used website data from 96,921 medium-high and high-technology firms to create a model of industry structure Our study leverages the framework presented in Ashouri et al. (2021) to devise a

transparent approach to creating a classification: we infer a classification to firms' website data using NLP and the hierarchical topic model-based MAG FOS categories.

Utilizing the firms' URLs with an automated website scrapping system, the textual content of firms' websites was retrieved – the approach is described in detail in Ashouri et al. (2021). The data platform uses the capacities built in BIGPROD1 project [www.bigprod.eu]. For retrieving and hosting the raw data, a 'hybrid' design was adopted, with part of the infrastructure being located on-site premises and the other part in the cloud (MS Azure Cloud Platform). Raw text collected from firms' websites, web scrapping task and MAG publications' text required cleaning and harmonization. Therefore, pre-processing steps involved cleaning procedures (e.g. removal of stop words and non-alphanumeric characters, stemming and lowercase transformation) applied to harmonize and increase the consistency of the text. For NLP to work, the natural language (text) needs to be transformed into a numerical vector form. Text vectorization techniques, namely tf-idf, Bag of Words and vectorization, are very popular choices for machine learning algorithms, can help convert text to numeric feature vectors. Therefore, to quantify and convert text into numerical representation in documents, we compute a weight to each phrase that signifies the importance of the phrase in the document and corpus. The tf-idf approach is a transformation applied to texts to get vector representation of vocabularies. Then it is possible to obtain the similarity of any pair of vectors to a quantified measurement.

Assigning FOS is now possible to text representations coming from firms' websites. The delineation of these categories on firms' website data and the descriptions of firms' products is very granular given the large range of FOS categories, the values are standardized descriptions of what a company is doing. Because these FOS categories are hierarchically linked, it is possible to easily assess how similar any pair of FOS categories are to each other. This can be used to go from low-level specific descriptors to high-level categories. In this study, we used the 100 most popular FOS ids. For each of the firms in the sample, their website was scraped and indexed using a pre-determined vocabulary. A weighted vector of vocabulary codes was then used to assign a vector of FOS ids to each of the websites. This process resulted in a weighted vector for each firm in the sample: a vector represents a firm's website content using FOS ids and their associated weights.

Expected results and implications We expect that the study will shed light on the extent to which firms engage in knowledge disclosures on their websites as revealed by the emergence of topics from website textual data. This will enable us to delineate different types of firms on the basis of their disclosure behaviour as well as to increase our understanding of how website disclosures may relate to other forms of disclosures such as patenting and publishing in terms content (e.g. what topics are disclosed on websites that are/are not disclosed in patents and publications). In this regard, by comparing the R&D topical signals received from firms' website content with the ones collected from patent and publication data, we can isolate firms' behaviour in communicating their activities to their stakeholders and examine the dynamics associated with this phenomenon (e.g. what topics are disclosed on websites before being disclosed in patents and publications). We expect the study to contribute to two main streams of research in innovation studies literature, i.e. research examining firms' knowledge disclosures and the role that these have in the innovation process, and research developing novel measures and indicators of innovation on the basis of the increasing availability of text data.

[2263] *Does Double-blind Peer-review Effectively Correct for Demographic Disparities in Research Funding?*

Emil Bargmann Madsen (Danish Centre for Studies in Research and Research Policy, Aarhus University), Philippe Mongeon (School of Information Management, Dalhousie University) and Jesper Wiborg Schneider (Danish Centre for Studies in Research and Research Policy).

Abstract

Background

We examine the 'Villum Experiment' (VE), a funding program instigated by the Villum Foundation, a Danish private funder who supports blue-sky research in the natural and technical sciences in Denmark. The VE instrument is supposed to support unorthodox ideas in their early phase. More specifically, the instrument was created for those research projects out of the ordinary that challenge the norm and have the potential to change fundamentally the way we approach important topics. The VE should therefore promote 'risky ideas' and 'new paths' in the natural and technical sciences. Interestingly, to mitigate well-known biases in peer review, applicants are kept anonymous to the reviewers. Assessments are solely based on short structured applications where the focus is upon the 'idea', no CVs or names are disclosed. Non-blinded peer reviews are seen as conservative and supposedly incentivise 'safe applications'. Likewise, exposure of names, affiliations and past performances through CVs is assumed to causes biases resulting in for example, Matthew effects, and gender and ethnicity disparities. A double-blind mechanism is assumed to alleviate such challenges. The questions is to what extent?

Methods

We use all application data (e.g. names, ids, full text) and review scores from five rounds of applications (2017 to 2021) - corresponding to 2000+ applications with around 250 funded projects. We examine different aspects of the VE programme, such as its mechanisms and potential impacts. Here, we focus on potential gender bias and disparities in who is funded. The current overall application and success rates, somewhat surprisingly, given the double-blinded mechanism, suggest a consistent gender difference where men are seemingly more successful than expected given their share of applications. Despite a double-blinded review process, women are 4.3 percentage points less likely to have their proposals funded than men (9.18 \% vs. 13.5 \%). To make sense of this persistent gender disparity, we use a series of bayesian multilevel models and post-stratification to investigate potential explanations.

Results

Deeper analyses reveal two important self-selection/sorting mechanisms and potential gender disparities related to the demographics of the overall researcher population. First, we show that gender differences in success rates are partly explained by women self-selecting into one evaluation panel ('Life Science') to a much higher degree. Where men are more evenly distributed across the four evaluation panels ('Earth and Space Science', 'Life Science', 'Physical Sciences and Mathematics', 'IT and Engineering'), 46 \% of women applicants apply within life science. Because success rates differ across panels, and the 'Life Science' panel has consistently lower overall funding rates, women tend to self-select into stronger competition. The overall success rate differences are then a case of Simpson's Paradox, where results almost reverse when dis-aggregated across evaluation panels and application years.

Second, more experienced applicants tend to be more successful in having their proposals funded, with professors more successful than associate professors, and associate professors more successful than assistant professors and postdocs. However, women comprise a much smaller fraction of the more experienced applicants. Gender differences in funding rates are therefore also a function of the demographic disparity in academic ranks more broadly.

Lastly, women comprise around 25 \% of professorships in Denmark and 15 \% within the natural sciences, However, among the applicants with the rank of professor, only 11 \% are women. Using a Multilevel Post-Stratification (MrP) model, we calculate weights and simulate success rates for each academic rank and gender combination among applicants as if they were proportional to the entire population of Danish researchers.The model shows that the remaining gender disparity in funding rates are likely influenced by a lower self-selection into the program by the highly experienced women, and differences would largely disappear if more women applied.

In summary, gender disparity can still arise even when doubled-blinded review standards are employed. Larger structural imbalances in field composition and career advancement in the science system contribute to differential success in funding competitions.

Significance

The results shed light on two important discussions within science policy. Echoing recent calls for attention \parencite{traag_causal_2022}, we exemplify the importance of distinguishing between gender bias (discrimination) or gender disparity (differences) when assessing fairness in the allocation of merit in science. Gender differences in funding rates can still emerge when bias (conscious or not) in review processes are extremely unlikely, due to indirect causal effects of imbalances in the scientific system. Assessing the mechanisms contributing to gender differences in funding rates are important as changes to peer-review systems cannot eliminate such disparity by itself. Unequal access to research funds are also a product of inbuilt differences in career advancement (i.e. a leaky pipeline), and less representation of women in some fields of science. Solutions to such disparities necessitates a better understanding of the driving factors, because gender bias and structural disparities are not easily solved using the same policies.

[546] *Capturing Research Field Dynamics through Multiplex Network Structures*

Duncan Thomas (Aarhus University), Maria Nedeva (The University of Manchester) and Mayra M. Tirado (Arizona State University).

Abstract

Background

Studies of science and science policy often rely upon analyzing the ‘structure’ of research fields. This is used to explore how scientific fields evolve, whether they are affected by policy and funding, and performance comparisons across universities and research systems (Porter & Rafols, 2009; Braam & van den Besselaar, 2014; Langfeldt et al. 2020). Traditionally, field structure has been investigated via citation-based relationships, touching upon fields’ knowledge pools (Van Raan & Tijssen 1993; Creswell 2009; Porter & Rafols 2009; Boyack & Klavans 2014). Elsewhere, as in classical sociology, structure is explored through a mix of social organisation and intellectual aspects, including the norms, intellectual conventions, governance rules and authority relations of ‘scientific communities’ (Merton 1968, Crane 1971, Whitley 2011).

In this paper, we instead explore co-existing 'structures' of a research field, comprising an 'interlaced', 'multilayered' or multiplex network phenomenon (Heimeriks et al. 2003, Teurtscher et al. 2014).

Rationale

Traditional approaches to investigating and mapping the structures of research fields, we posit, while in part useful to the study of science dynamics, have some unfortunate shortcomings. First, by assuming a unitary structure of science/scientific fields these approaches limit the investigation of complex, inherent dynamics. And second, by often inferring structures and relationships rather than mapping these directly, the explanatory power of traditional approaches is somewhat limited.

Still, unpacking the sources of inherent science dynamics, or the dynamics of scientific fields, is vital for understanding the evolution of science, the ways in which exogenous factors interlace with inherent sources to shape the workings of the sciences.

Methods

Building on an understanding of structure originating with 'new institutionalism' (Powell & DiMaggio, 1991) we assume that relationships can be empirically accessed through (social) exchange or distribution.

Using co-nomination to trace three different kinds of exchange occurring within scientific networks, we mapped three different structures in a physics field – intellectual, collaboration and technical. (For more on the use of co-nomination to map research fields please see Karaulova et al. 2020)

Social network analysis techniques were used to investigate further the links between the different networks/structures. The network maps were generated using VantagePoint and Gephi.

Results

To test this 'structures' perspective, we used multiple rounds of co-nomination analysis, a reputation-based approach combining snowball sampling and social network analysis (Karaulova et al. 2020). We mapped three exchange networks for a particle physics field.

We then highlight actors simultaneously active in one, two or three networks. This shows researchers performing multiple roles, and engaging multiple exchange relationships, perhaps not captured by citation-based approaches or study of single networks. It foregrounds the importance of other roles beyond intellectual influence, such as functions that technicians and equipment developers undertake, and social organizer roles that may help crystallize the field – a task more often associated with women, according to our in-progress analysis.

Significance

This 'structures' approach adds multidimensional character to whether scientists appear central or peripheral in a field. It has potential implications for how researcher performance is evaluated by universities, for organized mitigation of intersectional biases in science, and for how funders tackle coordination dysfunctions in fields developing over time (Tuertscher et al. 2014; Kozlowski et al. 2022).

Overall, it promises to transform how we study research fields and science dynamics, by shifting our perspective from one-dimensional 'structure' to key multiplex 'structures'. Using it to study additional cases could lead to better understanding of how research governance can support fields. It could also drive policy and funding to become tailored to bespoke dynamics of key field 'types', as revealed by their multiplex structures.

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[5790] *Research Governance and the Dynamics of Science: A Comparative Analysis of Governance Effects in Organisational Context*

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Abstract

Background This paper aims to contribute to, and advance, the understanding and empirical study of the effects of research governance on scientific fields by exploring the governance effects on a scientific field in the context of two different universities. That is achieved by building on a recent framework for the study of governance effects on research fields (Nedeva et al., 2022) and extending it, conceptually and empirically, by conducting a comparative analysis of the reported behaviour of members of the same research field, within the same governance regime and two rather different universities. This paper is the third within a research line on studying governance effects on scientific fields (Nedeva et al. 2022, Morales-Tirado, in progress).

Rationale Debates regarding the study of research governance effects on global scientific fields in the literature unfold along several lines. Some studies, quantitative as well as qualitative, investigate governance effects on context-specific research organisations, namely universities and research institutes (Lorenz 2012; Luukkonen and Thomas 2016; Vinkenburg 2017; Glaser 2019; Luo, Ordóñez-Matamoros & Kuhlmann, 2019; Thomas et al. 2020; Strinzel et al. 2021; Kozlowksi et al. 2022; Ramos-Vielba, Thomas and Aagaard 2022; Feenstra, & López-Cózar, 2022,). Other, more nuanced studies extend their research interest to include studying the effects of governance on the epistemic choices of members of local knowledge communities (Glaser, 2019). Methodologically studies of governance effects usually aim to measure change using opinion-based survey techniques, case study/interview approaches, bibliometrics or lines of investigation seeking to unpack the (soft) causality mechanisms that may or may not affect organisational, personal and group selections.

While contributing to the understanding of governance effects on science, these approaches share a significant shortcoming in that they generally fail to extend beyond the local conditions for knowledge creation and hence fail to capture the aggregate governance effects at the level of transnational, global research fields.

This was conceptually addressed in a recent paper (Nedeva et al., 2022) by proposing a novel heuristic for linking the characteristics of performance-based evaluation arrangements (PREAs) and the properties of research fields. Next, a comparative analysis of the governance effects of different governance arrangements of the same research field extended this framework empirically. This paper explores the (potential) difference in responses of the local members of the same research field, within the same governance arrangements and two different universities.

Methods We used a novel framework to study governance effects on scientific fields, one that recognises three contexts where different effects may occur, e.g., the research space context where performance based evaluation arrangements (PREAs) are embedded, the research field context where knowledge claims are assessed to award reputation (publications, grant capture etc.), and the context of research organisations where individual and collective performance are evaluated for organisational career purposes (Thomas et al., 2020).

We kept the PREA and research field contexts constant and allowed variance in terms of the organisational context. Hence, we interviewed members of research groups in two universities. To use a terminology from Paradeise and Thoenig (2015) one of the universities is a 'top-of-the-pile' and the other one is a 'wannabe'.

Our questions were designed to capture the interactions between university leaders (administrators) and the members of the local knowledge network, or research group. We conducted a total of twenty interviews (13 for a top-of-the-pile university and 7 for a wannabe university). We explored interactions (and power play) in the context of nine selection points (Nedeva et al., 2022).

Preliminary results We analyzed the interviews around selection dimensions concerning organizational authority, namely (1) organizational career, (2) knowledge production, and (3) knowledge dissemination. Results indicate that university governance arrangements matter but do not change the actions of this type of field members.

We contrast the responses of both universities around the selection of new group members, promotion and probation, and we find that for the wannabe university members, recognition of the university authorities is more important than for those from a top-of-a-pile organization. Yet, field considerations (e.g., field recognition) override organizational pressures. In regards to selection for access to research infrastructure, methods and skills, behaviour is unaffected by

local influences in both instances. Similarly, our results suggest that selections for access to knowledge networks, decisions over publication outlets and submissions for PREA assessments are dominated by F-type notions.

Significance This paper is an important empirical test of the framework for the study of research governance on scientific fields. We also believe that it contributes to the understanding and methodology for tracing governance effect on global scientific fields.

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[8812] *Policy levers to traverse the "Valley of Death" – which to pull, when, and how hard?*

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Abstract

Summary To meet the demands of the ongoing green energy transition, policy makers need to know how to induce market transformation towards low-carbon technologies. However, the widespread diffusion of new technologies is hampered by a variety of barriers: e.g. high upfront costs, uncertainty around performance, etc. There are abundant policy tools designed to overcome these barriers, but relatively little is known about which policy tools to deploy when, for how long, and how much. A comprehensive approach to designing a policy mix could illuminate the path forward to improved efficiency in policy support by taking advantage of synergies between individual policy tools. Here, we model the owner-broker interaction in green building technologies in a variety of randomly generated policy contexts. We then search through this parameter space for patterns in the combinations of policies – their sequence, timing, duration and strength – that reliably yield market transformation. Our findings contribute to a growing literature on policy mixes, and to the body of policy knowledge derived from computational social science approaches. This paper is a work in progress with preliminary results. Full results are expected in time for the conference.

Introduction / Background Governments have set aggressive timelines for net-zero decarbonization that requires widespread energy and sustainability transitions (H Res. 109; Weyant, 2011; Mallapaty, 2020; Dooley, Inoue & Hida, 2020). However, despite a clear acknowledgement of the need for energy and sustainability transitions, the institutions and policies that would drive these transitions remain unclear. The economics and innovation literatures call for a better understanding of "transitions management," acknowledging the role of emissions pricing, cost reductions for low-carbon technologies, and information barriers that slow the diffusion of nascent technologies (Meadowcroft, 2009). The "valley of death" describes the challenges of moving a nascent technology from basic science to widespread market penetration. The valley of death is often approached as a cost problem. Large private R&D investment results in high per-unit prices, and low demand at high prices prevents scaling up and decreasing marginal costs of production (Nemet et al., 2018). The dominant perspective on reducing these costs, and thus traversing the valley of death, centers on market mechanisms such as subsidies, carbon taxes, or cap and trade schemes. However, the implementation and effectiveness of these approaches has been, at best, incomplete (Geels et al., 2017). Politicians have been unwilling to move on these strategies or set emissions prices that are too low, and as a result, socially efficient externality pricing covers only a small portion of global greenhouse gas emissions (Geels et al., 2017; Weyant, 2011). We contend that the failure of conventional pricing

tools to pull nascent low-carbon technologies into widespread diffusion is the result of a policy mix that ignores the underlying information barriers that drive the valley of death. We frame the issue of high per-unit costs as stemming from "knowledge gaps" and information barriers that substantially increase risk and subsequently preclude significant investment from capital markets (Blackburn et al., 2020; Jaffe et al., 2005; Weyant, 2011). Many policy instruments, including public R&D investment, pilot projects, demonstration projects, public procurement, tax breaks and rebates, regulations and mandates, and other market instruments, have been shown to foster learning effects and reduce information barriers, risk, and costs (Bossink, 2002; Bossink, 2015; Edler, 2007; Aghion et al., 2009; Blackburn et al., 2020; Geels et al., 2017, Jaffe et al., 2005; Weyant, 2011). Despite the variety of tools and levers that can be pulled to induce market transformation, each instrument deployed in isolation may not generate enough learning or overcome sufficient informational barriers to drive the sustainability transition (Rosenow et al., 2017). The question of how hard and in what combination to pull these levers remains pressing (Nemet, 2010). We propose that synergies are likely to exist between various policy tools, and that coordinated efforts to implement carefully designed policy mixes can leverage these synergies to bridge the valley of death. Analyses of the interactive effects, temporal factors, and institutional dynamics of policy mixes are likely to shed light on how governments can design effective transitions management strategies (Flanagan et al., 2011) Here, we develop a theory of the valley of death with a particular focus on information issues that drive high costs, mechanisms that can be used to overcome these information issues, and specific policy tools that can be implemented to traverse the valley of death.

A New Approach: Building a Bridge with Policy Mixes Multiple market failures and barriers contribute to the technology VoD, thus, a "policy mix" of several instruments – some pushing from the supply side, some pulling from the demand side, and other acting to reduce informational barriers directly – are likely needed to bridge the VoD (Rosenow et al., 2017; Flanagan et al, 2011; Raven and Walrave, 2020; Fischer and Preonas, 2010; Weyant, 2011; Lehmann, 2012). Deploying a combination of cost-focused and information-based instruments has been shown to reduce the cost of transition management for emissions reductions compared to a single policy (Fischer and Newell, 2008). The design and implementation of policy mixes to spur nascent technology diffusions is beginning to take hold on the international stage (OECD, 2009). An attractive feature of the policy mix approach is that the effects-in-isolation of individual policies are unlikely to be additive when implemented together – rather the expectation is that synergistic interaction effects, temporal dynamics, and institutional dynamics will contribute to the success of the policy mix (Flanagan et al., 2011)

Methods Overview To demonstrate the framework for understanding the relationship between context and policy levels, we deploy several methods sequentially. First we build an agent-based model (ABM) of building development driven by owner-broker interactions in which we operationalize both contextual variables and policy levers. Second, we simulate the first two (of three) scenarios: a no-intervention scenario the establish a baseline and a random intervention scenario to explore the space of policy interventions. Next, we conduct an unsupervised cluster analysis on the cases with successful outcomes from the random intervention scenario to find groups of self-similar "pathways" to success. Next, we simulate a third scenario with strategic policy interventions based on the pathways to success identified in the previous step. Finally, we compare the distribution of successes across the three scenarios.

Preliminary Results Based on 10,300 simulations of our model, we identify solutions that improve the probability of successful market transformation. The random intervention scenario improves the expectation of successful outcomes over the no intervention baseline scenario from 15.2% to 22.3%. However, it does not do so systematically. The details of each random context are not used to inform policy design – this reflects a tremendously naïve approach to policy design. We improve upon the policy design by strategically connecting a policy prescription to a specific context, and in doing so demonstrate a further improvement to outcomes: increasing the expectation of success to 28.1%. These results can help inform how policymakers and other stakeholders can strategically deploy policy tools to accelerate green market transformation.

[5139] *University scientific coproduction becomes more social in crisis*

Joaquín M. Azagra-Caro (INGENIO (CSIC-UPV), Universitat Politècnica de València) and Alfredo Yegros (CWTS).

Abstract

See file attached.

[2058] *Exploring emerging trends in 5G industry from patent data using text mining techniques and network analysis*

Mehdi Rhaiem (Polytechnique Montréal), Davide Pulizzotto (Polytechnique Montréal), Ramdani Anas (Polytechnique Montréal) and Catherine Beaudry (Polytechnique Montréal).

Abstract

Background and rationale

5G wireless technology is speculated to dominate the communication market and is expected to stay highly competitive over the next few years. According to experts, the arrival of 5G networks will transform entire business domains and create an endless number of new ones (autonomous vehicle market, smart cities, smart factories, autonomous mobile robots, connected medical devices, etc.)(Palattella et al., 2016; Cheng et al., 2018). It is thus necessary to focus on the technology development of 5G wireless communication in order to understand the market trends and help managers and policymakers to plan their strategy regarding R&D activities. However, it is a daunting task to accomplish, since technology development is progressing very rapidly, and researchers struggle to obtain reliable data enabling them to identify key technologies. In this context, patent data represent a valuable solution, and it is a well exploited avenues to map technology development. Most of these studies are dominated by bibliometric and scientometric analyses that use indicators based mainly on structured bibliographical information. However, these indicators are increasingly called into question by scholars and experts for their low informative potential in predicting future trends and intra and inter-industry knowledge flows (Chung and Sohn, 2020). To overcome these limits, many authors have claimed that textual description and linguistic patterns efficiently provide information on technical attributes or knowledge contained in patent documents, which are more powerful in creating indicators about technology trends then bibliographical information. Thus, a stream of studies extended the well-known approach of text mining to analyze the textual content of patents. This article falls in this strand of studies. It combines text mining techniques and network analysis to reveal development trends of the fifth generation (5G) technologies for mobile communication through patent analysis. The paper addresses three questions: 1) What are the latent technological topics in 5G patents? 2) How they evolve in time? and 3) Which is the configuration between several domains of 5G and the main leaders of the industry? In this paper, we provide a more large and precise analysis of 5G technological trends, and we overcome some limits of previous studies. In particular, we use a large dataset, we develop a semi-supervised technique to filtering out irrelevant documents, we detect latent technological topics by using further textual fields then title and abstract and we perform statistical analysis to underline different technological development strategy between top players in 5G domain.

Method

The method employed in this paper consists of four main steps: 1) Data collection and preprocessing; 2) Filtering of irrelevant patents; 3) Detection of the most recurrent topics and focus group with experts; 4) Network analysis of the relationships between topics and the most important leaders in the 5G industry; and 5) Further statistical analysis. First, we aim to obtain the most exhaustive dataset possible containing granted patents related to 5G inventions. To do so, we use the service offered by PatSeer, one of the world's most comprehensive full-text patent collections covering more than 100 patent offices. We retrieve patents that: a) were granted between 2010 and 1st March of 2021; b) belong to a patent office among the G20 countries or one of the supranational ones; c) correspond to the most recent publication of his simply family, which groups documents covering the same invention; d) contain the full-text in the English language; and finally, e) contain a selected list of words in their title, abstract or claims. Our query identified 56,665 patents potentially related to 5G from 31 different patent offices. On the resulting corpus, we apply the most classical Natural Language Processing (NLP) steps to prepare unstructured textual data for further analysis. We get a Document-Term Matrix with 6,058 different unigrams and bigrams of word after having removed features which appear in less than 25 documents and more than the 50% of the corpus. Second, we filter irrelevant patents retrieved from PatSeer because of the ambiguity of some keywords of our query, such as "5G" or "millimeter-waves". To realize this operation, we implement a semi-supervised machine learning algorithm. The method consists of three steps: 1) creation of the training dataset for the identification of related and unrelated 5G documents; 2) training and test phases of the algorithm; 3) application of the best model to the dataset. The first step is initially assisted by a density-based clustering, the DBSCAN algorithm, which is executed on textual data. This process brings to the building of the training corpus, containing 6,000 documents belonging to 5G and 6,000 which do not. In the second step of this filtering operation, we train and test several supervised algorithms (Neural Networks, Naive Bayes, Random Forest, etc.) with several parameters and a 10-fold cross validation. Finally, we select the Support Vector Machine (SVM) algorithm which achieves a F1-score of 93% and we apply the best model to the original dataset, identifying 34,017 patents related to 5G. Third, we used the Latent Dirichlet Allocation (LDA) approach to detect the most recurrent topics in our dataset. After testing several parameters, the model with 50 topics obtained the best topic coherence score (0.63). A focus group composed by five experts (2 professors and 3 PhD candidates) of the department of Electrical Engineering at Polytechnic Montreal was conducted to drive the interpretation of the results. Forth, we perform a dynamic network analysis by following the following procedure: 1) splitting of our dataset into three time periods and selection of the top 20 assignees for each of them; 2) creating of a leaders-topics edge table by leveraging the probability distributions of topics over documents belonging to each leader and time period; and 4) computation of different measures of nodes centrality for network analysis. Finally, we estimated a linear regression for each topic, linking the mixture of the topic over documents, as dependent variable, and regions of assignees as independent variables.

Results

We stress a bipolar configuration of Chinese and American players. Actually, these two groups tend to be located on opposite sides of the network and to be connected with different groups of topics, underling different strategies in 5G

technological development. This constitutes the most import result of our study. On the one hand, American assignees focus more on “frequency division”, “Wi-Fi”, “User Equipment (UE)”, “Computer program”, “Frequency spectrum”, “Voice video call”, etc. On the other hand, Chinese assignees invest more on “Communication terminal”, “Signal detection”, “Network security”, “Relay station” and “Network performance”. The coefficients have highly significant effect, with the exception of the following topics, which have a no significant coefficient: “BICM”, “Antenna”, “Synchronization signal”, “Downlink uplink”, “Latency”, “V2X technology” and “Physical control channel”. This suggests that it exist a common interest in developing those technologies, and this is independent from the origin of the assignee.

Conclusions

This paper develops a topic-based patent analytics methodology to investigate technological trends and explore potential opportunities in 5G using patent data. The LDA topic modeling technique was applied to extract latent technological topics. The topic-firm network analysis is proposed to realize a competitive analysis, which is useful in shaping technology strategies for 5G business solutions.

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[9425] *The Impacts of Network Multiplexity on Successful Scientific Productivity: The Case of US STEM Faculty*

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Abstract

This study focuses on the impacts of multiplex social networks on successful science productivity measured as funded research grants. While previous studies have demonstrated the diverse impacts of collaboration networks on science productivity by looking at the size, diversity, closeness etc. (e.g., Gaughan et al., 2018; Melkers & Kiopa, 2010; Newman, 2001; Siciliano et al., 2018; van Holm et al., 2021), few have looked at the impacts of social ties beyond publications. A social network tie becomes multiplex when multiple functions of interactions are shared within a single relationship (Ferriani et al., 2013; Ibarra, 1995). We look at how ties become multiplex across research collaboration, data and material exchange, and socialization outside of work. Network multiplexity helps individuals take advantage of the diverse types of resources available in a single relationship as such ties are connected through difference exchanges and high level of trust (Coleman, 1988; Methot, 2010). At the same time, network multiplexity can harm one’s productivity as the costs of maintaining such a rich tie can be costly and time-consuming (Mayhew & Levinger, 1976; Methot et al., 2016).

In our study, we ask two questions: (1) How does network multiplexity influence successful grants of academic scientists? and (2) Does the relationship vary by gender? Understanding differential impacts of network multiplexity by gender is critical given that literature substantially demonstrates marginalization of women in receiving social network benefits.

We use a 2017 national survey on US academic scientists in three STEM fields (biology, entomology, and ecology) to explore the interactive effects of network multiplexity and gender on successful science production. Drawing from social network literature, we develop hypotheses on the reverse U-shaped relationship between network multiplexity and productivity and how the relationship varies by gender. Using linear regression model, we test theories controlling for individual characteristics, work characteristics and organizational characteristics. The results will demonstrate that 1) faculty who have more multiplex network within their social networks will be more productive, 2) the positive impact of multiplex network will be reduced after reaching a tipping point, and 3) the effects of multiplex network will be different between male and female scientists.

Our study has both theoretical and empirical contributions. First, we contribute to understanding the impact of social networks on scientific productivity by integrating literature from the fields of social network, gender equity and personnel management. Second, this study can provide implications for workplace socialization in higher education institutions. We expect our results to provide venues for STEM fields in academic institutions where they can find ways to connect faculty’s socialization and their productivity. The study will conclude with policy implications to improve faculty’s productivity by emphasizing the importance of social networks and the gender difference which connects to faculty retention.

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[3749] *Identifying Hot Topics Based on Export Activity*

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Abstract

Background and Rationale: The identification of hot or emerging topics is of interest to a broad variety of stakeholders. As such, it is one of the primary drivers of bibliometric analyses, especially those that attempt to characterize research areas through clustering of document sets. Once clusters are obtained, the hot or emerging clusters are most often identified as those that are growing the fastest or those with the youngest average age. In other words, most current studies identify hot topics as a production-based phenomenon where such topics represent 'areas of knowledge.'

Our previous work has also looked at the growth rate in the number of papers in a document cluster as an indicator of emergence. Using our comprehensive detailed global model of the research literature (Scopus, 52.9 million documents, 98,767 clusters) we improved upon a method to predict which clusters of papers would experience high growth (productivity) over a future 3-4-year period (Boyack & Klavans, 2022). Among the 81 independent variables tested – which included author-, semantic-, application-, network- and gender-based cluster level features – the best predictor was related to historical growth rate, a production-based variable.

More recently we have begun to investigate the citing and cited relationships between clusters. Other studies that examine citations between groups of documents have typically been framed as investigating 'knowledge flow' or 'knowledge diffusion' and have been done at a highly aggregated field or discipline level. This is consistent with the notion of document clusters as 'areas of knowledge'. We view clusters of documents differently. To us, each detailed cluster represents a research problem, and each paper is contributing a micro-solution to the overall problem. However, some micro-solutions are used outside the cluster. When a paper from one cluster cites papers in another cluster it represents the exchange of a 'micro-solution' between clusters. We refer to this as the export of a micro-solution from the cited cluster to the citing cluster. Concurrently, it is also an import to the citing cluster from the cited cluster. For example, when deep learning algorithms first appeared, they heavily imported micro-solutions from research on neural networks. Once deep learning was established, it began exporting micro-solutions to a variety of applications, for example facial expression recognition and online fashion recommendation. When considered in bulk, these historical imports and exports of micro-solutions may provide insights into how a research problem evolves over time.

This has caused us to reflect on the definition of 'hot topics.' Are hot topics those that experience extreme growth in production (micro-solutions to the problem at hand), or are they those that have high degrees of exports to other topics?

This study pursues the notion that it is just as important to predict topics that will have exceptional growth in export activity (as enablers of broad application) as those that will experience exceptional growth in production. In order to explore this issue further, we conduct two experiments that are described in the following sections.

Experiment #1: In the first analysis, we chose to use the 71 document clusters from our 2014 study (Small, Boyack, & Klavans, 2014) because they had been shown to be emergent and had been validated with external information. However, these document clusters were identified in an older model. We thus took the papers from those clusters and found them in a model used in a more recent study (Boyack & Klavans, 2022). In most (57/71) cases, at least 60% of the papers from the original set of emerging document clusters remained together in the new model. Thus, the clusters in the new model remain relatively true to the emergence identified in 2010. In several cases (e.g., for graphene oxide clusters), multiple of the original emerging clusters had merged in the new model.

We then looked at the publication trends of these 57 documents clusters using the method for characterizing imports and exports that were described in a third study (Klavans & Boyack, 2022). In that study, we defined an import or export link between clusters as cases in which a paper cites at least 4 papers in another cluster. These instances were summed over pairs of clusters to identify import and export patterns by year. We then calculated production, import and export shares for each cluster (in reference to the entire model). This process led to several observations. 1) Production activity peaked within several years of identification as an emergent cluster for all but five clusters. In roughly half of the cases the peak lasted a single year and was followed by a decline in production. In the other cases the peak time was flat for several years. 2) Import and production activity were roughly parallel and higher than export activity up until the year of emergence. 3) Export activity dramatically increased after the year of emergence and continued to grow at a very high rate until several years past the peak year.

The overall story here is that, in general, production grows along with import of micro-solutions from other clusters as a cluster is emerging. Once it has emerged, production growth continues but is dramatically outpaced by export of micro-solutions, especially once production in the cluster starts to tail off. This provides evidence that cluster exports continue to be important well after the time that a cluster would no longer be considered hot from a production standpoint, and that tracking and prediction of such exports may be very important from a decision-making perspective.

Experiment #2 To follow this up we are in process of reproducing the recent study in QSS (Boyack & Klavans, 2022) in which we published a method of predicting which clusters in a large-scale detailed model of the research literature would experience exceptional growth. However, in this experiment we will use export activity as the dependent variable rather than production activity. Dependent variables will be the same 81 features used in the previous study plus two new variables – historical trends in import and export activity for a document cluster.

Significance: We expect to find that the sets of clusters that achieve exceptional growth in production and in exports will be partially overlapping and partially unique. Examination of those clusters that are unique to the set of exceptionally growing exports will help us to know if we should be predicting exports in addition to or rather than production. Vetting of those clusters with expert will enable us to understand better the potential policy implications of exports.

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[8152] *Innovation policy making from the practitioner's perspective – A morphological design process for policy instruments – The case of Germany*

Carsten Schwäbe (Freie Universität Berlin), Martina Kovač (Freie Universität Berlin), Elina Pulenkova (Freie Universität Berlin) and Carsten Dreher (Freie Universität Berlin).

Abstract

Background and rationale

Tackling grand societal challenges requires new conceptual foundations encouraging a debate on the need for modified innovation policy approaches. While the discussion on mission-oriented innovation policy originated as an observation of an empirical phenomenon, only a few theoretical underpinnings have been undertaken so far. Some research focuses on the definition and operationalisation of missions and objectives of policy-making. Other scholars, including our previous research, attempt to improve the analysis of policy instrument mixes and their agile coordination, implementation and adaption in the course of dynamic innovation processes. Missions and associated failures are often rather broadly conceptualised and have only limited insights into the instrument design processes of political practitioners. A practice-oriented conceptualisation of types of innovation policies needs to encompass more analytical dimensions of importance for the policy design. Such policy intervention points are particular areas in the socio-technical system or its environment

along with the dynamics of transformation processes (such as the stimulation of niches or regime destabilisation). At these points, suitable policies are supposed to facilitate or support transformative change (Kanger et al., 2020). However, a situation analysis is needed for innovation policy practitioners, which requires identifying and prioritising technologies, relevant target groups, and specific functional strengths (or problems). In that way, the strategic directionalities and the relevant operative knowledge are provided as a basis for the instrument design processes and policy mix orchestration.

Our previous research on the agility of innovation policy has shown that successful instrument selection and design processes depend highly on clear and operationalized strategic objectives (Weber et al., 2021). To guarantee the practicability of recommended policy instruments, policies need to be developed in the context of existing policy mixes and to include the perspective of polity (Which innovation policy actors and structures of the innovation policy system are concerned?) and the required dynamic adjustment processes of policy instruments (politics) to guarantee necessary adaptions to the dynamics of the addressed innovation processes.

Research questions and objectives

The proposed research is developed within the "Innovation Policy Orchestra" project funded by the German Ministry for Research and Education. It aims at considering the complexity of design features and implementation practices of innovation policy instruments, including the role of the implementing policy actors and the dynamics of policy processes for adjustment and orchestration of instruments in the course of the addressed innovation processes. The project addresses the following research questions: • What kinds of analytical dimensions does the literature discuss for a situation analysis of policy intervention points in innovation systems, processes and mission-oriented socio-technical transformation? • What kinds of policy instruments and their specific design features can be identified to develop practical policy recommendations addressing the results of the situation analysis? • How can the situation and the instrument analysis be combined into a morphological design process that includes the orchestration of existing and new policy instruments? The objectives of the research project are two-folded. For the practice of innovation policy, a comprehensive morphological policy design process shall be developed, such that innovation policy designers, for example, in ministries and executing agencies, have a viable method to operationalise innovation policy strategies and the instrument selection and design. For innovation policy research, developing a holistic innovation policy design process helps to understand the practical challenges of innovation policymakers, which have been discussed as a crucial research gap in the literature. Existing typologies of innovation policy instruments, such as supply- and demand-sided instruments or technology-specific and neutral instruments, provide only limited insights on the instrument selection, as not all possible instruments and design principles are included. Through the in-depth discussion on instruments and their impact mechanisms, we aim to develop a holistic overview of instruments and design features to improve policy design processes for scientific policy recommendations and for the practitioners of innovation policy-making. Though new trends, such as the mission orientation, have been discussed in the literature, there is still a lack of practicable policy recommendations to implement an agile mission-oriented innovation policy. However, such policy recommendations require considering the specific national contexts of the innovation policy system. Therefore, the objectives of the proposed research project focus on the case of Germany. To share experiences and discuss the relevance of our research for other countries, we are motivated to present our research at your conference.

Methods

The proposed project follows a qualitative case study research design. In the first step, two structured literature reviews were conducted to collect the criteria for the situation analysis and the possible instruments and design features for the instrument analysis. As the literature reviews have demonstrated important research gaps, notably for polity and politics, our research project uses semi-structured expert interviews to consider the practitioners' perspectives on innovation policy. We are currently conducting interviews with the German Ministries for Research and Education, Economic Affairs and Climate Protection and executing agencies. Together with relevant policy documents, the interviews are transcribed and coded in an iterative process such that evidence contributing to the research questions can be structured and added to the morphological design process.

Preliminary results and significance

For structuring the morphological design process, we follow Zwicky (1948) and others using matrices as a creativity tool to analyse and solve complex problems. The morphological approach facilitates decision-making by providing relevant analytical dimensions and their specifications. For example, the analytical dimension of "target group" is subject to different specifications, such as SMEs or research institutes, which can be selected to know what kind(s) of target groups are relevant to address by policy-making. Two matrices have been developed, one for the situation analysis and one for the instrument analysis. The interviews aim at collecting the tacit knowledge and experiences from policy practitioners in order to get to know tacit and unknown design criteria, practical decision rationales and aspects from the policy design and implementation process itself. This new empirical perspective adds to the existing conceptual debates on operationalising mission-oriented innovation policy-making. As a result, our instrument analysis considers the entire scope of innovation policy instruments and design features by assigning the different kinds of possible policy inputs (financial, guidance, information) to specific activities to be addressed by the instruments (physical installations/infrastructures, knowledge generation, capacity building, market formation, innovation system building).

Both dimensions for the assignment of instruments are subject to specific design features, which we have collected from the literature and the qualitative interviews. The design features include relevant aspects of polity (Who of the innovation policy system is deciding and who is implementing an instrument? What kind of political structures and existing rules and regulations need to be considered?) and of politics (How are learning cycles based on monitoring and evaluation processes institutionalised?). We aim to finalise the interview analysis and the matrices in the spring of next year to present the results at the conference.

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[5508] *Mission-oriented policy learning for an agile energy research program – The case of Germany*

Carsten Schwäbe (Freie Universität Berlin), Fabio Voss (Freie Universität Berlin), Martina Kovač (Freie Universität Berlin) and Carsten Dreher (Freie Universität Berlin).

Abstract

Background and rationale

For Germany, the transformation of the energy system has become more urgent than ever. The necessary acceleration of climate protection and the gas supply shortage since the Russian war in Ukraine have initiated a reorientation of the German energy transition as a mission-oriented innovation policy strategy. Its objectives consist of a triangular between environmental objectives such as emission reduction and renewable energy diffusion, affordability and security of supply. However, recent developments have increased the importance of technological sovereignty and strategic industrial policy as additional policy objectives. In this situation, the German Ministry of Economic Affairs and Climate Protection aims at reconceptualizing its Energy Research Program until 2023. In a research project funded by the ministry, our team receives the opportunity to accompany this reconceptualization. The ministry's objective is to make use of a better operationalization of the overall socio-technical objectives of the mission-oriented energy transition. Moreover, the Energy Research Program shall be better coordinated with other stakeholders in the innovation policy system and other policies. These interfaces to different stakeholders and policy instruments need to be identified and explicitly addressed in a new governance concept of the program. For example, missing interfaces need to be discussed from both a theoretical and a practicability viewpoint for better coordination of how successful projects from the program can receive further support via regulatory or demand-sided instruments. In that way, the new Energy Research Program shall be embedded more narrowly to the mission - and guarantee better coordination with other existing innovation policy and energy policy instruments.

Research questions and objectives

The recently initiated research project has the opportunity to accompany innovation policy design processes in real-time to dismantle the processes of designing and coordinating policy instruments. The insights into the reorientation process help explore innovation policy from a practitioner's perspective, which needs to be included in conceptualizing policy recommendations. The project pursues two objectives. First, it aims to translate the existing knowledge from the literature and our previous research on an agile, mission-oriented science and innovation policy (Weber et al., 2021) to the German Energy Research Program's case. Thus, suitable and practicable policy recommendations for a new governance concept and possible instruments shall be developed and simultaneously discussed with the relevant policy actors. Second, the project aims to accompany the debate and the implementation process for the new Energy Research Program to explore what challenges practitioners need to deal with during the policy design and implementation process. Therefore, the project addresses the following research questions: • Which policy instruments and governance processes are part of the German Energy Research Program? • How can new research on an agile, mission-oriented innovation policy be conceptualized into practicable policy recommendations for the reconceptualization of the Energy Research Program? • What organizational capabilities are required for the concerned policy actors (ministries or project operators) to support the design and implementation processes and learning cycles within the Energy Research Program? The first research question uses previous research on the analysis of innovation policy instruments and their design principles to structure existing activities within the Energy Research Program. Such a structured view is missing so far. Based on the literature, the mapping of policy instruments and governance processes helps to find starting points for proposing policy recommendations. With the term governance processes, our project refers to the processes how instruments such as calls for projects address specific socio-technical needs of the energy transition and how they are designed in detail. Governance processes also include strategic adjustments of instruments along specific socio-technical needs. Moreover, these processes target the capability to select successful projects for further support or other policy instruments aiming

at increasing the production or diffusion of the successful technology. Governance processes include the monitoring of key performance indicators and evaluation activities to adjust instruments and governance processes. The second question focuses on the translation of existing literature to the case of the Energy Research Program. The third question examines the implementation challenges for policy actors' mission-oriented instruments and governance processes.

Methods

The research project is based on a qualitative case study design using different data sources. It consists of two phases. First, the mapping of instruments and the governance processes is conducted based on a structured review of public documents, the existing research literature and participating observations during meetings and workshops in the ministry. Simultaneously, a structured literature review on an agile, mission-oriented and transformative innovation policy, with a particular focus on the energy transition, is conducted. As a result of the mapping and the literature review, a proposal of possible mission-oriented governance processes will be elaborated and discussed in workshops with the relevant actors and stakeholders in the ministry. This includes the challenge to actively address the interfaces of the Energy Research Program with other ministries and instruments within the energy transition innovation policy mix. In the second phase, we accompany the implementation of the new Energy Research Program via semi-structured expert interviews in the relevant departments of the ministry, the project operators and other relevant stakeholders. Thus, we may refine the conceptualization of mission orientation in its daily policy implementation processes. The interviews, the participating observations and the public documents on the Energy Research Program represent the empirical base of the qualitative case study, which is analyzed in an iterative coding process using MAXQDA. As the second phase is supposed to begin in March 2023, we will present the proposal for an agile, mission-oriented energy research program and preliminary empirical findings on its implementation.

Preliminary results and significance

Our previous research on agile innovation policies suggests that mission-serving programs based on several instruments and governance processes require the connection between strategic objectives and the operative selection and implementation of policy instruments and their design features (Weber et al., 2021). The proposed project explores the connection between the strategic and operative levels of policy-making by considering how strategic objectives are operationalized in the Energy Research Program, for example, in the form of calls for projects. In addition, the identified interfaces to the concerned policy actors and to other instruments and programs of the German energy transition policy mix help to understand how coordination at the strategic and operative level of innovation policy-making looks like. Moreover, previous research has highlighted the problem that often new instruments are implemented without considering if existing instruments can cope with new challenges. As a result, programs and policy mixes become far more complicated than necessary (Flanagan et al., 2011). By explicitly identifying the instruments and design features of the program, we can analyze unnecessary policy path dependencies and discuss the option to replace or abolish instruments. Furthermore, implementing mission-oriented policy concepts on former purely supply-sided instruments such as direct project funding programs represents a new field because mission-oriented policy research often focuses on demand-sided measures for accelerating the diffusion of innovations. The proposed project fills this gap by using the long experience of this supply-sided program and by detecting the interfaces to other instruments within the mission-oriented innovation policy mix.

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[4197] *Technology Sovereignty: empirical implementations of a conceptual framework*

Rainer Frietsch (Fraunhofer ISI) and Henning Kroll (Fraunhofer ISI).

Abstract

Technology Sovereignty: empirical implementations of a conceptual framework

Background The global economy is in crisis mode due to the pandemic, the Ukraine war and the energy crisis. Even before that, an ever growing shift in the global economic focus already begun in the early 2000s, particularly in the area of research- and knowledge-intensive products as a result not only of the globalization of markets, but also the globalization of knowledge and supply chains. Supply chains could no longer be regarded as secure and dependencies were questioned. Protectionist tendencies in numerous countries, a politicization of the global economy - not least as a result of a newly evoked system competition between China and the "Global West" - as well as a specialization of individual countries resulting, among other things, from cost considerations, which in turn has led to major dependencies in individual technologies, had already presented many companies with major challenges before the current crises. The multitude of challenges at the business level aggregate into challenges and starting points for innovation and economic policy action at the macroeconomic level or at the level of sectors. The question of technological sovereignty - defined as

the preservation of options for action based on one's own competencies and stable networks - is of particular importance against the backdrop of the above-mentioned challenges. However, internationally integrated supply, production and ultimately innovation chains have created dependencies and links which, against the backdrop of the economic and political challenges mentioned above, can restrict or even jeopardize secure innovation processes and thus competitiveness. Changing markets and new competitors also have an impact on both technological sovereignty and competitiveness, and thus ultimately also on most countries' security of supply.

Concept With its policy paper , Fraunhofer ISI had suggested a concept for Technology Sovereignty (TS) and a first empirical implementation for its monitoring. That paper defines Technology Sovereignty as the freedom to choose between different options instead of being directly or indirectly single-dependent. The definition makes a strict distinction to autarky and protectionism. It stresses the need for collaboration and exchange as well as knowledge and competence building for securing a country's technological sovereignty. In a second - scientific - paper , we offered a theoretical underpinning derived from economics and sociology, when we emphasized Technology Sovereignty as being defined by agency at the state-level (government action). This makes TS subject to policy action, required to be taken by government, industry and science in a country alike. The theoretical and the first empirical implementations of the concept revealed, however, a need for fine-grained (at the technological level) demarcations of crucial inputs (natural resources, pre-products, system components) at the level of technologies or technological system. This paper aims to suggest an empirical approach that will, in addition, be implemented for a set of selected technologies, building on networks and collaboration structures of national economic/innovation systems. With reference to the basic concept for defining, measuring and evaluating technological sovereignty presented by Fraunhofer ISI, this paper compiles and evaluates key statistical indicators for describing and assessing technological sovereignty versus dependency.

Methods To be able to enter at the level of technologies, IPR data (patents, trademarks) are used as one of the main data sources. The development or stock of competencies in key technology fields is an essential building block in securing the technological sovereignty of nations. Hence, bibliometric analyses - i.e. not only the counting of scientific journal publications, but also the use of citations and thus an assessment of the visibility and relevance of corresponding contributions - provide an indication of the intensity and quality of knowledge generation. In addition, the feasibility of a selective analysis of trade data is examined. While patents can be used to implement the delimitation of specific technologies in a fairly targeted manner, it is generally necessary to switch to more highly aggregated product groups (e.g. 'vaccines' in their entirety) in the case of trade data. We develop a technology-specific set of networks at the level of companies and research institutions with the help of co-patents, co-publications, and trademarks. For this purpose, we will resort to technology definitions that can be demarcated for all these indicator dimensions. In a next step, we aggregate each of these networks to the level of countries. At this level, we will also take into account the ownership of companies from BvD Orbis as well as inventor versus assignee country of patents, so that a potential international command of national technological competences can be modelled as well. The resulting networks will be merged in a multilayer network analysis. This will be set at the technology or at least technology field level, allowing a focus on essential technologies. The goal is to determine the extent to which countries have control over and/or access to particular technologies. With this multi-layer network analysis, we hope to be able to work out who collaborates with whom (and who does not) and also what the ownership relationships are. Inputs (value chains) cannot be directly mapped in this way, but the linkages between countries (based on links of companies and research institutions) are able to show technological collaboration.

Results As the project is still in a very early stage, comprehensive results are not yet available. We expect this analysis, however, to provide better insights into the interdependencies and also the network density itself. If there are many unconnected players in a technology field, then there are at least potential alternatives in the global network - hence a larger freedom of choice and room for policy action. From bibliometric and patent data analyses we already learned that international collaboration and exchange has increased in the past years. These kind of analyses, however, have employed individual indicators only or analyzed them separately, while an integrated assessment of a country's Technology Sovereignty based on multiple dimensions has not been attempted in this way, to the best of our knowledge.

[8302] *Towards a conceptual clarification on large-scale research infrastructures*

David Eggleton (Science Policy Research Unit (SPRU), University of Sussex).

Abstract

Background and rationale

This conference presentation provides a conceptual clarification for ‘Large-scale Research Infrastructures’ (LSRIs). While no consensus exists amongst academics and policymakers regarding definitions, it does need to be conceptualized in terms of large scientific instrumentation, facility, and equipment clusters requiring large investments with complex engineering. Based on this, the key concepts that differentiate LSRIs from other RIs are complexity and scale, both physical and investment, both of which are examined here. LSRIs are often extremely substantial facilities with

construction budgets in the billion US dollar range and are frequently organized as international collaborations between national governments for financial expediency. Many different terms have been used to refer to LSRIs, but the lack of established conceptual frameworks has created practical investigational challenges. This presentation draws on a literature review to conceptualize LSRIs as a subcategory of megaprojects incorporating a high or 'super high' level of technological uncertainty, providing a starting point for future research.

Literature Review

The most relevant concepts and literature for understanding LSRIs are those of Large International Science Projects (LISPs), 'Big Science' projects, Megascience, and the directly relevant LSRI literature. While there are other potential conceptions of LSRIs such as Major Research Equipment and Facilities Construction (MREFCs) or ESFRI landmarks, these are mainly intended to allow RIs to benefit from specific funding accounts or to showcase key offerings.

Large International Science Projects (LISPs) The Large International Science Project (LISP) concept will be familiar to informed policymakers but has been relatively underutilized as the RI concept became dominant. Its defining characteristics are that at least two countries must collaborate with a working rule that projects should exceed $US1 billion in construction costs. Previously, the LISP concept has been used to examine project-relevant challenges of maintaining the funding pipeline, cultural impact, the factors that can affect membership policy and decisions by national governments.

Big Science The term 'big science' has been attributed to two phenomena that are seemingly interrelated. The first, of greater relevance here, characterizes an organizational change whereby entire laboratories with workforces numbered in hundreds became devoted to a single research agenda. The second refers to the exponential growth in generation of scientific knowledge resulting from these changes. Generally, big science implies at least one, and usually most, of the following: big budgets, extensive staffing, significant infrastructure and substantial laboratories. This term 'big science' has become extremely pervasive. It has been examined from scientometric perspectives, economic perspectives, and even as an approach for tackling major societal challenges.

Megascience Despite the popular reference to the growth in scientific outputs and laboratory size as 'Big Science', some distinguish between 'Big Science' and 'Megascience'. Even as 'Big Science' was emerging, large scientific projects were sufficiently rare that categorization was not a pressing concern for scholars: some have argued that megascience evolved during the 1970s Oil Crisis, characterised by aggressive financial constraints in most areas of government budgets. Larger projects, notably those at the particle physics laboratory Fermilab in the 1970s, opened up new avenues of scientific enquiry and secured long-term government funding. The increase in size and scope of these particle physics projects and experiments soon led to a situation where it became difficult to identify a clear project endpoint. Each experiment led to a need for further upgrades to answer additional questions, so a judgement as to when a project had definitively concluded could be problematic.

Large Scale Research Infrastructures (LSRIs) The domain of LSRIs shares some overlap with that of 'Big Science' projects examined above. However, Big Science tends to focus on the physical sciences whereas LSRIs are linked to a broader range of disciplines. The increasing prevalence of LSRIs, often requiring the application of organization to research, may appear to be at odds with the historic perception of science as the product of individual toil. Concerns over research productivity and relative prioritization resulting from these trends have been issues for several years and now have extended to other types of research organizations. However, the scale of resources and construction costs required to realize the experimental aims frequently made it unrealistic for a single national budget to bear a spend of this size. Greater internationalization through disparate legal approaches has been one response to this issue. Yet the issue remains that the definition of 'large' has not yet been addressed.

Conceptualization

One challenge when examining LSRIs from policy or management perspectives relates to conceptualization– the identification of a lower boundary above which a research infrastructure is considered 'large'? This conference presentation draws on the megaproject domain to set the conceptual agenda for future work and to guide the individual researcher.

Megaprojects Although the project management literature does offer project organization and tracking suggestions lessons, it does not focus on the size of recent development budgets. Such projects are often referred to as megaprojects; many scholars have used the $1 billion figure as the transition marker for the transition from project to megaproject. Megaprojects have an association with national prestige that makes them the target of political interest. National and occasionally supranational authorities are therefore often stakeholders and their management has previously been well examined. In most megaprojects, the client usually lacks the technical understanding to create detailed specific technical designs before submitting for tender; most briefs therefore reflect general goals that the final product must satisfy. This is a deliberate policy that gives contractors the space to design and make technical decisions. This is not the case for LSRIs where such technical competence is available 'in-house' and allows for a very different model. Equally, one of the characteristics of LSRIs is that previous RI generations can often be used as supporting infrastructure for the current generation.

Technological uncertainty Many projects can be managed using standardized methodologies which can be found in bodies of knowledge, both internally held by the organization and externally in databases. These standardized methodologies can inform organization, scheduling, and budgets. However, more innovative or complex projects may require greater tolerance of budget or schedule changes, since as novel solutions may need to be devised for unanticipated challenges. Some projects identified as LSRIs have been described as requiring the use of bespoke new technologies, or the use of new technologies on an unusually large scale. Another consideration relates to complexity. Projects can be broadly categorized by complexity into three categories. These three categories are assembly, system, and array. LSRIs can be thought of vast arrays comprising a 'system of systems', with each component having very tight tolerances, generally constructed with the intention of acquiring new data to facilitate new research discoveries. This desire to extend the frontiers of knowledge often requires researchers to design new materials, fabrication techniques, or analytical programs to realize their experimental aims.

Significance

There exists a longstanding literature deficit: identification of a precise point at which a research infrastructure become large. By drawing on the relevant management literature to address this gap in theory, future researchers examining LSRIs will now have a starting point from which to devise robust inclusion criteria. This presentation also offers new conceptual frameworks from which to approach such examinations.

[1996] *Transformative Innovation Policies as sociotechnical niches: An illustrative case from Colombia's Social Appropriation of Knowledge policy*

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Abstract

Background and rationale

Transformative Innovation Policies (TIP) have emerged as a new framework to understand the relationship between policies and the great challenges towards sustainability (Schot & Steinmueller, 2018). In this line, there are growing discussions about how those policies look like in practice and what they entail, particularly in emerging economies (Ordoñez-Matamoros et al., 2021). These discussions have tried to explore the role of innovation policies in fostering transformative processes in local communities and understand what logics and enablers could trigger such processes (Pinzón-Camargo et al., 2022). In the same way, efforts like those led by the Transformative Innovation Policy Consortium (TIPC) have been focused on discussing the TIP's features and implementation paths towards achieving social transformation. In this vein, the TIP study has focused on the meaning, features, and interactions between policy and communities to address great challenges (for example, Haddad, et al., 2022).

A line of inquiry to complement and expand the study of TIP, or policies with transformative potential that existed before the TIP framework conceptualization, seeks to explain and learn how new transformative-policy paths emerge. Although this line of inquiry resonates with the studies about policy change in the frame of Policy Studies, we focus directly on the role of actors and how they build policy niches. In this regard, reflections on TIP aimed at transitions offer relevant insights on the role of policy for long-term sociotechnical change, specially from the macro and meso level point of view. However, further reflection is needed regarding the embedded character of policy in transition processes and its performance at the micro level.

Following the literature on the multilevel perspective on sociotechnical transitions (MLP) (Geels et al., 2004) and strategic niche management (SNM) (Schot & Geels, 2008), we argue that, while TIPs shape the development of sociotechnical niches, TI policymakers perform as institutional entrepreneurs that play an active role within sociotechnical niches, conducting policy experiments that result in new policy instruments. These instruments are policy technologies that can contribute to broader sociotechnical transitions by introducing institutional transformations at the regime level.

With that in mind, we aim to disentangle how new policy instruments come about within 'policy niches' while shedding light on the strategies actors play in transforming institutions so that such political technologies can be scaled up.

We combine three theoretical branches in this study in two layers. In the first place, we consider Strategic Niche Management (Caniëls & Romijn, 2008; Schot & Geels, 2008) along with Institutional Entrepreneurship Theory (Battilana et al., 2009; Pinzón-Camargo, 2022) to understand and explain how policies work as niches and what role plays institutional entrepreneur in those policy niches. In the second place, we rely on path dependence and path creation theories (Garud & Karnøe, 2003; Karnøe & Garud, 2012; Garud et al., 2010) to unfold how the policy niches with transformative potential could evolve in new path-transformative trajectories (Pinzón-Camargo, 2022).

Methods

This study follows Yin's case study approach (2018) by developing an illustrative case based on the Social Appropriation of Knowledge policy in Colombia. This policy emerges in earlies 90s in the frame of international discussions about the public understanding of science. In Colombia, that discussion evolved as a bet for opening dialogues between scientific knowledge (Academia) and traditional or ancestral knowledge (civil society) to meet local communities' needs based on mixing those knowledges.

The illustrative case selected is supported by 16 semi-structured interviews with policy actors involved in developing the Social Appropriation of Knowledge path and beneficiaries from academia and civil society. Besides, we consulted white papers, policy documents, public videos, reports, and other public archives associated with this policy.

The data collected in this study were processed using the software Atlas.Ti. In this study, we identified a set of categories from the three theoretical branches mentioned above based on Pinzón-Camargo's (2022) work. Those categories were the starting point to reflect on the data collected. At the same time, the theory was confronted by the practice. In this vein, we followed an abductive approach (Awuzie & McDermott, 2017; Lu & Liu, 2012; Patokorpi & Ahvenainen, 2009). Thus, we are going back and forth between theory and data in our analysis to suggest a plausible interpretation of the following research question, how path-transformative policy niches are built and fostered?

Results or anticipated results

We anticipate three types of results. In the first place, the illustrative case analysis will provide a heuristic to combine the three theoretical branches used to study policies as niches and the role of institutional entrepreneurs in building the niches and fostering path-transformative policies. In the second place, based on the heuristic assembled, we will reflect on the relationship and limitations of assuming policies with transformative potential as niches. Finally, we will identify roles and strategies performed by actors in the process of building policy niches with transformative potential.

Significance

This work will have a threefold contribution. In the first place, from the theory, we will give fined-grained in discussing and deepening the role of actors in transformative changes, following the claim made by different authors (de Haan & Rotmans, 2018; Farla et al., 2012; Pinzón-Camargo, 2022). In this case, we will focus mainly on the role of policymakers as institutional entrepreneurs. However, we acknowledge that the agency is distributed and relational (Cabero Tapia, 2019; Garud & Karnøe, 2003; Pinzón-Camargo, 2022), which means that there will be other actors that could support processes of transformative change from different roles. In the second place, we will contribute to explore of institutional entrepreneurs, in this case, performed by policymakers in the Global South, supporting filling the gap of exploring in more detail these actors of change in different settings (Battilana et al., 2009). Finally, from practice, reflecting on the transformative potential of policies and their possible understanding as a niche, along with the analysis of actors, will provide insides into features, strategies, and processes to lunch policies with transformative potential.

[1297] *From Crisis to Survival: How Informal Businesses Harness Innovation to Evolve their Businesses*

Nazeem Mustapha (Human Sciences Research Council) and Nicole van Rheede (Human Sciences Research Council).

Abstract

Introduction In South Africa, and many other African countries, the informal sector accounts for a significant proportion of economic activity. Informal businesses also localize goods and services for the communities within which they operate, providing accessibility to essential products and amenities that would otherwise be accessible only outside informal areas. Their understanding of local customer need and community dynamics often informs their pricing and payment terms. However, access resources such as funding, skills development and insurance that enable businesses to evolve and grow into sustainable micro-enterprises remains a challenge. For these reasons, informal businesses are particularly vulnerable to risk, which not only affects the owner, but employees and customers in the local community. One way in which owners respond to risk to stabilise, sustain, and even grow their businesses is through innovation. Innovation is crucial for informal businesses to compete and continue to provide cheap, flexible options for low-income households. A concern is that informal sector public policy and support programmes tends to be directed at formalisation, through business registration (Jorgenson, 2010). Our research shows that business registration is not an accurate indicator of graduation from informal to becoming a sustainable forma business. Business evolution is more accurately represented along a continuum of intermediate states rather than depicted as binary opposites of formal and informal. The argument presented in this paper is that, by supporting innovation in informal enterprises, progression along this continuum can be promoted towards building sustainable micro-enterprises. The emphasis should be on building capabilities to formalise.

Methods This study draws on a survey of innovation in informal enterprises, using methodologies adopted and adapted from informal sector research and the standard Oslo Manual, together with qualitative interviews and digital life stories of business owners in the informal sector. A total of 996 businesses were used to determine the varying degrees of informality in the informal sector, complimented by 48 qualitative interviews and thirteen digital stories. The research

was conducted in a peri-rural area of the KwaZulu-Natal province in South Africa during 2019-2021. We present an analysis of events that prompt a response of innovation for informal business owners, which enable their businesses to survive or grow, and how these responses manifests in varying levels of informality over time. Importantly, the bottom-up approach adopted through the research design, which identified informal businesses by local community interviews and self-identification allowed for the inclusion of businesses that had at some point been registered as formal enterprises. The analysis adapts criteria developed by Mbaye and Gueye (2020) to determine the level of informality of informal businesses in the study. The criteria applied include registration status, business premises, number of employees, financial records, as well as a having separate bank account, and access to financial resources from formal financing institutions. The criteria were inversed for the analysis, meaning that if a business was not registered, it would be assigned as having met the criterion. Similarly, if the business did not operate from a separate premises, had no employees or financial records, etc., the criterion would be met, and the corresponding level of informality was assigned. The number of criteria met by each informal business corresponded to a level of informality ranging from 0 (formal) to 6 (totally informal). Findings and Discussion Our results show that every business in the sample met at least one criterion, meaning that none of businesses in the sample were considered completely formal. Most businesses in the sample met five criteria and were thus considered mostly informal. Using qualitative data, the study explored the relationship between innovation and levels of informality. The study found that negative events, which places the informal business under risk, acts as a catalyst for innovation as a response to mitigate or remove the risk to the business caused by the event. The nature of these events, which the study refers to as innovation events, include personal or financial difficulties such as crime, debt, illness, or the loss of a close relative. The data showed that these responses often led to business survival or growth, which causes a change in the level of informality of the business, either by increasing thereby becoming more informal, or decreasing by becoming less informal.

Approaches to support informal businesses are often directed at formalization through business registration, and support in the form of skills development or financing are often reserved for registered micro enterprises (CeSTII, 2021). In South Africa, registration of an enterprise requires an application to be submitted to the Companies and Intellectual Property Commission (CIPC), which can be submitted online or via participating banks. The cost of registration is R125,00 and registers the business with the South African tax authority, South African Revenue Service (SARS). It also requires financial reports to be submitted annually to the Commission. The cost and requirements for business registration are often unattainable for informal business owners, and programmes to facilitate registration do not consider the realities of businesses in the sector, such as those provided by the Small Enterprise Development Agency (SEDA). Policy support for informal businesses to move from informal to formal is underpinned by a binary and linear understanding of formality and informal business growth, referred to as the Vuvuzela Graduation Model. The model depicts formality in direct relation to business size. In our analysis, business size and registration status are merely two of the attributes considered in the evolution of informal microbusinesses. And the end-state we consider is whether businesses become sustainable economic entities.

An investigation of the qualitative data suggested that the nature of innovation events can be classified into the categories of financial or personal. Innovation responses ranged from actions taken to start the business, seeking additional avenues to market the business, to adding new goods or services for customers. We explored the determinants of the innovation response and found that competition, opportunity identification, social capital, having the existing skills, as well as family responsibility motivated owners to respond innovatively to crisis as enablers of business growth or to sustain its income stream. Thirteen of the seventeen innovation responses led to a change in the level of informality in the business, all of them resulting in decreased formality. The four innovation responses that did not result in a formality shift showed that business owners took action that had formality-shifting potential, such as learning new skills or adding new products or services to grow their business.

Nine of the seventeen business owners reported more than one innovation event. Of these, five business owners had innovation responses that led to a change in informality. The remaining four demonstrated potentially formality-shifting actions. The relationship between the change of informality after innovation event one and after innovation event two are not cumulative, meaning that the business does not necessarily become more formal after each innovation event. Our findings also show that potential formality-shifting actions do not necessarily shift formality after the second innovation event. The business may decrease, increase, or depict no change in formality at multiple points along the evolutionary trajectory towards complete formality. Even in the event of a business becoming totally formal, formality can shift, and decrease, depending on the outcome of the innovation response. Box 2 Mandla's Flowers and Vegetables Conclusion Business size or registration is not an accurate indicator of growth or formality. Instead, the focus on formality as an outcome may very well be displaced. Many business owners use formal registration as a tactic for achieving contracts from public service organisations especially. An increase in the number of employees does indicate greater sustainability of the business in many cases. But this is very much sector-dependent, and the nature of employees, whether family or not, needs to be looked at to assess sustainability. Should not the long-term sustainable functioning of enterprises be the true goal?

Crisis events catalyse innovation in informal businesses. Informal sector researchers have in the past documented innovations as they perceived it. By and large these tended to focus on artifacts that were significantly enhanced or even

transformed for use in informal businesses. It is only by using the concept of innovation systems that we are able to make the connection between innovation activities and the trigger events for business growth.

[5486] *Covid-19 and Beyond: Arguments for a New Innovation Policy*

Sujit Bhattacharya (CSIR-National Institute of Science Communication and Policy Research).

Abstract

Background and rationale The Covid-19 pandemic has shown the vulnerability of nations, global institutions, and humanity at large to cope with this disease. It has underscored the need for a Great Reset that calls for a revisit by nations, the global institutions of the premise and assumptions of the growth discourse, and the translations based on them. This need for a reseat has long been echoed by low and middle-income economies in their struggle for addressing developmental challenges such as health, and climate change, for achieving the target set for SDG goals, etc. The pandemic has shown the vulnerability of coping with the pandemic even in OECD economies and exposed various fault lines in these economies. A large consensus is emerging that contemporary growth models which underpin contemporary policy framing are not resilient enough to cope with the various shocks. New innovative approaches during the pandemic have played a major role in fighting the pandemic against adverse circumstances. They have challenged the dominant models of innovation which are centered on growth models. The paper is motivated by the issues raised above to look more closely into the research and innovation systems. Primarily the paper centers on to what extent the conceptual/theoretical framework that guides present policy discourse and implementation needs a revisit. The paper draws from these to make a more informed argument, suggestive pathways in the context of innovation and innovation policy Method The paper is exploratory research drawing from a large body of scholarly work across different strands of research within innovation and STS, and development studies. It has selectively drawn from a huge body of literature covering COVID-19 and past-pandemic discourse. The challenges of climate change and green growth, and issues of technology transfer therein, were also examined to see to what extent they echo the struggles and challenges faced in containing the pandemic. Results A 'New Normal' emerged for fighting the disease. Collective global response, local networks, frugal innovations, open sharing, exploring new daring pathways, novel public-private partnerships, etc. that in some ways the pandemic compelled to take, provided solutions and hope to mitigate the severe impact of this pandemic. Research became more OPEN with the global sharing of research findings, genome sequencing, data, tools, and techniques which gave leads for drug/vaccine development. Many innovations happened in the face of institutional voids and resource constraints (frugal innovations) that were characterized by being low-cost, affordable, and 'know-how' that is easily transferable and replicable demonstrating an alternative pathway to prevention and costly healthcare. Face masks, sanitizers, and PPE kits were made from reuse of existing material, make-shift hospitals, containment zones, low-cost oxygen cylinders, and ventilators that were not as sophisticated but could provide critical make-shift support that became life savers in the face of the weak health infrastructure. The development of Covid-19 vaccine/drug was more complex and difficult due to high levels of uncertainty surrounding the virus i.e. its effect on the human body, its rapid mutation, pathways it chose to enter and target different functions, etc. Inspite of these challenges, different treatment options, and vaccines were available within a year or so which in normal development takes between 10 to 15 years. This was possible due to various novel strategies and radically different approaches adopted. Repurposing Strategy "old drugs, new use", Global coordinated among them, the WHO 'Solidarity Trial' and Access to Covid-19 tools (ACT) accelerator and new platforms for drug/vaccine development, the proactive regulatory system can be cited as key enablers in bringing new vaccines within the unimaginable time frame. Discussion and Conclusion The covid-19 exposed various fault lines. However, drawing from the stories of resilience, unprecedented response, and some extraordinary moves from countries to fight this pandemic have also suggested new ways forward. Many of these were transient measures to address the alarming challenges. Frugal solutions are more accurately felt now not only in Global South but also in the Global North. The pandemic also highlighted the need to move towards a more inclusive innovation system framework, which would be open to incorporating local expertise and informal knowledge systems beyond the actors and institutions of the formal economy. As spaces of frugal innovations vary widely and are of variable quality, their adoption and scalability call for innovation systems to strengthen these frugal innovations and create institutional mechanisms for supporting them. The innovation systems on the other hand need to see that adherence to formal standards should not lead to eroding the essential essence of these frugal innovations. Greater attention is also needed for other forms of innovation, such as user-led and open innovation (see e.g. von Hippel, 2005). Innovation Systems (IS) approach has given a more nuanced understanding of factors that leads to the failure of the research-innovation ecosystem that hinders the creation, translation, and diffusion of technologies. The attention to different forms of failures in IS approach is distinguished under 'system failure' (Woolthuis et al. 2005) and augments the 'market-failure' rationale for policy intervention. Infrastructure, institutional, network, and capability failure are the key domains covered under System failure. Many instances were observed wherein the STI ecosystem could not perform due to these failures. Many other types of failures were observed which have been pointed out by Weber and Rohracher (2012) namely Directionality, Demand articulation, Policy coordination, and Reflexivity failure that could be seen impeding the institutions effectively during the shock

exhibited by the pandemic. Informal innovations have been largely neglected within the IS framework. Greater attention is also needed to other forms of innovation, such as user-led and open innovation (von Hippel, 2005). The post-pandemic transformation calls for rethinking development more broadly. Long-term transformative change in our industrial society needs to expand the criteria of "success" in economic development beyond growth and profit to include inclusiveness, equity, trust, and sustainability. The important role of public funding behind successful Covid-19 vaccine development has largely remained invisible (Cross et. al., 2021). This is also true of many vaccines and drugs in the market including blockbuster drugs. The voices that are suppressed when price reduction is demanded by activists, by low and middle-income economies in the access and equitable debate have high merits. Inflating the pricing of patented drugs which results in deadweight loss, costing of drug development which suppresses the huge public funding, equity and access are issues that are raised in these debates and calls for globally coordinated action plans and sensitivity of high-income economies to regulate the big drug MNCs which operate as a cartel to inflate prices. The covid-19 pandemic has shown the importance of 'commons' that calls for shared resources managed collectively in providing economic activity and livelihoods, mutuality, and building trust and solidarity. Amartya Sen (Sen, 1999) who had cautioned the uncritical acceptance of the notion of 'growth identical to development' makes one rethink the new policy framework which is just, equitable and inclusive and at the same time creates/promotes innovation and entrepreneurship.

[376] *Learning to evaluate transitions and missions policies*

Erik Arnold (Technopolis and Manchester Institute of Innovation Research) and Emily Wise (Centre for Innovation Research (CIRCLE) and LU Collaboration Office, Lund University).

Abstract

The 'turn' in policy towards addressing societal challenges calls for a radical rethink of how to do research and innovation policy. Our paper focuses on evaluation in this new policy environment. Challenges for evaluation include the increased scope of the policies needed, devising theories of change that are challenge- rather than push-based, tackling complexity, and new roles for evaluation in the life cycles of policies that tend to be longer than those of traditional research and innovation interventions. Policymakers and evaluators alike need to embrace and incorporate lessons from the fast-growing literature on transitions and missions. The paper will synthesise results from our own and others' research on evaluating transition- and mission-like interventions, deriving operationally relevant conclusions for evaluators and policymakers.

[7864] *Building the Future Science Policy Workforce Through Undergraduate Opportunities*

Adriana Bankston (STEM Advocacy Institute).

Abstract

Science policy is critical for addressing today's societal challenges and impacting communities across the country. Many undergraduate and graduate students in the sciences are interested in engaging in science policy opportunities and transitioning into these careers. Whereas many of these opportunities are geared towards PhD-level scientists or graduates, a very small number of undergraduate students have access to relevant courses and mentorship in science policy, which is critical to their growth in the field.

Undergraduate students interested in science policy may not want to or be able to pursue a Masters or PhD programs in the sciences, and career pathways and opportunities should be created for undergraduate students to enter into science policy careers through pathways other than pursuing a graduate degree. This expansion would develop a broader framework for how undergraduate students can enter the science policy workforce and contribute to societal change through science policy training.

The STEM Advocacy Institute (SAi) is an incubator that seeks to enable and accelerate the building of new tools and programs expanding pathways of access between science and society. The Bankston Lab at SAi is looking to build out the organization's policy branch, and developing innovative ways to bridge science and society through science policy. Given SAi's strong focus on training undergraduate students, and the lack of training opportunities for this population in science policy, the lab currently focuses on this population. A strong focus on this area is needed in order to build the science policy workforce of the future and offer diverse pathways for students to engage.

SAi's Bankston lab members recently performed several analyses to assess the current landscape of science policy training for undergraduate students, which was recently published as a preprint (https://www.biorxiv.org/content/10.1101/2023.04.15.537026v1). In this work, we examined existing opportunities for science policy career development for undergraduate students and conducted focus group-style workshops to collect feedback from such individuals engaged in science policy. We also researched opportunities available for undergraduate students in currently available databases, which revealed a lack of training opportunities in science policy for both

current undergraduate students and bachelor's degree-holders. We look forward to presenting this work at this conference in order to raise awareness of the need for science policy training for undergraduate students and showcase our work.

This work aims to highlight the gaps in science policy workforce development and lays out recommendations for filling these gaps to support undergraduate students. Recommendations for change across stakeholders include: science policy training within their undergraduate curriculum in universities; expansion of science policy and educational training by scientific societies and non-profits; and funding opportunities that incorporate undergraduate science policy student training and mentoring.

[9275] *How to make research data available and ensure compliance with the OSTP Memo*

Mark Hahnel (Digital Science) and Heather Luciano (Digital Science).

Abstract

In August 2022, the Whitehouse Office of Science and Technology Policy announced new requirements from federal agencies "Ensuring Free, Immediate, and Equitable Access to Federally Funded Research". Namely, this requires executive agencies and departments to:

Update their public access policies as soon as possible, and no later than December 31st, 2025, to make publications and their supporting data resulting from federally funded research publicly accessible without an embargo on their free and public release; Establish transparent procedures that ensure scientific and research integrity is maintained in public access policies; and, Coordinate with OSTP to ensure equitable delivery of federally funded research results and data.

In 2019, we saw the number of open access academic papers published globally, passing 50% of all papers published. There are also many new business models and routes to support open access as the push has steadily gained moment since it was first conceived in the 1980s. Authors and funders have a plethora of green and gold open access publication routes, although managing the cost implications of the latter is an ongoing discussion.

Open academic data is largely a new concept to researchers and funders alike. Whilst several fields have been benefiting from making data available for some time, for example, genomics and astrophysics - many communities are struggling with the concept of where and how to make their research data accessible. Several are struggling even with the concept of what 'data' means to their field.

The State of Open Data report from Digital Science surveys researchers on their attitudes and concerns with regards to open academic data. Since 2016, we have monitored levels of data sharing and usage. Over the years, we have had 25,000 responses from researchers worldwide providing unparalleled insight into their motivations, challenges, perceptions, and behaviours toward open data. The State of Open Data is a critical piece of information that enables us to identify the barriers to open data from a researcher perspective, laying the foundation for future action. This year's report also includes guest articles from open data experts at the National Institutes of Health (NIH), the White House Office of Science and Technology Policy (OSTP), the Computer Network Information Center, Chinese Academy of Sciences (CNIC, CAS), publishers and universities.

A separate Digital Science report led by Ripeta is titled The State of Trust & Integrity in Research has insights into how researchers are actually acting in practice when it comes to open research data. It demonstrates that improved data sharing policies will boost public trust in research

In addition to its detailed analysis of the five major funders, Ripeta found that with regard to 62 key funders worldwide: 71% of funders required data management plans 68% of funders covered expenses of data management and sharing 66% specifically mentioned data sharing repositories as a mechanism of making data publicly accessible 26% of policies mentioned how long data should be retained.

Locating funding agency policies proved to be particularly difficult, with many not surfacing through web searches. There was also significant policy variability between funding agencies, with many policies having differing requirements for implementation. Utilizing Ripeta's services, funders and government agencies have the ability to analyze and monitor compliance within established open science or data management and sharing policies, while also identifying areas of good institutional research practice.

Exclusive analysis by Ripeta in one section of the report compares the policies and practices of five major world funders: the Bill and Melinda Gates Foundation, the European Commission (EC), the National Institutes of Health (NIH) in the United States, the National Natural Science Foundation of China (NSFC), and the German Federal Ministry of Education and Research (BMBF). The analysis shows that although each of the funders have their own policies in place to support data sharing, there are discrepancies between those policies and how they translate into practice. For example, the number of research papers published in open access (OA) journals varied greatly depending on the funder. The NIH (95%) and the Bill & Melinda Gates Foundation (93%) far outstripped the representation of OA publications of other funders, especially the NSFC (33%).

This session will discuss what we know about how to encourage researchers to make their data available and how we can ensure compliance with the OSTP memo going forward.

[8766] *Gender bias in funding evaluation: A RCT field experiment*

Laura Cruz-Castro (CSIC Institute of Public Goods and Policies (IPP)) and Luis Sanz-Menendez (CSIC Institute of Public Goods and Policies (IPP)).

Abstract

Evaluation of proposals for allocation of research funding is done mainly through peer review. Some research concludes that there is gender bias in research funding; others sustain that gender differences exist but bias evidence is elusive and findings are contradictory. Despite some conceptual ambiguities, the debate revolves around to what extent the (potential) existence of gender bias in research assessment is causing gender differences in outcomes.

Evidence in observational approaches is either based on outcome distributions (e.g. success rates by applicants' gender) or at best on modelling bias as the residual, once all relevant variables are considered. In observational research causal claims are usually mixed with simple statistical associations.

The standard problems of selection bias, confounding, lurking or unobserved heterogeneity have not always been properly addressed in previous observational research on funding research and peer review. Research addressing the links between research funding and gender bias has often faced problems of validity, both external validity (as it usually referred to a single country, funding agency or funding instrument) and internal validity, more related to the research design and the causality approach.

The funding organizations usually define the criteria for quality or merit assessment and their weighting. If gender bias exists in research funding, it would be the outcome of the reviewers' assessment, under the evaluative framework set by the funding agency.

Trying to overcome validity shortcomings, in this paper we use an experimental design in which, instead of trying to identify the causes of observed effects (observational approaches strategies), we aim to measure the effects of a cause, the treatment effect of the gender of the principal investigator (PI) in a research funding proposal score.

We embedded a hypothetical research proposal description in a field experiment and with the research design we addressed some of the most important challenges of the "experimental approaches" that help to avoid bias estimates: 1) authenticity of the treatments: whether the treatment used in the study resembles the intervention of interest in the real word; 2) the realism of participants: whether the participants in the experiment resemble the actors that usually participate in this type of process; 3) the genuineness of the context: whether the context within which subjects are receiving the treatment resembles the context of interest, and 4) the truth of the outcome measures: whether the outcome measures resemble the actual outcome of theoretical or practical interest.

Our subjects were the reviewers selected by a funding agency, and the scoring task was done using the same criteria, framing and weighting of the call, additionally it was implemented simultaneously to the agency peer review assessment.

We manipulated the item in the proposal, which described the gender of the PI, with two designations: female PI and male PI. Treatment was randomly allocated with block assignment and response rate was 100% of the population, avoiding problems of biased estimates in pooled data.

Our results show that proposals led by female PIs received a lower mean score than the ones from male PIs, but the differences were not statistically significant. The origin of the small difference was that female reviewers assessed female PI proposals less favorably than male PI proposals.

Contrary to previous research, we find no evidence that male or female PIs received significantly different scores, nor did we find evidence of same-gender preferences of reviewers regarding the applicants' gender. Thus, we cannot reject the null hypothesis that PI gender has no significant effects on scoring, nor do we find support for the matching hypothesis between applicant and reviewer gender.

[9186] *A cluster analysis of innovation barriers in agricultural sector: A k-modes machine learning algorithm approach*

Yasser Buchana (Human Sciences Research Council).

Abstract

Background and context

In the last few years, innovation profiling and segmentation has become an essential method in academic and policy circles for analysing innovation behaviour of firms. When firms innovate, they are often faced with a wide variety of

challenges or impediments. These are more pronounced in the agricultural sector, especially, since businesses in the agricultural sector have experienced a variety of issues that have hampered their innovation efforts. These obstacles include, among other factors, resource (financial and human), institutional and regulatory, as well as, environmental factors (climate change, droughts, floods, etc.).

Meanwhile, in an effort to address some of the challenges to innovation faced by agricultural businesses, policy-makers have often applied a blanket approach to design policies which, in some circumstances, have failed to meet the needs and requirements of agricultural businesses. Some of these policies have not produced the desired effects due to a lack of understanding of the characteristics and profiles of innovation in agricultural businesses and, in particular, the barriers to innovation in these firms. This is reflected in weak innovation performance in agricultural businesses, which has remained much lower when compared to other sectors of the economy, especially those in developing nations.

Innovation remains nonetheless a critical vehicle for addressing the sector's challenges, notably those of poor productivity, provided that a conducive framework for innovation is developed which addresses the impediments to innovation in the sector. This can help ensure the agricultural sector's long-term viability and sustainability (Ulvenblad et al., 2018).

Unfortunately, simple aggregate indices of the number of innovation-active enterprises that consider a specific barrier to innovation as very important provide little relevant information for policymakers. To gain a better understanding of the structure and complexity of barriers to innovation in the agricultural sector, it is necessary to profile businesses based on the barriers they face, given that alleviating or at least minimising barriers to innovation may stimulate more innovations in the sector, thereby increasing the number of businesses that are actively engaged in innovation.

Objectives Although existing literature on innovation barriers has, to a limited extent, explored the different types of barriers to innovation in other sectors of the economy, the primary goal of this study is to investigate clusters of agricultural businesses based on barriers to innovation they experience.

Methods

This study used data from the South African baseline Agricultural Business Innovation Survey covering the period 2016-2018 (Agri-BIS 2016–2018). The Agri-BIS 2016-2018 was based on the guidelines of the Organisation for Economic Co-operation and Development's (OECD) Oslo Manual (OECD/Eurostat, 2005). The survey used the methodological recommendations for the Community Innovation Survey (CIS) of the European Union (EU) countries, as provided by Eurostat, the Statistical Office of the European Commission. The survey focused on ascertaining how agricultural businesses innovate. The core questions asked about the businesses' product, process, organisational and marketing innovations. The survey also asked questions about the different innovation activities and outcomes.

To determine the barriers to innovation, the survey incorporated additional questions on the factors that impede agricultural innovation. These questions asked businesses about the different factors that they considered highly important during the reference period 2016–2018.

This study applied a K-modes machine learning clustering algorithm to analyse the clusters of agricultural businesses that have experienced a wide range of innovation barriers. Python programming language was used to implement the k-modes machine learning algorithm on the dataset using the Scikit-Learn and pandas library.

Significance and contribution

This study makes an important contribution and bridges a key gap in literature in that, it is one of the first of its kind to apply a machine learning algorithm to cluster agricultural businesses in terms of the barriers that affect them. Secondly, this study allows for a more detailed examination of the implications in terms of prospective innovation policy instruments targeted at alleviating impediments to innovations on weak innovation performance in agricultural businesses as a result of the different types of barriers. The results may be used to inform policy by better targeting instruments and tailored policies to that address barriers to firm innovation in specific clusters in the agricultural sector.

[2816] *A Realistic Evaluation of Science Policy - Generating Learning for Spanish Public Administration Institutions*

Armela Dino (Spanish Ministry of Science and Innovation (ES)/ University College London (UK)).

Abstract

BACKGROUND & RATIONALE My research uses for the first time a critical realist approach to evaluate science policy. By analysing the highly reputed Spanish government Centres of Excellence programme with which I was directly involved as a policy analyst, my research brings forward findings that are suggestive of the possible benefits of a critical realist approach to the evaluation in science policy. The bases for problem solving are grounded in understanding the complexity that science policy evaluation has faced in the past decades (Cozzens 1997; Georghiou 1998, Salter and Martin, 2001; Shapira and Kuhlmann 2003, Martin 2011, 2016, 2019, Feller 2017) and seeing how the critical realist approach understands complexity. After drawing the conceptual model of impact of the policy under study and once

having understood where it has worked better, under what conditions and why (Pawson and Tilley, 1997, 2003), the research suggests that the critical realist approach could help in solving the challenges science policy evaluation encounters. I suggest an explanation to the relation of challenges such as an increased need to understand impact, the ever-changing context, the need to adapt to the methods to the variety of the demands, the need to have a broader view of the knowledge and its validity, and to be more useful and generate learning, could be solved through the realist features of a pattern of outcomes, the generative causality (Greenhalgh 2014), the theory as a unit of analysis, and the "emancipation for change", - a term created during my study meaning the rise in the implication of the policy makers in the process of analysis (Pawson, 2006) and the use of a policy oriented language. The study that I aim to present understands the complexity of science policy evaluation from the realist perspective and brings forward learning to the public administrations – by including my perspective as an insider at the policy department where the programme was running.

METHODS A programme theory driven realistic evaluation approach was pursued, through using qualitative methods and the techniques of documentary analysis, semi-structured interviews and participant observation. Data collection followed Maxwell (2012) approach in a realist setting. Designed in two stages for drawing the conceptual model of impact of the policy makers who designed the programme, and understanding the effects the programme had in the awarded centres, the research used three techniques: - The documentary review of both formal public information on the SO programme, and press releases and web information, and scientific and communication information on the awarded centres. - The 25 semi-structured interviews carried out with top policy makers and top awarded centres' research directors (20 centres). The UCL Research Ethics Committee guidelines were strictly followed. The double matrix NVivo query technique – first time used in policy evaluation - guaranteed the visibility of all the context-mechanism-outcome connections. - Participant observation was carried out in the work placement and through the visits to the centres to enhance understanding on the programme results with a conceptual refinement function (Pawson and Tilley, 1997). RESULTS The decision to apply a critical realist approach to understand the impact of the "Severo Ochoa" Centres of Excellence Programme was taken after having revised the ways the evaluation of science policy was carried out in general, and more specifically that of the performance based institutional funding instruments (PBIF) and centres of excellence (CoE). As a result of the analysis, a general way of evaluation was detected, focusing on performance, systemic changes and economic impact, and more specifically focusing on publications, on the broad changes in the scientific system, and in the economic activity. These studies fall under the positivistic perspective at large. For decades now science policy scholars had identified issues related to the approaches of evaluating science policy. My research brings forward through the realist evaluation of the "Severo Ochoa" Centres of Excellence Programme has used as a pilot study a new critical realist approach to understand from a realist angle the impact of the programme by addressing the science policy challenges. The results of the theory driven realist evaluation of the "Severo Ochoa" Centres of Excellence Programme that understood what works best, under what conditions and why in all the awarded centres during the first round of the programme (a total of 20 of them), highlights a wider range of outcomes with the realist lens to where the programme with its mechanisms worked better and why. Aspects such as scientific quality, impact, partnerships, sponsorships, strategy, governance, administration and management, relations with funders are analysed. In addition, 1) the research shows that talent attraction and retention is a prime effect of the SO programme. It has affected all the centres in terms of their capacity and ambition to attract and retain top world Human Resources in their field of activity. This effect shows no dependence on the contextual aspects in terms of the centre's ambition. The centres that have had autonomy in their Human Resources management have been more effective in attracting and retaining talent. 2) There are strong indications that the mechanism of funding with its dimension of flexibility/versatility has been important to enable growth in the awarded centres in all the contexts. 3) Agency and self-esteem is an effect that was drawn as a conclusion of the research, with no specific pattern in the contextual aspects. SIGNIFICANCE The critical realist perspective used here has enabled a rethinking of science policy evaluation responding to identified challenges of the discipline – it has brought novelty at both academic and policy level. It is the first time that a realistic approach is used in evaluating science policy. My presentation will outline how programme theory seen as a unit of analysis allows a broader epistemology, then it checks on the generative causality for better understanding of context, followed by the cumulative theory testing component for a more adaptable social inquiry; a pattern of outcomes for a greater accountability, and finally, emancipation for change for more and better use of policy evaluation. The contribution my research makes, beyond contextual or descriptive comparison, is the approach it takes to reach these results, focusing on a thorough understanding of the policy through the policy insider perspective. This specific study indicates that the investment in intense data collection and analysis, especially qualitative data can bring forward benefits on the effectiveness of possible changes to the policy instrument and the development of new policies, if that is the case. These changes would be backed with evidence that is possible to be drawn, all it requires is support and capacities. The integration of qualified staff as part of the evaluation process, from data collection to learning and policy design, provides an actual mechanism for this to be realised, compared with the more traditional way of outsourcing evaluations, seen randomly in public policy evaluations.

[6712] *The role of external knowledge in industry development and sub-market formation: the case of lithium-ion batteries*

Sergey Kolesnikov (University of Cambridge), Deyu Li (Utrecht University), Martin Beuse (E3/DC GmbH) and Laura Diaz Anadon (University of Cambridge).

Abstract

Background and Rationale

The development of many existing clean energy technologies and products has relied on the integration of knowledge and components that originated in different technological fields and industrial sectors. Therefore, to be able to design better public policies that support and accelerate clean energy innovation required for the decarbonization of the global economy, it is important to understand how such external knowledge contributes to the emergence and subsequent evolution of new technologies and industries.

Existing literature on industry evolution has emphasized the role of technological breakthroughs or discontinuities in the evolution of different industrial sectors, which is typically associated with undermining the competence of industry incumbents or enhancing the position of entrepreneurial new entrants. In many cases, these discontinuities are the result of technology spillovers that contribute external knowledge from other fields to innovation in the industry.

In this literature, industry disruption associated with technological breakthroughs usually leads to the emergence, growth, and eventual dominance of new sub-markets—specialized markets within a larger market. However, the emergence of sub-markets does not necessarily require technological discontinuity. Another stream of the literature suggests that sub-markets may also emerge in response to heterogeneous user needs, especially those unmet ones, offering an alternative to a supply-side view of the industry life cycle. It is not yet clear what role, if any, external knowledge plays in the emergence of sub-markets that serve new or previously unmet user needs.

In this study, we address this gap by investigating how external knowledge has contributed to the co-evolution of lithium-ion battery (LIB) technology and industry composition (i.e., actors and sub-markets) since the early 1970s. LIB is widely considered to be one of the key clean energy technologies contributing to global decarbonization efforts. The original LIB technology architecture emerged from a series of major scientific and technological breakthroughs which were awarded the Nobel Prize in Chemistry in 2019. More recently, the LIB industry has been dominated by the demand for batteries for electric vehicles (EV). These industry characteristics offer an opportunity to investigate both the supply- and demand-side perspective on the role of external knowledge in industry evolution.

Methods

We track how external knowledge has contributed to the co-evolution of LIB technology and industry composition over time by process-tracing external knowledge sources, main innovating actors, and the subsequent impact on technology and industry development for a set of 84 important LIB-related inventions assembled through a systematic literature review on the LIB history. In addition, for more recent inventions with a yet-unclear impact on future technology and industry development, we focused on inventions associated with 18 prominent companies and start-ups currently identified as promising by LIB industry experts, using Crunchbase to track the disciplinary and industry background of their founders and investors.

Results

Based on our findings, we divide the history of the LIB industry into four periods. The first stage, “incubation”, started in the 1970s with Stanley Whittingham’s discovery of electrochemical intercalation and concluded in the early 1990s with the commercialization of the first-generation LIB by Sony. In this period, the knowledge base of what we know today as the lithium-ion battery was formed by many scientific discoveries and technological breakthroughs, with most of them bringing external knowledge from other fields to solve critical scientific and technical problems emerging on a trajectory toward the first working LIB. Innovation during this period was mostly driven by researchers and inventors in large corporations, universities, and public research institutions.

A “stabilization” period followed the incubation stage during the 1990s when LIBs demonstrated superior performance compared to other rechargeable power sources and quickly started to dominate the market for consumer electronic devices. During this period, the LIB technology design stabilized, with the majority of LIB innovations being incremental improvements of different components or manufacturing processes developed by corporations to improve LIB safety, performance, and manufacturing cost. Notably, very few of these innovations involved external knowledge, indicating a decline in its importance for the LIB industry during this period.

The third stage of “expansion” started around the early 2000s when the market success of LIBs for consumer electronics attracted the attention of users and producers seeking alternative applications for LIB technology, such as power tools or electric vehicles (EV). Different and often unique user needs in these applications required adapting LIB technology to those needs, often relying on external knowledge about these applications. Furthermore, universities, also attracted by these opportunities and often supported by public R&D funding, leveraged their knowledge from other fields beyond LIB, such as nanotechnology or materials science, to experiment with alternative battery concepts or components that were previously abandoned or had not yet been commercialized but were now considered promising for new applications.

The fourth stage, "diversification", started around the early 2010s with the onset of demand-pull public policies that supported rapid growth in the EV market. The resulting dramatic increase in the demand for LIBs created a new rapidly expanding sub-market of LIB for EVs, which is characterized by multiple emerging and competing LIB and post-LIB technological trajectories rather than a single dominant technology design. Two new types of actors entered the LIB industry in this period. One is incumbent car manufacturers as actively engaged downstream users who bring a wealth of external knowledge from the automotive industry. Another is a booming number of start-ups, often created as university spin-offs, that seek to commercialize LIB innovations and alternative battery concepts developed in the previous period.

Significance for Policy

By analyzing the history of the LIB industry and technology, we find that external knowledge has been instrumental in the emergence and evolution of this industry. However, its relative importance varied over time. Initially, external knowledge provided a crucial contribution to the formation of the knowledge base of the emerging LIB technology. It was significantly less important during the stabilization stage. In the following two stages of expansion and diversification, which were characterized by the emergence and rapid growth of a new LIB sub-market for EVs, external knowledge, again, became important for the adaptation of the existing LIB knowledge base for new applications driven by user needs and demands. Particularly in the most recent period of diversification, demand-pull public policies provided crucial support for the integration of external knowledge into the LIB industry knowledge base by incentivizing the entry of new types of innovating actors.

Our findings provide important implications for policies supporting clean energy innovation. Policy mixes should combine supply-side and demand-pull policy instruments to facilitate the generation, identification, transfer, and integration of external knowledge into clean energy technologies. For example, R&D funding policies, particularly at the incubation stage, should be designed in a way that makes relevant external knowledge easily identifiable and accessible to researchers and inventors, e.g. by encouraging multi-disciplinary team composition and cross-sectoral learning. Demand-pull market incentives, particularly during the expansion and diversification phases, can attract new entrants to the industry, e.g., incumbents from other industries that provide external knowledge about promising new applications and user environments, or university spin-offs and start-ups that ensure technology lock-in is avoided. Finally, policies that support industry coordination efforts, e.g., through public-private partnerships or road-mapping exercises, can help identify and close gaps in the industry knowledge base where external knowledge can be productively applied.

[7337] *Research generality as a measure of interdisciplinary impact: A case study of the NC State Genetic Engineering and Society Center*

Zachary Brown (NC State University), Tisha Mentnech (NC State University) and Richard Li (NC State University).

Abstract

Many traditional research institutions in the past decade have significantly increased their investments in the creation of interdisciplinary research 'clusters' of faculty and scholars. These clusters are usually intended both to open new lines of intellectual inquiry and to bring a more concerted focus from diverse disciplinary perspectives on highlighted societal challenges, for example climate change and agricultural sustainability, global water and sanitation access, and the social implications of novel biotechnologies (the list goes on). However, measuring the impact of such interdisciplinary efforts remains a significant challenge to evaluating the return on these investments, and often traditional quantitative measures of research impact using bibliometrics and citation counts suggest mixed performance of such clusters compared to traditional academic departments (e.g. Yegros-Yegros et al. 2015). Yet administrators of research institutions and funding agencies continue in many cases to scale-up these investments, suggesting either that they are not making performance-based decisions on research investments or that they believe there is value to these investments beyond what traditional bibliometric evaluations imply.

In this paper, we propose a novel (as far as we are aware) bibliometric indicator of interdisciplinary research impact. Our proposed indicator is motivated by the empirical economic and innovation literature addressing patent value and quality (Jaffe and Trajtenberg 2002; Squicciarini 2013). In the patent literature, one measure of quality is the patent's 'generality,' defined as the unique number of technological areas embodied in the patent's forward citations. Intuitively, a more foundational, broadly applicable patent will be cited by subsequent patents from across a more diverse array of technologies. And some empirical research on the economics of innovation suggests that a patent's generality is partially predictive of its value, e.g. as proxied by renewals (Bessen 2008). An analogy to patent generality can be readily made in scientific research, based on the number of research areas embodied by the forward citations to a given publication.

We demonstrate the use of this generality indicator in a small-scale case study of the Genetic Engineering and Society (GES) Center at North Carolina State University (NCSU), launched in 2015 and which brought together six core faculty from NCSU departments of agricultural and resource economics, applied ecology, entomology, forestry and environmental resources, and public administration. Using our proposed generality indicator as our outcome of interest, we apply standard program evaluation techniques to assess whether the GES Center's formation affected the generality

of member faculty research. We conducted Web of Science (WoS) queries of all GES faculty research publications coming out five years before and after they joined GES. We also construct lists of 'control' faculty from the same disciplinary departments as GES faculty and with comparable academic rank and tenure, and perform the same WoS queries for these control faculty. From the 706 total research publications retrieved by these queries, we then obtain the current 9,184 citations to these publications and enumerate the number of unique WoS-classified research areas embodied by the citations.

We then take these data and use standard statistical models from program evaluation – namely, difference-in-differences (DID) regression – to evaluate the impact of GES Center membership on research generality. We find that, while GES Center faculty do not produce research that is significantly more highly cited than their departmental comparators, they do produce research that is significantly more general, i.e. each GES faculty member is cited across a wider array of research areas. For faculty with 100% appointments in traditional departments, we find a clear maximum of 10 effective citing research areas that any one faculty member can typically achieve. In contrast, the GES cluster averages 20 effective citing research areas per faculty member. We then go on to apply DID regression to evaluate whether these differences between GES and traditional departmental faculty are causal or selective. Preliminary results suggest that selection accounts for essentially all of the difference: That is, GES Center formation brought together faculty whose research had more general impacts, but does not appear to have produced more general research over the timeframe studied.

These results at a minimum strongly suggest that the proposed research generality indicator is able to bibliometrically capture unique performance aspects of interdisciplinary pursuits that can be used in research policy. For example, our results regarding the GES Center could have different implications for administrators of research institutions versus funding agencies: For example, finding a lack of causal effect from GES Center formation may be evidence of a failed investment from a funder focused only on shorter-term research output. In contrast, a research institution may have good reason to view a pure selection effect as a worthwhile outcome in its own right, e.g. to get faculty with high research generality to work together to build interdisciplinary capacity (which may in the long-run have greater albeit uncertain impact).

Of course, further validation of this indicator is necessary beyond a single, small-scale case study, and we would like to discuss future applications with attendees at the Atlanta Conference. There are also important practical details that may affect the broader applicability this indicator. For example, research area classifications are not objective and can vary significantly between different publication databases, e.g. WoS versus Scopus. In order to operationalize this indicator to inform research policy, future evaluations of its utility will need to be done with different databases and research area classification schema.

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[3877] *Government support to spur innovation in remote regions in Canada – Evidence from two Canadian Federal programs*

Claudia De Fuentes (Saint Mary's University), Joniada Milla (Saint Mary's University), Hao Lu (Saint Mary's University) and Soheil Ahmadi (Saint Mary's University).

Abstract

The impact of innovation efforts has been recognized as an important economic and social process due to the outcomes that it generates, both in terms of the production and accumulation of knowledge throughout the innovation process and the innovative products and processes that are generated to address a specific problem or demand. Governments throughout the world implement policies to support firms innovation decisions to innovate and to spur their innovation intensity, with the main objective to contribute to the social element of knowledge creation and innovation, and address social needs via the formulation of government priorities. Some of these forms of government support have a federal reach, while others have a regional focus and recognize the context specificities in the design of support programs. This paper aims to contribute to the analysis of the impact of two government support programs that have a regional focus. We contribute to the understanding of two main elements: i) input additionality specific for the Northern Territories and the Atlantic Provinces in Canada; and ii) output additionality, considering the main outcomes expected in the design of two prorams that operate at the regional level. Our results suggest that for input additionality, government support for R&D, contributes fo firms increasing their R&D investment in R&D and innovation activities. However, relevant to output additionality, our results suggest that these forms of government support have a positive effect on some of the outcomes

highlighted in the policy design, for example productivity and exports; while also contributing to longer-term effects that have wider impacts at the regional level, namely creation of jobs, and higher qualified jobs. This has important implications in terms of policy making, since government support contributes to alleviate the financial burden to engage in R&D and innovation activities, while at the same time contributing to improve firm performance, and job creation. However, we did not observe impact on some other outcomes highlighted by the policy design of these two instruments.

[9930] *Large-scale assessment of editors' impact on publishing in the social sciences*

Andrew Herman (University of Copenhagen), Mathias Wullum Nielsen (University of Copenhagen) and Jens Peter Andersen (Aarhus University).

Abstract

The scientific elite wield considerable power in shaping the evolution of scientific research (Azoulay et al., 2019; Chu & Evans, 2021) and reap sizeable rewards for their contributions (Allison et al., 1982; Merton, 1968; Xie, 2014). Opportunities to enter the scientific elite, however, are limited and are distributed with clear disparities across any number of social cleavages. This presentation reports on research that tackles the issue of publishing in elite journals, perhaps the most salient mechanism for entering the scientific elite (Heckman & Moktan, 2020), and in particular, the effect that journal editors have on that process.

Research shows that editors and reviewers are more likely to support papers that are closer in topic to their own research areas (Krieger et al., 2021), and which are written by academics who are nearby in the collaboration network (Dondio et al., 2019; Ductor & Visser, 2022; Teplitskiy et al., 2018), who have won notable awards (Huber et al., 2022), and are members of elite professional networks (Crane, 1967; Laband & Piette, 1994). Current estimates of editorial gatekeeping's effect size are small, but it is difficult to know how much confidence to place in these results, since much of this work is focused on contexts where an editor is unlikely to be an active gatekeeper on the one hand, or an effective gatekeeper on the other. We have a growing number of studies set in non-elite and in multidisciplinary journals (Dondio et al., 2019; Teplitskiy et al., 2018), while those studies that address elite journals have virtually all been in economics (e.g. Colussi, 2018; Ductor & Visser, 2022; Laband & Piette, 1994).

Our project will provide the most substantial evidence to date relating to an editor's effect on the publication process. We have collected the most comprehensive longitudinal dataset of journal editors in the social sciences, with over 3000 editors at over 1000 journals. This allows us to make examine the level of editorial influence in elite journals, specialist journals, and the broader mass of journals in each social science field. The breadth of the data mean that we can also provide some of the first looks at editorial gatekeeping outside economics in the social sciences.

To make full use of this data we are leveraging the Web of Science with state-of-the-art author disambiguation to assemble multiple measures of the distance between authors and editors. The Web of Science itself is used to assemble the collaboration network in science, the canonical approach to judging editorial gatekeeping. We also assemble the institutional affiliation network to provide an alternative view on the same principle of relational closeness. To further control for the topic similarity between authors' research and an editor's research we link papers to their SPECTRE document embeddings, high-dimensional text embeddings provided by Semantic Scholar. All of these measures of similarity are allowed to vary over time, not only as editors change at journals but also as researchers' (and editors') research interests evolve over time.

Using a series of field-specific relational event models (de Nooy, 2011; Quintane et al., 2014; Schecter & Quintane, 2021) we will report on the likelihood that someone gets published in elite journals, conditional on their distance from the current editor(s). We expect effect sizes to be small, but also for them to vary substantially across fields and across the journal hierarchy.

The most significant limitation to our research is that we do not have access to reviewers, nor can we pair them to the papers they evaluated. Editors of course can and do still wield power over the publication process, but it is typically less direct than that of reviewers. Another area where our design falls short of what would be ideal is that we cannot disentangle self-selection by authors themselves from editorial decision-making. Researchers at least in part—though this almost certainly varies dramatically across (sub)fields—make their choice of which journals to submit to on the basis of the identity of the current editor. This means that while it is entirely reasonable to speak of the effect that editors have on a person's likelihood of publishing in a given journal, it is insufficient to prove that owes to editorial gatekeeping, specifically.

Still, we are optimistic about our paper's potential. There are three main contributions we expect to make with this research. It will (1) provide a rare look at elite publishing practices in social sciences other than economics; (2) highlight variation in how editors affect elite publishing across several social science fields; and (3) document variation in terms of how editors affect publication across the hierarchy of journals within a field.

[8945] *Quantitative Modeling of Science-Policy Engagement – Leveraging Behavioral Science to Strengthen Legislative Science Advice*

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Abstract

Background and Relevance Techno-scientific innovation needs democratic guidance. For democracies to revisit societal values in light of technological transformation, science must rethink how to engage with legislators. Legislatures represent diverse constituent interests, act as a forum of debate on controversial issues, and scrutinize government action. Therefore, legislators are responsible for aggregating, articulating, and representing societal interests and values in light of scientific progress. Researchers, conversely, should contribute to the co-development of a shared knowledge base to inform parliamentary action and the direction of future research.

Knowledge Gap Previous behavioral science-based research addresses the behavioral determinants of researcher engagement with industry and the public, but evidence on science-policy interaction remains scarce. On the policy side, quantitative modeling remains focused on the executive. Therefore, evidence on the behavioral determinants of legislator research use is urgently needed to promote engagement effectively and efficiently.

Research Question Focusing on the individual engagement behavior of researchers and legislators, which personal and institutional factors drive engagement activities and research use? How can quantitative modeling inform change in the science system? The core hypothesis motivating the study is that the institutional support research organizations offer (e.g., incentives, resources, training, or recognition) promotes policy engagement.

Theoretical Framework The study adopts an interdisciplinary approach linking science-for-policy studies and behavioral science. The study leverages behavioral science theory to explain and model researcher-policymaker/legislator engagement behavior. The COM-B model, developed by Michie et al. (2011), structures the inquiry. The COM-B model posits that (C)apability, (O)pportunity, and (M)otivation determine (B)ehavior. Researchers can apply the COM-B model by operationalizing the domains for any target behavior. The unique advantage of the COM-B model among behavioral science models is that it systematically links the framework domains (C, O, M) to specific types of behavior change interventions. This linkage allows me to translate the research findings into actionable practitioner guidance for research organizations seeking to support engagement.

Data and Methods Situated in Germany, my empirical research design combines two methodological approaches: First, I conducted 22 qualitative interviews with highly-engaged researchers and legislators in Germany around a data-rich technology policy case study in early 2022 (A). Based on these semi-structured 30-60-minute interviews, I conducted a two-step qualitative content analysis. In the first step, I assigned primary deductive codes based on the COM-B model, and in the second step, I derived inductive sub-codes following Mayring (2000) and Hsieh and Shannon (2005).

Second, I developed and conducted two quantitative, psychometrically validated survey studies based on the COM-B model for knowledge ex-change behavior with 1,115 researchers and 162 legislators from federal and state parliaments in Germany in mid-2022 (B). The goal of the survey studies was to quantitatively test the external validity of hypotheses developed in the interview study (A) for larger samples of researchers and legislators using multiple regression analysis. The survey design operationalizes the COM-B model based on insights from the interview study and literature on science policy engagement. I leveraged or adapted validated item batteries wherever possible. To operationalize researcher policy engagement, the dependent variable, I adapted Tartari et al.'s (2014) Academic Engagement Index for policy engagement activities. I validated the selection of engagement activities in focus groups with 16 experts in the field of knowledge exchange.

Results Based on the interview study (A), I aggregated the core motivations of researchers for policy engagement, their institutional support, and engagement activities in a Sankey chart. The qualitative data supports the hypothesis that institutional support leads to more in-depth policy engagement. For legislators, the interview study findings demonstrate that they adapt their engagement strategies to their limited time, often prohibiting engagement with researchers whose communication does not meet their needs. Moreover, legislators tend to favor the field of their academic training. In general, they demand more researcher engagement and, in particular, more consideration for their needs as knowledge users.

The survey studies (B) compare the relative effects of variables in the domains of capability, opportunity, and motivation in driving science-policy engagement. I identified that for researchers, mission-driven motivation to solve societal problems and apply research findings is the strongest predictor of researcher policy engagement, followed by communication skills and institutional support. For the researcher survey, the multiple regression model explains 32.7% of the variation in policy engagement behavior (adjusted R2). For legislators, preliminary results suggest that motivation and capability (specifically, research literacy) are the strongest drivers of research use. In the area of opportunity, social influences (specifically, injunctive norms) promote evidence use. Different regression model specifications explained 40.9% to 44.4% of the variation in legislator research use.

Understanding the interplay of these three determinants (capability, opportunity, and motivation) can inform the design of evidence-based behavioral change interventions; for example, institutional support mechanisms for researchers engaging with policymakers/legislators. Ideally, such support structures should target the most critical determinants of engagement behavior to optimize their effectiveness.

Limitations Modeling human behavior is inherently challenging. Even methodologically rigorous survey research remains limited. This study has three limitations: First, survey respondents (and interviewees) self-selected to participate in the study creating the risk of non-response bias. Second, respondent errors or necessary parsimony may negatively affect their precision with which survey item scales capture the underlying constructs. Lastly, though the data may carry implications for science policy systems globally, I encourage caution in extending conclusions outside the study's German context.

Conclusions and Policy Issues As research organizations acknowledge their new responsibility as interlocutors in societal transformation processes, they are obligated to build institutional capacity. Specifically, they should create new organizational structures to support their researchers in integrating increasing demands for policy engagement with expectations for excellence in research and teaching.

Based on the behavioral model, I propose an evidence-based approach for research organizations to support policy engagement in practice- novel to Germany. My interactive practitioner resource catalog presents support mechanisms currently in use and highlights how they compare in terms of efficiency. By translating the study findings into actionable guidance for research organizations, I hope to contribute to more strategic, evidence-based capacity-building of organizational structures to promote engagement between research and policymaking.

[3926] *Exploring Alternatives for Measuring National Scientific Capacity*

Caroline Wagner (The Ohio State University) and Travis Whetsell (Georgia Tech).

Abstract

Rationale No standard measures exist comparing science capacity across nations. Many proxies attempt to capture the underlying construct or dynamic of scientific capacity. The Organization for Cooperation and Development (OECD) compares subsets of wealthy nations . The National Science Board's Science and Engineering Indicators Report compares a limited number of nations based on investment in R&D, performance indicators (output), an intensity indicator for eight nations (Table RD-7), and a comparison of country R&D performance for 17 countries (Table RD-8). UNESCO reports on national statistics and indicators in its Science Report . Data without a workable framework or theoretical construct inhibits comparisons for policy purposes, a gap which we seek to address with this study. Across the literature, we find authors choosing many different, distinct variables or clusters of variables to compare nations. These analyses are customized for the purpose of a single article, and they do not provide consistent measures. A descriptive theory of scientific capacity and a standard set of measures would help to compare nations. However, no research program has adequately examined nations conducting science to produce a useful set of indicators or a national science capacity index. This paper reviews the literature to identify and assess the variables used to measure national scientific capacity. A complex-systems heuristic is presented to hierarchically categorize indicators and provide a multi-level theoretical framework for the categorization of numerous indicators. Next, we present data regarding indicators of national scientific capacity and conduct an exploratory analysis to assess measurement coverage, clustering, and convergent /discriminant validity in relation to other well-established variables. Lastly, we seek to ultimately move towards a composite index of indicators which may be of use in both theory testing and policy decision making.

Literature Support This paper draws inspiration from earlier efforts to compare nations on science capacity (alternately termed 'impact' (King, 2004), 'wealth' (May, 1997), or 'productivity'' (Cole & Phelan, 1999). Each of these measures has merit in themselves, but they do not disambiguate the individual national measures to an internationally comparable set--which we acknowledge is a challenging task. We approach this task by, first, defining the construct of interest as one of 'capacity' rather than productivity or impact—since those latter features will include contributions from international collaborations, which confound measures of national strength. We view capacity as the explicit and latent resources, capabilities, and competencies available to a nation to absorb and exploit new knowledge from wherever in the world it emanates (Porter, 2011). Capacity will not always be evident in outputs such as number of papers published or number of citations, or as inputs such as government or private sector funding. Thus, additional measures related to scientific and technical human capital (Bozeman, Dietz, & Gaughan, 2001)., regarding number and quality of researchers in a nation are important. So too needed are measures that capture the position of the nation within the international network of scientists (Whetsell, 2022), as nations may leverage relationships and network position within the system to deploy domestic capacity. Measures of national infrastructure, rule of law, political climate/academic freedom, and regulatory quality also need exploration (Coppedge et al. 2011; Grimm and Saliba, 2017). By proposing a broader approach than taken by King or May, we combine measures to propose a composite index. The index will distinguish among inputs, capacity, and outputs, with a complex systems view of hierarchical but loosely coupled interdependence between inputs,

capacity, and outputs (Simon, 1996). Further, complex systems theory suggests that measures across nations often manifest empirically in highly skewed distributions that suggest power law dynamics where we can test efficiency of national systems (Katz, 2006; Wagner, 2009).

Methods Science capacity can be defined as the resources, capabilities, and competencies needed to create and support knowledge creation, conduct research and development, and disseminate science. Nations invest in science capacity in accordance with policy to the extent that resources are available. In the 21st century, in imitation of the wealthy nations, many more nations have adopted a science policy that targets science capacity building, and with some success. Data are now available that were lacking just a few years ago. We suggest that a greater variety of indicators can be used to assess national capacity to increase the "likelihood of converging to an accurate understanding of knowledge produced by research" (Kostoff, 1995, p.8) where a collection of indicators is more likely to give a better evaluation of research strength than one indicator alone (Martin, 1996). We begin by exploring the usefulness and complementarity of more than 12 indicators, grouped into three theoretical domains of their tiered contribution to science capacity: 1) facilities and infrastructure are needed to support and build capacity, represented by national wealth, and an educated populous who contribute to and create demand for knowledge economy; and social order and political environment; 2) means by which science is conducted, including numbers of trained scientists and engineers; R&D spending; institutions and equipment, and openness to international engagement; and 3) output of scientific and technological knowledge and its diffusion to the larger world through coauthorships; scholarly articles; citations and their impact; teaching; and patents as a proxy for embedded knowledge and demand. Frame (2005), in attempting a similar project, noted that "quantitative indicators of scientific and technological activity are often of questionable validity and reliability. This is particularly true in lesser developed countries, where the lack of data gathering skills may frequently result in the development of misleading indicators…." Frame did, however, find correlations among a similar set of indicators to those used in the current study (science and technology manpower data, expenditure figures, student enrollment in higher education, and number of degrees conferred), suggesting that the approach can have some validity. Data have improved. The Frame approach has new validity.

Efficiency of Investment A composite index of scientific facilities, means, and output could provide a useful measure of national science capacity, which we explore. We note that, at the time when variables were collected, capacity may be underused, used efficiently, or a nation may be outproducing what would be expected based on inputs. Thus, capacity should not be viewed as a fixed state but rather a continuous dynamic state that has here been measured at just one point in time, so dynamics must be considered in future research. As with any complex system, change and interrelationships are non-linear and there are multiple sites of agency with intricate levels of causality that cannot be fully captured in an index. To go beyond our variables and give a sense of science efficiency among nations, we will consider a Triple Helix (Leydesdorff & Etzkowitz, 1996) context—and explore how to contributions of these characteristics can aid in efficient use of resources.

Conclusion In this paper we propose an approach to measuring national science capacity based on a set of indicators, tied to previous research, presented within a complex-systems theoretical framework. We attempt to apply these concepts to compare the scientific facilities, means, and output of nations. We hope that the approach suggests pathways forward for the community to create useful tools for assessing current science capacity and for supporting international collaboration, and we look forward to comments.

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[7593] *Innovation in Capacity Building for Applied Policy Research: The Advanced Rehabilitation Research Training (ARRT) Project - "Inclusivity at the Edge"*

Nathan W. Moon (GA Tech/CACP), Paul M.A. Baker (GA Tech/CDAIT) and John C. Bricout (University of Minnesota, School of Social Work, Workforce Development and Research Lab).

Abstract

Background and rationale The field of disability and rehabilitation research has well-developed literatures with regard to the science of rehabilitation as well as extensive research related to the broader field of disability studies. Much of the work, however, focuses on the condition of the individual relative to barriers and associated barrier mitigation, and it is less related to the larger policy and regulatory contexts within which the field and their associated stakeholders operate. Thus, there remains a gap and, consequently, an opportunity at the intersection of rehabilitation, technology, and enabling policy to enhance and advance the full participation of people with disabilities, and the aging, in workforce participation, as well as social and community activities. The nature of policy broadly impacting people with disabilities can be seen as a spectrum of interrelated, though distinct, domains: ranging from medical reimbursements to mandates for equitable employment and community participation (Title I of the Americans with Disabilities Act and rulemakings by the Office of Disability Employment Policy), to regulations and policies governing accessibility and usability of assistive technologies (Rehabilitation Act and rulemakings by the U.S. Access Board, FCC, and FDA). A new generation of "smart" and connected objects with assistive potential, has become available, ranging from wearable computing devices (wearables) worn by individuals to connected physical objects in the environment such as sensors and specialized displays. We refer to this connected ecosystem, in the broadest sense, by the common term "Internet of Things" (IoT). The design of these devices and their services, and associated policy, remains largely open and unfixed, thus presenting opportunities for the active participation of people with disabilities, alongside designers, developers, and manufacturers, to address unmet social, cultural, and technical needs. An inclusive design process, taking into consideration the characteristics and needs of a wide range of users during the conceptualization of the devices, rather than after they have been developed, can proactively address such issues as technology abandonment or discontinuance while enhancing acceptance of these technologies as socially acceptable and culturally appropriate. It is important that the intelligent devices in the IoT be trustworthy and able to resist cyber-attacks. Progress gained in wireless, digital and technological accessibility must be diligently maintained in next-generation technologies, which requires an understanding of, and engagement with, policymaking to ensure the accessibility and usability of these technologies for individuals with disabilities. This paper presents the structural framework guiding an in-progress policy innovation - Georgia Tech's Advanced Rehabilitation Research Training (ARRT) Project ARRT program, a five year project funded by National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR) is designed to train rehabilitation engineers and disability-focused specialists to develop and evaluate policy oriented toward advancing the adoption of information and communication technologies to enhance the engagement opportunities.

Approach/Methods Wirelessly connected devices such as IoT, wearable devices, voice assistants, and sensor-based applications, can be used to help a person increase their personal independence by improving both personal capabilities (i.e., the ability to control one's environment, including lights and temperature) and contextual accessibility. Iteratively, the inclusion of target populations in an authentic participatory process helps designers, researchers, engineers, and industry collectively innovate. It also contributes to capacity building solutions to the challenges faced by the aging population and people with disabilities, incorporating the innovated solutions with inclusive policy and accessible technology. More broadly, it can impact and inform the development of policy, assuming the underlying technological systems, data collection, and analysis are suitably designed and deployed (Farmer, Bricout, Baker & Solomon, 2022). Policies and healthcare systems should rely on quantitative data to ensure the best impact on society, but no database exists that represents the aging population in a holistic and deep way, making it difficult to create effective personas. The ARRT program is based on an iterative policy design process that couples problem identification with stakeholder participation to generate policy responses. In this case we started with the basic program design and objectives, and prepared foundation material used to run a stakeholder-face design workshop that was used to generate input to refine the program parameters for the selection and training of 4 postdoctoral policy fellows. This workshop initially considered the following questions: - How is "inclusivity" defined, and who decides what is/isn't inclusive? - What is the relationship between accessibility and inclusivity? - What is the role of policymaking and regulation in this? - What of other issues related to ethics?

Value-sensitive design (VSD) allows ethics to be inscribed into the design process, and participatory design approaches can help ensure ethical products (policy/technology) from start-to-finish, but the policy implementation process can undermine positive design effects by leading to inequitable access, roll-out, or quality. Evidence suggests, for instance, that with effective communication AI can enhance human design teams. AI institutes shared practices when working in collaboration with humans, both engaging and influencing human capabilities and values. As such, we must consider how AI affects human well-being. As human-AI (including human-robot) collaborations are becoming more common new ethical frameworks must be developed. Technology policy must incorporate more inclusive design processes that include

underrepresented groups such as people with disabilities, and there is a need for policies to anticipate ethical issues around AI accountability, responsibility, and accessibility. A second round, participant driven exercise then considered the following questions: - What policy opportunities exist? What barriers remain? What are the met and unmet needs through policy? - What tools, policies, and practices (and technologies themselves) can address ongoing needs? Following consideration of these discussions, we next deliberated on what would be guiding parameters for training policy professionals, through Georgia Tech's Advanced Rehabilitation Research Training (ARRT) Program on Inclusive Technology and Policy Design. Approaches included: • Hybrid or virtual co-worker model for Fellows working remotely from one another • Apprenticing (short-term) with technology developers, workforce trainers and vocational rehabilitation • Focus groups and feedback sessions with consumers and their family members on value- and user-centered technology design, development and adaptation • Annual convening with Fellows and ARRT Research Team

Initial Results The workshop structure was based on three sequential steps: 1) a context session considered the diversity of people with disabilities, for whom their disability experience influences, and is influenced by, identity, demographics, institutional factors, cultural interactions, socioeconomic status (i.e. poverty), and structural factors (i.e., systemic racism, ableism), 2) a policy session, where participants noted a disconnect between legislative mandates and emergent policies that do not always reflect their intention, whether due to lack of funding, technical guidance, and 3) a design parameters session for a program of postdoctoral training of practitioners capable of engaging the issues raised throughout the afternoon. Culminating in a final set of recommendations, five major themes for effective training emerged: 1) attention to design parameters based on inclusivity, ethical and meaningful participation, 2) sensitivity to factors associated with identities, language, community context, and culture, 3) an ability to engage, and "speak to the person," while recognizing the presence of multiple audiences and perspectives, 4) the need to anticipate need, aspirations and expectations, and 5) the role of "frames" (i.e. the shaping of interpretation of social problems from specific perspectives) and an ability to understand the impact of different frames (e.g. policy frames, design frames) and reframe as needed.

[5146] *[Panel Proposal] Quantitative Methods for Assessing the Use of Research Evidence in Legislatures*

K. L. Akerlof (George Mason University), Henriette Ruhrmann (Technical University Berlin / University College London), Afagh Mulazadeh (University College London) and Basil Mahfouz (University College London).

Abstract

Research on the conditions under which evidence use is most likely to occur in legislatures has historically been hindered by limitations in available data and relevant metrics. Without formal systems for the citation of evidence, tracing the policy impact of engagement between the scientific and legislative communities can be challenging. However, new methodologies may offer the opportunity to address these deficits and, in turn, build scholarship on evidence-based policymaking processes and reveal ways to bolster institutional capacity for decision-making on complex scientific and technological issues.

Four interdisciplinary studies from the United States, United Kingdom, Germany, and international datasets illustrate the development of potentially transformative quantitative methodologies for the study of evidence use: machine learning, natural language processing (NLP), and behavioral modeling. K. L. Akerlof and colleagues employ data analytics and machine learning to explore institutional patterns in citation and quotation from the U.S. Congress and National Academies of Sciences, Engineering, and Medicine (NASEM). Similarly, Afagh Mulazadeh's study identifies and analyses the explicit sources of scientific knowledge on antimicrobial resistance used in UK parliamentary scrutiny by applying NLP across two corpuses she is building using open data and Elsevier's International Center for the Study of Research (ICSR) lab database. Combining ICSR and Overton databases, Basil Mahfouz analyzed more than 15,000 education policies published by governments throughout the COVID-19 pandemic to evaluate if decision makers used the 'best' available scholarly knowledge. In contrast, Henriette Ruhrmann from the Technical University Berlin applied quantitative behavioral modelling based on psychometrically validated survey data from 1,115 researchers and 162 legislators in Germany to predict science-policy engagement.

These techniques from the computational and quantitative social sciences offer the potential to shed new light on how legislatures use evidence, what types of evidence, and what drives researcher engagement and its use by legislators. Focusing on legislatures is a highly relevant extension of an existing body of research on science use for policy that predominantly focuses on the executive branch of government. Further, the methods enable researchers to evaluate the effectiveness of legislatures at using scholarly research, at scale and with the potential to replicate the studies in different geographic contexts. The panelists will also describe current methodological challenges.

Panelists & Presentation Titles:

• Akerlof, K. L. Detecting Evidence Citation and Quotation in the U.S. Congress: A Methodological Case Study • Ruhrmann, H. Quantitative Modelling of Science-Policy Engagement – Leveraging Behavioral Science to Strengthen Legislative Science Advice • Mulazadeh, A. Identifying and Analysing the Explicit Sources of Scientific Knowledge Used in

UK Parliamentary Scrutiny: A Case Study on Antimicrobial Resistance (AMR) • Mahfouz, B. School Closures: Did Policy-makers Use the Best Science in Designing Education Policy During the COVID-19 Pandemic?

[6346] *A Toolkit for Demonstrating Societal and Economic Impact of University Research*

Andrew Plume (Elsevier BV), Christina Zdawczyk (Elsevier BV), Alice Li (Cornell University), Patrick Govang (Cornell University), Nick Fowler (Elsevier Ltd) and Mark F. Hurwitz (Cornell University).

Abstract

Background and rationale The demonstration of the societal and economic impact of a university remains challenging owing to a paucity of data that connect the education and research activities of the institution to short- and long-term outcomes. We have pursued the connection between education (PhD alumni) and economic (employment) outcomes and the connection between grant income (research) and patenting (innovation) to demonstrate how actionable insights can be developed for one institution (Cornell University).

Methods In this study, we have linked and enriched data available within Cornell University with datasets relating to career outcomes from an online social network and research publications to demonstrate the post-graduation career trajectories of doctoral holders. We have also linked research grants, publications, and patents awarded to Cornell researchers to explore gaps in translation activities from the funding inputs to the research and innovation outputs of the university more directly. This work was conducted under an approved IRB protocol requiring all personally identifiable information to be held securely and only aggregated deidentified results distributed beyond the authorized project team.

Results Using a cohort-based approach, we have determined the current employment of all PhD alumni from two Cornell colleges with a high degree of precision and recall. Across the cohorts studied (graduates from academic years 2000, 2005, 2010, 2015 and 2020) we were able to show that 79% could be unambiguously identified in a popular online social network using just their full name and known former affiliation to Cornell University. Of these, 1 in 10 alumni leave the US shortly after graduation while more than 78% remain in the US up to 22 years post-graduation. Of those that remain in the US, alumni are predominantly based in a small number of north-eastern and western states with high background rates of PhD employment. Half of Cornell PhD alumni are currently working in industry, and another one-third in education; the remainder are largely in government or non-profit organizations. For graduates working in industry, government and non-profit sectors, 'scientist', 'engineer' and 'researcher' roles are most common. Additionally, we anticipate that the exploratory work linking research grants to publications and patents will be able to help identify different patterns of funding sources tied to innovation outcomes based on research focus or department at Cornell. By comparing these links across departments at Cornell, we expect to uncover gaps between funding and levels of engagement in innovation activities and understand whether these differences can be partially explained by relative focus on basic to applied research activities.

Significance Our analysis of PhD alumni career outcomes indicates that the value of the research-based education and training that the higher degree reflects is retained in the wider economy irrespective of whether the individual pursues an academic career path or exits the sector. In the case of Cornell University, those that do leave academia tend to remain within the US, gravitate towards parts of the country where knowledge-based work is abundant, and occupy roles that capitalize on the knowledge and skills they developed during the course of the PhD. The anticipated findings from the work exploring linking Cornell grants to innovation outcomes will help identify existing practices within departments that could benefit from Cornell resource investment, enabling the university to focus on specific academic units in supporting translation activities for societal and economic impact.

Conclusion We have shown in this work that the societal and economic impact of an institution such as Cornell University can be demonstrated by combining data available within the university with other publicly- or commercially-available datasets. To that end, the economic benefit of PhD alumni who remain within the country and take up employment beyond academia that utilizes their doctoral training and skills can be effectively demonstrated, and the innovation outcomes of research-oriented grant income can be connected directly through advanced mapping approaches. Taken together, we suggest that this is the beginnings of a toolkit that other institutions may wish to develop and adopt for their own specific circumstances and that can inform and monitor university strategy and policy-making.

[4448] *Detecting Evidence Citation and Quotation in the U.S. Congress: A Methodological Case Study*

K. L. Akerlof (George Mason University), Lazar Kovacevic (Inverudio Inc.), Dieter Pfoser (George Mason University, Dept. of Geography and GeoInformation Science) and Erica Goldman (Federation of American Scientists).

Abstract

Background and rationale As policy issues have increasingly become scientific and technological in nature, research information pervades the work of legislatures. Yet, since the U.S. Congress has no requirement to cite its sources, it remains unclear where the evidence comes from, who is using it, how, and to what end. These represent core questions about how science impacts society on which new techniques in data analytics and machine learning may be able to shed light. We investigate the extent to which digital records from the U.S. Congress can reveal patterns in evidence citation and quotation through a case study of an organization mandated to provide government advice, the National Academies of Sciences, Engineering, and Medicine (NASEM). As a private, non-profit organization congressionally chartered during the Civil War, the National Academies is directed to "investigate, examine, experiment, and report on any subject of science or art" for any department of government. This presentation will review methodological challenges and findings from three types of analyses of congressional and NASEM data: 1) which entities in Congress cite the National Academies most frequently and in what contexts; 2) co-occurence of National Academies references with named entities; and 3) the development of techniques for identifying National Academies quotations in Congressional documents.

Data All available text from U.S. Congressional data—hearings, bill text, committee prints, and the Congressional Record and reports—were downloaded between June-October 2022 from govinfo (API), the Sunlight Foundation and GovTrack.us-maintained Congress github site (bulk) and Propublica (bulk) sources. National Academies consensus and workshop reports were downloaded from the NASEM site in HTML form in May 2022.

Approach overview Meta-data and processed information was deposited in a mongodb document store. The document data was analyzed using a python-based data mining approach. Our ETL (Extract-Transform-Load) process used minimal steps during the transformation phase. Data was loaded locally as it was available. Minimal metadata was associated with files to enable matching across various sources, i.e., subsequent versions of the same bill have different abbreviations in the file names. Only the latest version of a bill/document has been used. The content itself of the document was converted to text from original html or pdf format. For data analysis we used Python and its libraries sbert, sklearn, and faiss; mongodb for meta data storage and full text index; and Pdf2jpg and easyocr for image-based PDF-to-text conversion.

Analyses For the first two sets of analyses, we identified named entities and their co-ocurrences within all sentences in the congressional document texts, limiting the results to those related to the National Academies. In order to detect Congressional quotation of NASEM documents, we conducted a three-step analysis. First, all sentences from the NASEM reports were indexed using faiss with their vector embeddings using the sbert sentence transformers library and its pre-trained paraphrase-multilingual-MiniLM-L12-v2 model. All sentences from congressional documents were also embedded with the same sbert model. For each sentence within the congressional documents, the top 10 most similar sentences from the NASEM reports were selected for more detailed analysis in steps two and three. In the second step, common legal verbiage, such as the titles of acts and statutes, were removed using a SVC (support vector classifier) trained on sbert embeddings of selected human coded (labeled) sentences. Finally, unlike in the first step, which measured semantic similarity based on vectors, exact phrase-based quotations were identified, based on matching of k consecutive tokens. We experimented with k and (no)stemming.

Results Initial results illustrate the frequency with which the National Academies (sciences, engineering, and medicine, and the National Research Council) have been cited within congressional hearing and bill text between the 103rd and 117th sessions of Congress. Within all available bills and ~95% of downloaded hearings at the time of the analysis, 332 bills and 188 hearings referenced the Academies, which represents ~0.2% of total texts. Most of the citations are for the National Academies (216), National Academy of Sciences (127), or National Research Council (94), with fewer references to the National Academy of Medicine (26) and Engineering (6). Bill meta-data indicated that the following topics were areas in which the Academies were most likely to be cited: health, armed forces and national security, and science, technology, and communications. The committee hearings most likely to reference the Academies in bill texts include: House Committee on Science, Space, and Technology, House Committee on Appropriations, and House Committee on Veterans' Affairs. The committees associated with the bills that cite NASEM most often include House Energy and Commerce, House Transportation and Infrastructure, House Science, Space, and Technology, and House Armed Services.

Anticipated results A more comprehensive named entity recognition (NER) and co-occurrence analysis is still being processed and will be available with faceted analysis in relation to various government document properties, like the few mentioned above. In the third analysis we distinguish between potential directionality of the quotation based on the sequence of publication dates, i.e., whether the text was published in congressional or NASEM documentation first. We note that many 'quotations' actually refer to previous congressional documents, further, many of the semantically similar sentences refer to different concepts, documents, or events. To address the noise in the findings, the sentences have been stemmed and the analysis conducted on a longer sequence of k consecutive tokens, starting with 8 tokens. We will show examples of successful quotation detection as well as false positives.

[8082] *Teaching a virtual dog new tricks – Drawing intelligence from science, technology, innovation and policy documents*

Catherine Beaudry (Polytechnique Montreal).

Abstract

This purposefully multidisciplinary session brings together science, technology and innovation (STI) scholars with specialists of natural language processing (NLP), machine learning (ML) and other text mining experts, as well as subject matter experts in economics and management of innovation, sustainable development, climate change adaptation and mitigation.

Dramatic and extreme climatic events have filled our screens and daily lives with the reality of the challenges that lie ahead. As the planet overheats, we must collectively put our shoulders to the wheel to identify the best solutions to reduce, and even erase, our carbon footprint. Climate chaos knows no frontiers, which warrants a coordinated approach. STI are crucial parts of the solution, and the scale of collaboration required is unprecedented. Policy makers of all countries need to understand the incidence of each other's policies. Most data gathered and analysed focuses on a single country or region. We need to intermingle and cross-analyse these policies, mechanisms, impacts is a more coordinated way. As time is ticking, we need to accelerate the way we analyse and react to these changes (both climatic and policy-wise).

Beyond their traditional measurement and evaluation purposes, indicators also act as powerful incentives. If we are to identify and monitor in real time the policies that work best on let's say climate change mitigation, we need more rapid and (semi-)automated tools. As more and more new data (websites, Internet, online policy documents, etc.) become available, ML and Deep Learning applied to these textual data represent a source of newness for Humanities and Social Sciences. Their potential can been exploited to build new tools that assist policy makers, companies executives and researchers to foster or analyze the innovation process.

This session will concentrate on identifying the lessons drawn from using traditional qualitative methods to analyse climate policy documents and "responsible" certifications, build indicators and stringency metrics, compared with what would transpire from an NLP-based approach. After a brief presentation from the three panelists highlighting different and complementary points of view, the session will launch into a discussion between the panelists and with the participants regarding the challenges and risks linked to analysing STI documents and policy documents using automated techniques, counterbalanced by the advantages and value of such an exercise. They will reflect on the last development in NLP, in order to build new methods and indicators, the advantages and disadvantages that Transformers models, such as BERT (the virtual dog of the title), have after a fine-tuning process on specific tasks related to STI domain.

The discussion will also address the measurement and evaluation possibilities and challenges of using these types of data combined with new data that stem from the web (e.g., from corporate websites and certification databases such as B-Corp). For instance, the panelists and participants will be asked to reflect on the level of understanding of the text that is required to build indicators that stem from new web-scraped data: Does a crude measure/count suffice? Or is a more in depth understanding of the text required?

Titles and short abstracts of the three papers:

Evaluating Canadian Climate Policy Mix Stringency

Alaz Munzur, William Scott, and Jennifer Winter University of Calgary

Jurisdictions around the world implement a mix of policies to mitigate climate change, which are increasingly complex and exhibit substantial variation in coverage and stringency. Comparing policy progress and assessing policy impacts requires understanding the relative stringency of climate policy mixes between and within jurisdictions over time. A variety of indicators have been developed to compare policy effort between countries but, such approaches fail to capture the subnational heterogeneity present in federations such as Canada and the United States. This project seeks to fill this gap by developing a comprehensive climate policy database for Canada and a subnational climate policy stringency index.

Digital tools for tracing policy action through COVID-19 - Exploring the innovation strategies of 24 countries with natural language processing

Hunter McGuire, Jan Einhoff, and Caroline Paunov OECD Directorate for Science, Technology and Innovation

This paper applies natural language processing (NLP) to understanding how countries' vision for science, technology and innovation (STI) priorities has evolved through COVID-19. The analysis was conducted on a sample of 313 STI strategy documents from 24 countries that were released between 2013 and 2021. Structural topic modelling, an NLP technique for exploratory text analysis, is used to analyse these documents across a variety of thematic topics. This approach finds that STI strategy documents issued after the COVID-19 pandemic have not substantively changed the topics that they discuss. It also suggests that environmental sustainability, while an important overall priority, has a considerable variety of meanings in different national contexts, that competitiveness remains a goal both before and after the pandemic began, that employment is an important goal in STI strategy, and that digital technology, infrastructure, and data are all treated as important tools for innovation in the future.

Creation of new indicators with a specialized Deep Learning model for innovation studies – Testing the B Corp Certification

Davide Pulizzotto, Pietro Cruciatta, Michaël Héroux-Vaillancourt, Catherine Beaudry Polytechnique Montréal

This paper proposes a tool that uses web-based data to provide new indicators on numerous innovation dimensions. We built this tool based on recent advances in Natural Language Processing (NLP), in particular the creation of pre-trained language models like BERT that seems to better capture the semantic facets of natural languages. The algorithm and the data allow the tool to have several advantages such as real-time analysis, minimum building cost, granularity and large sample size that make it appealing.

Thus, we first develop a specific BERT model, provisionally called InnovBERT, and then we use the tool to create an indicator of the environmental culture of companies. This topic was chosen because the dramatic climatic events of the last years bring a sense of urgency and push the government's need to allocate more funds to further promote environmental protection and the sustainability culture of companies. We test the tool on the B-CORP dataset which provides scores on the environmental performances of thousands of companies. Our hypothesis is that the environmental indicator provided by the tool is correlated with the score given by the B-Corp organization.

[8829] *Making Urban Sustainability Transitions happen: Transformative Innovation Policy in Six European Cities*

Lasse Bundgaard (Université Gustave Eiffel), Gudrun Haindlmaier (AIT Austrian Institute of Technology & University of Vienna), Philippe Larédo (Université Gustave Eiffel & University of Manchester), Rémi Manesse (Université Gustave Eiffel), Mireille Matt (INRAe), Tatjana Neuhuber (University of Vienna) and K. Matthias Weber (AIT Austrian Institute of Technology & Université Gustave Eiffel).

Abstract

Background and research questions Against the background of a steadily rising rate of rapid urbanization and the mounting pressures imposed by climate change, pollution, austerity, aging populations, limited resources and inequality, cities are facing unprecedented challenges along with potential disruptive events and external shocks (Fastenrath et al., 2019). Cities are not only particularly vulnerable to these challenges, but also well-positioned to address and navigate these changes through the tools of urban innovation policies in conjunction with other local policies (Bulkeley et al., 2019). In fact, with the shift of political agendas to matters of sustainable developments, the center of gravitation in innovation policy is shifting from national to urban and international levels. Cities are knowledge centers in their national economies; multiple actors with resources and capabilities can be mobilized in local milieus to experiment, co-shape and co-design solutions in order to build resilient and sustainable systems (Bulkeley et al., 2016; Fuenfschilling et al., 2019; Geels, 2005;).

Our research thus starts from the following assumptions: - Pro-active innovation policies are emerging at the local level, accompanied by the novel tools and activities available at this level too. Formulating, experimenting with and implementing novel policies and solutions in cities differs significantly from other levels of government, but is not yet well understood. - Cities are democratic entities where futures are imagined and alternative directions of change are contested through much more direct citizen feedback than at higher policy levels. Cities formulate overarching visions and policies, yet initiatives tend to be placed within sectoral departments, usually characterised by strong fragmentation, which complicates the horizontal cooperation needed for experiments as well as collaboration with internal and external actors and stakeholders. - The most daunting step in transition policies is to move from individual experiments to broader and generalised transformations. In order to enable sustainable transitions, local contexts will need to address all stages of the policy cycle from envisioning and design to implementation and learning, in order to generalize innovative solutions and thereby contribute to a wider transformation process. Moreover, local policies are also required to practically address emerging constraints and mobilise the opportunities offered by national and transnational/European policies in order to accelerate transitions. Generalisation of innovations is driven by yet another important dimension in the context of urban innovation policies, namely the mutual learning processes across cities. Current European policy initiatives try to foster cross-city replication and adaptation processes.

The objectives of this paper are i) to propose a conceptual framework for Transformative Innovation Policy in Cities that takes into account the aforementioned changing features of urban policies for sustainable transitions, ii) identify common patterns, differences and their determinants across a range of cities in Europe, iii) point to some lessons learned from these experiences for urban innovation policy in general.

Approach and methods Underpinned by literature research, a series of internal workshops and a preliminary study on the case of Amsterdam (Bundgaard et al. 2022), we have developed as part of an abductive research process, a five-layer conceptual framework. The Framework seeks to better understand the processes of shaping and implementing both incremental and transformative innovation policies in the urban context. This framework covers the guiding visions

behind transformations, the mental models underpinning innovation policy, the organisational and institutional structures and processes for – mainly incremental – innovation, the spaces and conditions for experimenting with radical novel solutions, and the processes of transformative generalisation to turn these experiments into widespread practices. Based on this framework, six case studies have been conducted in three European countries(Sweden: Lund and Malmö, in France: Pau and La Rochelle, in Austria: Linz and Klagenfurt). By assessing and comparing the preliminary results of these cases we aim to deepen our understanding of advanced practice in their pursuit. The empirical investigation is based on secondary sources on strategies and policies of the six selected cities and a programme of interviews with policymakers, partner organizations, CSO's and other stakeholders, to complement and refine our theoretically founded framework and allow us to further explore the instruments and activities relied upon for the purpose of transformative change further. The framework is planned to be operationalized and made accessible to policymakers through a series of workshops over the course of 2023.

Expected results Through this work, we expect to identify what policies, instruments, activities and actors are central to the emergence of sustainability-oriented innovation and transformation policies in cities. Moreover, we want to develop more differentiated hypotheses on the influence of the respective national contexts on the scope and practices of urban innovation policy, by taking into account both the differences between the institutional conditions in the three countries, and how they determine what kinds of policies are actually promising and feasible. Building on this knowledge we expect to provide insights into "good practice" in terms of what can proactively be done by municipalities and other stakeholders to facilitate and steer cities towards sustainable futures. Through the advancement of our conceptual framework, we hope to devise novel inroads for how Transformative Innovation Policies in Cities could be better understood, designed, assessed and ultimately improved.

Significance of research approach and findings There is a growing demand for novel sources of inspiration and knowledge to help city authorities develop and implement truly transformation-oriented policies and thus to better cope with the challenges of sustainability in an increasingly turbulent global and societal environment. Solutions for complex challenges call for inter- and transdisciplinary approaches. Current policy and governance challenges are characterized by high uncertainties in transformation processes, multi-actor settings and often face a shortage of organizational capacities and domain/system knowledge to design, implement and manage complex change processes. Consequently, the framework developed is fed by contributions of scientists from different backgrounds and disciplines (such as sociology, urban planning, economics, geography, political science, innovation studies etc.), who apply the respective context-specific lenses on the case studies in the selected cities. Moreover, it is inspired by dialogues with practitioners from local authorities to European policy and various stakeholder organisations. With these ingredients, we hope to mobilise our insights for a more transformative governance of cities.

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[4803] *Gender and transformative innovation in Africa: Strategic policy interventions to enhance participation of women in the 4th industrial revolution.*

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Abstract

Overview This paper explores changes in policy interventions required to enhance the participation of women in transformative innovation and the 4th industrial revolution in Africa. Based on a narrative inquiry into the lived experiences of 20 female entrepreneurs and innovators in selected marker spaces in Johannesburg, S. Africa and Nairobi-Kenya, the findings highlight key attributes and managerial competencies which women naturally possess and are key to transformative innovation processes; which if harnessed could help them overcome the major barriers and constraints they face in the innovation and entrepreneurship fields. The paper contributes towards the growing literature on gender and innovation in Africa and could guide strategic policy interventions towards enhancing the participation of women in transformative innovation and 4th industrial revolution in Africa. Women entrepreneurs, transformation innovation, 4th Industrial revolution(4IR), STI policy Introduction Innovation has become a vital component of sustainable development

in today's globalized economy and enhancing the participation of women in innovation processes should be a key component of every country's development policies. Indeed, innovation and technology are seen to provide unprecedented opportunities to reach those who are the most likely to be left behind, hence the need to focus on enhancing the capacity of all players, including men and women; in order to accelerate industry-wide transformational changes and remove the major barriers to sustainable growth and competitiveness, especially in developing countries still struggling with technological and economic catch up (UN Women, 2017).

Advocating for the participation of more women in innovation processes, scholars within the gender and innovation field argue that economic growth and development is highest if the innovative capacity of the entire workforce is exploited, and not just a portion of it, such as is the norm in current discourse on innovation, with the male as the dominant player (Pettersson, 2007; Nahlinder, Tilmer and Wigren, 2015). Several studies reveal that in general, there is a clear statistical pattern that women are less involved than men in innovation and in the creation of scientific and industrial knowledge (Scuotto et al., 2019; Team & Iwu, 2019; Chengadu & Scheepers, 2017; Frietsch et al., 2009), an exclusion which is even more pronounced in transformative innovation processes; which are disruptive and technological in nature ; involving engineering, design and usually R&D processes, which are historically male dominated fields(Nahlinder 2010).

Emerging opportunities for women in innovation processes

Recently, innovation research is seen to be redirected in new pathways that can lead to more transformative changes, in order to adequately address pressing global challenges confronting the world today. development (Daniels & Tang, 2019). This thinking about alternative innovation pathways is being articulated under different labels; including responsible innovation, inclusive innovation, social innovation, grassroots innovation, frugal innovation and transformative innovations, among others(Chataway, Hanlin & Kaplinsky 2014; Mulgan, 2007; Gupta 2012;Radjou & Prabhu 2014; Schot and Steinmuller,2018).Contemporary insights indicate that these new innovation pathways will require different skill sets and competencies , different from current innovation, which could give a new lease of life to the visibility of women in innovation and technology processes. This is so as sectors previously considered to be beyond the purview of innovation, such as the public, non-profit and social sectors, where women traditionally dominate become crucial in the shift to making innovation more transformative, with greater impact on society.

In addition, the concurrent shifts towards the 4IR; characterized by disruptive technologies such as artificial intelligence, robotics, the Internet of Things, 3D printing, etc. are expected to transform the future of work as the world moves deeper into the knowldge economy. According to the International Labor Organization, the traditional hierarchical organizational models are transitioning rapidly to more unstructured or 'adhocracy' teams within smaller, nimbler enterprises, which will require a more diverse workforce with different skill sets and talents, with an emphasis on soft skills such as emotional intelligence, cooperative problem-solving, communication, and stakeholder engagement. In terms of gender, women have been found to possess more of these qualities, in addition to having better managerial approaches suited to this new discourse – being more democratic, interactive and transformational, among other attributes that have been found to be key to creativity and innovativeness in teams (Kraemer- Mbula and Garba, 2018). Some scholars note that women also enjoy an edge over their male counterparts when it comes to group communication skills; being better listeners with greater tendency to collaborate and share information and knowledge (UN women, 2017); attributes that have been found to be important factors in technology transfer processes preceding transformative innovation.

While previous studies and policy interventions on gender and innovation in Africa have often focused on exogenous factors, such as the challenges and barriers facing women in innovation such as low of access to finance, low levels of education , as well as entrenched cultural norms and beliefs that exclude women from business and innovation processes (Mandipaka,2014; Kyalo & Kiganane, 2014; Mahemba & Bruijn, 2003), this study takes a more endogenous approach by exploring the personal attributes and gender based managerial competencies that could give women a leverage and enhance their participation in transformative innovation within emerging technology sectors and the strategic policy interventions needed to build the capacity of women to recognize and leverage on these competencies. Research objectives This paper seeks to explore the natural attributes and personal characteristics of women that can enhance their participation in transformative innovation and 4th industrial revolution in Africa. The main objective is to identify and define how the natural attributes and competencies possessed by women confers them with the human, relational, structural and social capital advantages that can enhance their participation in the digital and 4IR economy in Africa. The paper seeks to answer the key research question, 'how can women leverage on their natural attributes and gender based competencies to enhance their participation in transformative innovation and the 4th industrial revolution in Africa'? Research Design and Sampling techniques This study took a qualitative approach; based on narrative inquiry in order to capitalize on insights derived from in-depth interviews that capture individual stories of female participants in predominantly male dominated makerspaces. A key characteristic of narrative inquiry is that it captures individual's experiences in great detail; including respondents' personal views, opinions and their social interactions with others; reliving them as stories in a chronological sequence (Chase, 2018). This research design was found to be especially important in this study to allow the voice of the women to be heard, since most studies on women and innovation has often used the unit of analysis as the firm and often quantitatively determined the factors affecting their growth and performance, without capturing the human element. Population sample consisted of 20 female respondents (10 in Nairobi and 10 in Johannesburg) whose projects involved transformative innovation within any aspect of the 4IR such as

AI, robotics, 3D printing etc. The respondents were subjected to online interviews lasting about 1- 1.5 hours each, which were recorded and later subscribed The narrative interviews followed a three step approach; beginning with participants first sharing stories of how they came to be in their current position, which was followed by detailed narratives on gender based aspects of the participant's stories. The final phase was semi-structured interview questions that were focused on the participant's personal views and opinions on the challenges faced and how they have handled them in order to exploit their full potential in the makerspaces Data analysis The recorded interviews were transcribed and entered into qualitative analysis software Atlas Ti for coding and further analysis to come with thematic representation on the intersection between gender, transformative innovation and 4IR. Efforts were made to give voice to the respondents from the early stages of analysis, so as to create rich opportunities for the discovery of new concepts with regard to gender and transformative innovation. Findings Common themes emerged across the stories but also clear differences were found among the respondents interviewed in this study, based on their personal attributes. The common themes converged first on the gender; the fact that as women, they all faced some form of gender based bias in the predominantly male makerspaces, which contributed greatly towards the negative aspects of the narratives. On the other hand, there were positive narratives of how the makerspaces gave the participants advanced technical skills and access a wide range of resources that they would ordinarily not be able to get on their own. The positive narratives were dominated by the respondent's belief that their key attributes and competencies have greatly contributed towards their success in the makerspaces, many times performing better than their male counterparts. The women in this study general believe that although they faced greatly challenges and barriers in these makerspaces, their final products were better and had more impact in the market and society as evidenced by their sales levels and feedback from their leaders and from the market. Many of them narrated how they leveraged on patience, resilience, attention to detail, collaboration and communication skills to get an edge over their male colleagues.

[9370] *Government Funding and the Development of Innovation and Entrepreneurship Ecosystems*

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Abstract

Background and rationale

Access to funding is known to be critical for the emergence and consolidation of new innovative ventures. There are several studies mentioning funding as one of the pillars on which Innovation and Entrepreneurship Ecosystems (IEEs) are based, although there is still a lack of systemic knowledge about funding sources and their effects on ecosystems (Frimanslund et al., 2022). Although there are several types of private funding, such as venture capital and business angels, here focus on discussing the role of government funding for the development of ecosystems, since public funding dedicated to support scientific research - either applied research aiming at innovation directly, or more basic research - functions as trigger for innovation and the creation of new knowledge-intensive companies. Thus, the purpose of this article is to show how non-reimbursable funding from public sources affects the dynamics of IEEs, particularly in the context of emerging economies, where other sources of funding tend to be scarcer.

Literature Review

It is important to distinguish between the two groups of grants from public research support agencies that promote the development of IEEs. The first, direct, consists of programs aimed at applied research that focus on innovation, such as the Small Business Innovation Research (SBIR) in the US and Fapesp's Innovative Research in Small Businesses (PIPE) in Brazil. Such initiatives are based on two fundamental principles: (i) the existence of market failures in the process of funding entrepreneurship and innovation; and (ii) the expectation of socialization and economic gains arising from the success of the companies supported. In these cases, public sources of funding not only generate liquidity for the ecosystem (Autio & Ranniko, 2016) but also act as indicators of the potential of selected projects. The relationship between knowledge-based firms and public research institutions can increase their innovative potential, which reinforces the role of public institutions as relevant agents in the entrepreneurial ecosystem. Also, public research funding improves the systemic conditions of IEEs, as it provides early-stage funding for technologies that will be the basis of new products and services. The second group, indirect, involves all support for scientific research, including basic research, which eventually may translate into the generation of innovation and new ventures. The prerogative of this group is supported by the knowledge spillover theory of entrepreneurship, which identifies the production and circulation of knowledge as assets that are strongly attached to territorial spaces and support the development of entrepreneurial and innovative activities. The approximation of new and existing enterprises with universities fosters gains in terms of technological capabilities (Audretsch et al., 2020). Furthermore, academic research itself can create opportunities for economic exploration, making universities relevant cradles for the emergence of new innovative ventures (Fischer et al., 2019). In both cases – direct and indirect – the role of public funding in ecosystems in incipient stages has a more relevant relative

weight. This is due to the lack of maturity in the configuration of the IEEs, in which the presence of private capital still falls short in achieving traction.

Method

The methodology is divided into two fronts: 1) Literature review. The research envisages carrying out a literature review on public funding and the development of Innovation and Entrepreneurship Ecosystems (IEEs). The search was carried out in Scopus and Web of Science, selecting scientific articles from 2015 to 2022. The search occurred by topic, ordered by relevance. From the initial list of articles identified, the most relevant ones were selected according to the research objectives. 2) To advance in the development of methods, metrics, and indicators for the analysis of public funding in IEEs, we proceeded with the following steps. a. Develop an approach for the specific case of Unicamp. b. Work with Unicamp's licensing and technology transfer data. Licensing cases: Connect companies with supporters by crossing the name of inventors/technologies/dates with Fapesp's global base. Spin-offs: Connect companies with supporters by crossing the name of inventors/technologies/dates with Fapesp's PIPE base. Data gathered from companies in the science park: Check the relationship between companies in Unicamp's Science and Technology Park and Fapesp's support. We carried out a survey and subsequent triangulation between the unstructured data provided by the Unicamp Innovation Agency (Inova) with the structured data provided by Fapesp. This enabled the analysis of the direct and indirect connections between public funding and IEEs.

Results

This article contributes to academic research and literature in two different ways. First, the confirmation of the gap identified in the literature concerning the lack of studies focused on the role of government funding for the development of innovation and entrepreneurship. Second, our analysis demonstrates the relative centrality of public funding within the context of an IEE embedded in a developing country. This will allow us to developed a more nuanced picture of the role played by public sources dedicated to research in shaping the dynamics of such ecosystems.

Implications & Significance

This article brings a few important lessons. First, we came to the conclusion that it is important to strengthen government funding to promote both applied research aiming at innovation and basic research capable of generating new ideas. Second, it is critical to assess the role of public funding in generating new ventures in selected IEEs through mechanisms capable of measuring this effect; for such, we recommend the assessment of licensing and technology transfer data, university spin-offs, and companies located in science parks.

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[8716] *Monitoring and evaluation of regional agricultural innovation in emerging economies: assessing the conditions for further operationalization in the case of Casanare, Colombia*

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Abstract

Background and rationale

Science and innovation are core practices for agricultural development, and the extent to which knowledge is successfully produced, transferred, and applied often defines the trajectories of agricultural development processes. This subject has been captured by the concept of Agricultural Innovation Systems (AIS), which describes the interactions between multiple agents within a given institutional setting that shapes innovation processes, in this case for agricultural development (Rajalahti et al., 2008; World Bank, 2012; also see Tropical Agriculture Platform).

In emerging economies, the dynamics that take place within AIS are often shaped by variegated knowledge sources at the regional level, especially in rural agricultural systems where overlapping institutional settings and diverse actors perform a role from situated practice. In such settings agricultural scientific colleges are still weak (Goyeneche, et al., 2019), making it difficult to assess AIS on the base of scientific metrics.

This is the case in Colombian regions, where knowledge is subject to hybridization processes. In such settings local and scientific knowledges interact in the different phases and domains of the AIS. Therefore, the coexistence of multiple emergent patterns and diverse degrees of sophistication makes it difficult to track the specific features and configurations shaping the AIS' capacity and performance.

The growing institutionalization of the Colombian AIS demands further consolidation of mechanisms for monitoring and evaluating (M&E) agricultural innovation to enhance informed decision-making (Ordóñez-Matamoros, 2013) at the regional level. This practice generates knowledge about the system, which favors strategic direction towards the objectives set to achieve innovation (Hekkert et al., 2006).

However, in a context of emerging practices, such measurement needs to transcend the traditional approaches that tend to overemphasize bibliographic scientific output, innovation patents, and results-based management, usually of a linear and short-term nature, to assess better the variety of practices that take place in regional AIS.

While there have been theoretical contributions to develop logical models for M&E mechanisms of the Colombian AIS, considering the particular institutional trajectory of the country in that regard (Londoño, Ordóñez-Matamoros & Uribe, 2021), further research needs to advance on the operationalization of such frameworks in order to assess their relevance in regional contexts.

This paper reflects on a pilot project implemented in the Casanare region in Colombia, assessing the conditions under which a M&E mechanism should be operationalized as a tool for the strengthening of regional AIS.

Methods

We rely on the framework of Londoño, Ordóñez-Matamoros & Uribe's (2021) to examine the scope and limits of the proposed monitoring and evaluation model, as well as the conditions for its regional operationalization and possible challenges for its scalability to other regions.

Empirically, the paper builds on primary data from three workshops conducted to involve local actors in the definition of a set of indicators for M&E in Casanare's AIS, as an instrument to make the M&E process effective. The first workshop aimed at identifying, validating, and formulating indicators for monitoring and evaluating science, technology, and agricultural innovation. The second workshop maintained the same general objective but focused on the validation of indicators. Finally, the main objective of the last workshop was to start the process of collecting information for the calculation of indicators. This last workshop collects information from the 47 most relevant actors of the AIS and is essential to see the effectiveness of the mechanism evaluated.

The initial battery of indicators was built by revising different sources of secondary information. Among them, national and departmental policies on agricultural innovation, laws, research products, and an advance that the National Government has been implementing in the form of a national survey of agricultural science and technology. Furthermore, the direct involvement of the authors in this project offers multiple lessons that allow a better interpretation of the gathered information.

The case of Casanare offers a relevant context in which agricultural innovation can be regarded as an alternative to extractive industrial practices that pose challenges for sustainability transitions at the regional level. Casanare is known for its oil extraction economy, as well as extensive livestock farming and monoculture crops of palm oil, which entail diverse social and environmental tensions.

Anticipated results

In Colombia, there is a theoretical and methodological approach to how the M&E mechanism for agricultural innovation should work. However, the operationalization of this remains a challenge for the country because it depends on the environment and the characteristics in which this mechanism is developed, and Colombia is a country composed of diverse regions that have different populations and geographical and productive characteristics. Therefore, the results will allow validating this methodological and theoretical instrument and show whether the country can implement a standardized M&E model for all departments based on knowledge of the internal and critical relationships of the system. Consequently, these show the requirements of capacity and coordination in various management levels of the tools of follow-up and monitoring to go deeper into its territorialization and homogenization.

Significance

This research adds to the growing literature on AIS, with a special interest on the regional scale and M&E practices, which remain underexplored. The regional scale in this case suggests possible pathways for the implementation of national AIS and policies in that realm, while considering emerging practices and interactions between actors whose knowledge is built upon multiple sources beyond the scientific. This research suggests possible ways to cope with complex emerging practices for monitoring and evaluation purposes, so that M&E mechanism in AIS can better inform policymaking.

This paper also contributes to a better understanding of innovation policy and practice in emerging economies. The Colombian case offers an interesting landscape of growing institutionalization of AIS at the regional level, along with multiple sustainability challenges that can be better addressed by means of agricultural innovation. However, such

endeavor can only be fulfilled with relevant information and data on the performance of AIS, and M&E systems are a necessary condition to this.

[6811] *Ethics, Justice, and Policy: On the Dangers of Innovation*

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Abstract

Background and Significance "That's not ethics! It's innovation! And it's dangerous!" These phrases, addressed by an engineer to a philosopher – me – have served as a kind of Zen koan, which means they call for a response. What was it that I, the philosopher, had said to provoke such a reaction? I had talked about going beyond merely following rules, codes, or laws and making ethical decisions rooted in one's autonomy. How else could one decide, after all, if one did not own one's decisions? Would simply following the rules not take the decision out of decision making? What sense of 'innovation' underlies the contrast with ethics, conceived as rule following? Must all innovation violate a rule or rules? And what danger comes with suggesting that people ought to make their own (and ownable) ethical decisions? Of course, one could make the wrong decision. Making wrong ethical decisions could be dangerous, too, in the sense that doing so could lead to other bad consequences. But making correct ethical decisions also often means facing danger. Whistleblowers, to choose but one example, often face reprisals, even if they do everything right. We could argue that anyone who punishes whistleblowers is themselves wrong for doing so; but that hardly removes the danger that accompanies whistleblowing. So, what is ethics? What is innovation? And what makes innovation so dangerous?

Methods This presentation addresses these questions by considering three cases.

1. NSF's new TIP Directorate In 2022, the US National Science Foundation (NSF) established its first new directorate in 30 years – the Directorate for Technology, Innovation and Partnerships (TIP). According to NSF's website, the point of the TIP Directorate is "maximizing NSF's impact."

"NSF has advanced the full spectrum of fundamental research and education in all fields of science, technology, engineering and mathematics, or STEM, for more than 70 years — from foundational, curiosity-driven research that has led to new knowledge about our world, to use-inspired, solution-oriented research that has directly impacted people's everyday lives. At every stage, investments across this spectrum have been deeply intertwined.

NSF's TIP Directorate doubles down on the agency's commitment to support use-inspired research and the translation of research results to the market and society. In doing so, the new directorate strengthens the intense interplay between foundational and use-inspired work, enhancing the full cycle of discovery and innovation." (https://beta.nsf.gov/tip/latest, accessed 10/31/22)

In what sense is the new innovation directorate itself an innovation? How might it be dangerous? Is NSF wrong to double down on impact?

2. The Ethics of Community-engaged Research NSF is increasingly recognizing that community-engaged research – itself arguably an innovation – raises ethical concerns (https://www.nsf.gov/geo/opp/arctic/ace/community.jsp, accessed 10/31/22). Although Indigenous communities may have their own policies governing the ethics of community-engaged research, and some countries (such as Brazil) have laws governing researchers' engagement with Indigenous communities, there is no policy governing the ethics of community-engaged research as a whole (i.e., beyond Indigenous communities). To put the point differently, there is nothing resembling the Common Rule, which governs the ethics of human subjects research, for community-engaged research. This section of the presentation discusses an effort to fill this gap.

3. Incorporating Social Justice into Engineering Ethics Education This section of the presentation discusses an effort to integrate considerations of social justice into an engineering ethics class. In collaboration with an engineer, the author has re-designed an engineering ethics class around the idea of social justice to test whether doing so may allow us 1) to reorient the focus from professionalism to include social and cultural impacts; and 2) to integrate discussions of ethics and social justice in novel ways through the engineering context. For reasons to be addressed in the presentation, 'ethics' and 'social justice' are treated as separate subfields within the discipline of philosophy. Although it suggests an innovative approach, perhaps bringing these subfields together is dangerous (for the students in the classes, for the instructors, and for society once engineers educated in this way are unleashed on society). Although all three cases relate to the idea that innovation is dangerous, this last case is the one most obviously related to the fear that innovation in (or in place of) ethics is dangerous.

Results All of these cases represent nascent examples of the interplay between ethics, justice, and innovation. We have yet to see how any of them play out. For this reason, it is too early to report definitive results.

Conclusion To claim that innovation is dangerous and for that reason should not replace ethics misconstrues ethics, innovation, and danger. We should avoid the contrast between 'safe' ethics conceived as rule-following and 'dangerous' innovation conceived as rule-breaking. We should also avoid the contrast between ethics and innovation, since

innovation within ethics is not only possible, but also desirable. Moreover, innovation can be ethical, as well as dangerous. In fact, we will be better off if innovations incorporate concern for ethics from the beginning.

[5958] *Understanding Career Transitions of Applied Researchers to Universities. Evidence from Germany*

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Abstract

Introduction This paper analyses the conditions and factors influencing non-university researchers' career transitions back into academia. In knowledge-intensive economies, research is performed in various institutional settings, in private and public organisations and covers a multitude of different purposes. Research in some key scientific research areas like artificial intelligence or big data is nowadays no longer driven by public research alone, but is intricately connected to public applied research and industrial R&D. Thus, research careers are increasingly forged in diverse knowledge production environments. However, previous scholarship on researcher mobility has focused predominantly on single-sector careers within universities. Inter-sectoral career transitions, in particular those of applied researchers from public research organisations (PROs) and industry into higher education, are still poorly understood. Given the variety of knowledge-intensive sectors where research careers are de facto built, this is a serious limitation.

Conceptual Approach In order to explain why some researchers may choose to transition back to universities, we draw on the notion of instutional proximity. Although all researchers, regardless of their domain of occupation, adhere to fundamental rules concerning the scientific method, in practice, their work is shaped by sector-specific institutional logics. Since career scripts associated with professional success differ across institutional domains, over the course of their career researchers develop distinct intellectual and social capital portfolios tailored to the respective institutional referents and optimised to enable career advancement within their sector. Opportunities and desirability of cross-domain transitions are determined by the possibility for researchers to advance their careers within the institutional referents of a different sector. Institutionally proximate sectors share formal and informal rules, goals, systems of meaning and a professional language. As proximity decreases, institutional referents begin to differ more strongly and the transaction cost of knowledge exchange and collaboration increases. Therefore, the higher the degree of proximity between domains, the more similarities there will be between expectations of successful research careers, the higher the synergies in the researchers' portfolios of skills, capacities and networks. Cross-sectoral transitions between institutionally more proximate domains will therefore have lower barriers. However, hiring decisions will also likely differ in specific situations, e.g. for early career hires vs senior hires since these types of researchers bring different kinds of value to universities.

Empirical Approach Germany offers a rich context for the study of cross-domain transitions due to the functional differentiation of its national research system. We focus on three pillars of the German system: universities, industrial applied research sector, and applied PROs. The latter are represented by Fraunhofer-Gesellschaft in our study. In academia, performance evaluation and, consequently, career advancement, depend in similar measures on scientific reputation, visibility within relevant peer community, and strong research metrics. Corporate researchers tend to work in an environment, which is functionally separated from academia and shaped by its own, dominant institutional reference system that is characterised by profit-orientation and intellectual property protection. Industrial researchers are less likely to publish research papers, apply for public funding or present their work at conferences due its proprietary nature. PROs are characterised by a degree of institutional hybridity. They are involved in producing scientific knowledge, but are also in contact with user environments. In PROs, institutional logics from various societal spheres co-exist and overlap, meaning that they may complement or contradict each other. Fraunhofer-Gesellschaft, the research organisation with 76 institutes in Germany, embodies key characteristics of an applied research PRO. Its mission is "to partner with companies to transfer original ideas into innovations" that benefit society and strengthen the economy.

Hypotheses Barriers to research career transitions into academia are high due to the idiosyncratic features of the academic career scripts. However, some parts of the academic sector look for high potentials that bring in complementary skills, which academics struggle to acquire. Therefore, in some cases cross-domain transitions into academia take place. We offer several hypotheses regarding the factors that might ingluence them. First, a researcher's publication activity is likely to matter as high-impact scientific publications are the cornerstone of scientific credibility: H1. Applied researchers who publish more and in more acclaimed journals are more likely to transition to universities. Second, there will likely be sectoral differences among transitioning researchers. Since institutional referents of applied PROs overlap with those of universities', we propose: H2a. The rates of transition of applied PRO researchers are higher than of applied industrial researchers. However, institutional proximity will be likely to have dynamic effect. Early career applied researchers should be attractive to hire for universities because of similarity in capacities. At senior career stages, capacities and networks of applied researchers become very different that those of academics regardless of the sector.

Therefore: H2b. Differences in transition rates between applied PRO and industrial applied researchers decline with scientific age.

Method We use publication data from Elsevier Scopus ranging from 2010 to 2021 to identify instances of career transitions of 18,595 German authors who are affiliated either with industry or with Fraunhofer-Gesellschaft in the beginning of their career, but that later acquire university affiliations. We identify 927 individuals who have transitioned to universities. Based on this data, we create a panel dataset at the author-year level comprising a total of 30,430 observations. We split the data into a Fraunhofer sample and an industry sample. We define our dependent variable University Affiliation as a binary variable taking the value of 1 if a researcher is affiliated with a university at an author-year and 0 if no university affiliations are identified. The change from 0 to 1 measures acquired university affiliations or co-affiliations and therefore, we interpret them as instances of career transitions. We include the following independent variables in the analysis: Publication Stock; Mean Journal Impact Factor; Scientific Age. The following controls are included: co-publications between Industry researchers and university researchers; co-publications between Fraunhofer researchers and university researchers; affiliations with Max-Planck institutes and Helmholtz Centres; Female Gender. We estimate the models using probit regressions.

Results Around 8% of Fraunhofer researchers and around 3% of industry researchers transitioned to universities at some point in their careers. The three hypotheses are supported. Fraunhofer researchers transition to universities more frequently due to their greater institutional proximity and their competences presumably have a better fit with the academic system. Transitioning to universities is an easier - and hence more viable - career choice for them than for their peers in industry, especially during their early years. Later on, researchers moving to long-term contracts in Fraunhofer institutes are likely to begin to align more strongly with non-academic incentive systems and the number of transitions converges to those of industrial researchers.

Significance The lack of academic appointments of external researchers indicates missed opportunities, because recruitment of professionals from outside academia can offer tangible benefits to universities. Researchers with cross-sectoral experience are able to facilitate attitudinal alignment, knowledge exchange between domains and act as drivers for collaboration. Thanks to their external experience, they can identify original research questions, new impulses for application-driven research directions, which can lead to novel outputs characterised by both scientific excellence and societal relevance. Lowering the barriers to cross-sectoral transitions will improve the quality of knowledge production process in academia. Our findings further provide an indication of how different degrees of domain proximity influence the scale and the driving factors of cross-domain career transitions.

[5185] *Quasi-experimental analysis of academic mobility: an example of the Polish international exchange program*

Adam Ploszaj (University of Warsaw).

Abstract

BACKGROUND AND RATIONALE

Scientists have been mobile since the beginning of modern science (and also in pre-modern times), but it was not until the twentieth century that researcher mobility grew in strength. An essential factor in the development of academic mobility is the emergence of modern science policy. International mobility programs became a widespread measure implemented all over the world. The importance of the academic mobility phenomenon has made it a subject of numerous analyses. However, the existing research on academic mobility has considerable limitations. First of all, most of the analyses of international researcher mobility are descriptive, concentrating on the presentation of data (e.g., origins and destinations, length, number and type of stays, resulting publications, etc.) but lacking a detailed analysis of causal mechanisms and effects. Consequently, the common-sense hypothesis of mobility's positive influence on academic careers and increase in productivity and quality is frequently tested merely with the use of information on the population of mobile researchers (e.g., based on opinions of mobile scholars or their research output before and after mobility event). Existing studies much less frequently involve research plans, which would allow for the comparison of mobile and immobile groups and, consequently, for discussing causality. The possibility and necessity to apply the quasi-experimental approach to academic mobility research – or even more broadly to science policy – has been underlined more and more frequently (Fortunato et al. 2018). However, the quasi-experimental approach has rarely been used so far. The few works using quasi-experimental design in science-of-science analyses pertain mainly to the evaluation of grant competitions' effects (Ayoubi, Pezzoni, & Visentin 2017; Benavente et al. 2012; Bishop 2012; Gaughan, Ponomariov, & Bozeman 2007; Hall et al. 2012; Jacob & Lefgren 2011; Langfeldt, Bloch, & Sivertsen 2015; Mealli & Rampichini 2012) and – significantly less frequently – to student mobility (Oosterbeek & Webbink 2011; Parey & Waldinger 2011), as well as the effect of science evaluation system's change on publication patterns (Butler 2003), and scientific collaboration (Azoulay, Graff Zivin, & Wang 2010; Boudreau et al. 2017; Catalini 2018; Catalini, Fons-Rosen, & Gaulé 2016; Iaria, Schwarz, & Waldinger 2018). The quasi-experimental approach, however, defined as regression discontinuity design, difference-in-differences,

and propensity score matching methods – in the knowledge of the author of the application – has not been broadly used in analyses of academic mobility, and particularly not in assessing the impact of programs supporting academic mobility.

DATA AND METHODS

In this paper, I analyze the M. Bekker program, implemented in 2018 by the Polish National Agency for Academic Exchange (NAWA). The program is addressed to doctoral degree holders employed in universities and research institutes in Poland. The program offers scholarships for visits to recognized foreign research institutions in order to conduct scientific research, obtain materials for scientific work, complete a postdoctoral fellowship or carry out other academic activities, including teaching. In the first call (2018), 519 applications were submitted. The success rate was 30.1 percent. Thus, the sample consists of 156 successful applicants (experimental group) and 363 unsuccessful applicants (control group). The data used in the analysis include (1) the data from Polish National Agency for Academic Exchange, including the scores received by applications (this is a key variable enabling regression discontinuity analysis) and various data describing the applicant (gender, age, discipline), and their outcoming (type, prestige) and incoming institutions (type, prestige, country); as well as (2) the data collected for this paper, including publications of the successful and untuneful applicant and their citations (based both on Web of Science and Scopus). The number of papers and citations are the main outcome variables that are analyzed. To evaluate the causal effect of receiving the mobility grant, I use three methods: regression discontinuity, difference-in-differences, and propensity score matching.

ANTICIPATED RESULTS AND SIGNIFICANCE

Triangulation of three methods ensures not only the robustness of the analysis but also allows for assessment of to what extent less demanding methods can substitute for more challenging approaches (in particular, proposals' evaluation scores are difficult to obtain, thus, in many cases, regression discontinuity design cannot be implemented). Furthermore, the results of the quasi-experimental analysis are compared with the results of the evaluation based on a survey of successful applicants and their post-mobility reports. This allows shedding light on similarities and discrepancies between objective evaluation methods (quasi-experiments) and assessments based on data submitted by grantees. The results can have significant implications for academic mobility founders willing to enhance their evaluation procedures.

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[2284] *Does Institutional Context Matter for How Gender Influences Innovation? The Heterogeneous Impact of Gender Diversity on Technological Evolution*

Zeynep Yavic (The Ohio State University) and Rafael Corredoira (The Ohio State University).

Abstract

This study examines how gender diversity affects innovation outcomes and how countries' formal and informal institutional context impacts this relationship. We argue that societies' written and unwritten rules determine the extent of cognitive differences between men and women and lead to greater diversity in their perspectives and knowledge, particularly in societies where traditional gender role attitudes are dominant. Such increased disparity results in greater returns from gender-diverse teams in countries where gender equality is relatively less emphasized by their institutions. Data from the United States Patent and Trademark Office (USPTO), World Bank's survey on Women, Business, and the Law, and news articles from Reuters around the world allow an inclusive and generalizable conceptualization of gender diversity's impact on innovation. The findings indicate that increased gender diversity results in better innovation outcomes, and institutional context moderates this relationship. These findings suggest that it is necessary to consider institutional structures related to gender role attitudes to understand the impact of gender diversity on the technological influence of inventions.

[9199] *Innovation Policy Governance in Africa: insights from Nigeria and South Africa*

Chux Daniels (SPRU, University of Sussex Business School, UK), Abiodun Egbetokun (National Centre for Technology Management) and Blanche Ting (University of Johannesburg).

Abstract

Thematic areas and topics addressed: Innovation Policy; University/industry/government interaction; Societal impact

Background and rationale

The 2030 Agenda, unanimously adopted at the UN, positioned science, technology, and innovation (STI) as key means of implementation of the SDGs. The SDGs provided an aspirational account for the desired future for human development with an actionable agenda. To this end, Africa's long-term development strategy, the Agenda 2063 and other relevant framework, especially the Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024), have been aligned to the SDGs, to help achieve the transformative change that Africa aspires to. Similar frameworks to STISA-2024 exist at the regional levels. In West Africa, we have ECOPOST (the ECOWAS Policy for Science and Technology) and in Southern Africa, there is the Southern African Development Community (SADC) protocol on STI. Relatedly, countries across Africa have formulated or are in the process of implementing STI policies, to ensure that STI contributes to development. Nevertheless, implementation and evaluation of these policies remain weak. One reason for this weakness is the lack of governance frameworks that spell out authority and accountability, define and control outputs and outcomes, and help steer benefits from STI policies, projects, programmes, and portfolios towards transformation.

In this research, we examined the innovation policy ecosystems in Nigeria and South Africa – two of the leading economies in the African continent. Both countries have made important progress in their STI over the past decades, with a strong emphasis on innovation, inclusivity, and a renewed focus on addressing societal and environmental challenges. The National System of Innovation (NSI), continues to be, rightly so, defined and function as a network of institutions. However, vital aspects of interactions, learning and collaboration among NSI actors and stakeholders in policymaking remain weak. The NSI remains highly fragmented, requiring improvements in coordination at various levels. Effective governance can help address many of the challenges in the NSI and optimise the gains from innovation policy in ways that focus on transformative change by responding to economic, social, and environmental concerns.

Methods

The methodology and approach involved desk research to review relevant literature and stakeholder interviews. The review of literature and secondary sources was supported by stakeholder engagement events, including two workshops held in June 2021 (one for each of the country), consultations with stakeholders and a review of a draft report by experts and practitioners. The data collection commenced in March 2021 with the desk review and was completed in July 2021.

Results

1. Governance of innovation policy and ecosystem: coordination and fragmentation Key challenges remain in the governance of STI policy concerning formulation, implementation, coordination, monitoring and evaluation (M&E), funding, research and development (R&D). The general oversight which governs policy relevant research on, and analysis of, national innovation is organised at different levels. There is a need for a centralised governance structure with executive powers, implementation authority and an overarching framework to provide for coordination and governance across the NSI. This is essential to reducing fragmentation and strengthening the coordination of the actors and stakeholders in the NSI.

2. Matching demand- and supply-side innovation policy interventions There are many innovation policy interventions, programmes, projects and partnerships in place – some by the government while others have been put in place by the NSI actors, including development partners. However, supply side thinking remains pervasive, with continued emphasis on science, and technology push, that is, a linear model of innovation. Demand speaks to issues of unemployment, poverty, and inequality. Citizens want jobs, reduced poverty and inequality, and greater inclusion in innovation and development. Nevertheless, in many instances, it is unclear what STI policy interventions or knowledge exchange activities are in place to, directly, respond to, or address some of these societal demands.

3. Capabilities and data for research, innovation, and policy Policy initiatives, interventions and programmes have been put in place to build and strengthen capabilities and skills in STI. These initiatives include programmes on Research Chairs, Centres of Competence (CoCs), and Centres of Excellence (CoEs). Nevertheless, there remains a severe shortage of skills in areas such as engineering, entrepreneurship, innovation, and management needed to match development aspirations and objectives. In many cases, finance is available; that is, funding is often not the limiting factor. Gaps in capabilities and skills have implications in areas that include i) collection, processes and management of data and evidence to inform policies and policymaking; ii) conducting innovation and R&D surveys, indicators, metrics, assessments, and measurements of innovation, R&D; iii) development of policy instruments for innovation policy; iv) boosting innovation outputs, patents, IPRs, commercialisation, industrialisation, and economic growth and v) STI policymaking and governance. Progress in strengthening STI policy governance can contribute to addressing the gaps in capabilities and data for research, innovation, and policy.

4. Policy implementation, evaluation, experimentation, and learning There are significant evolutions in the Nigerian and South African science and innovation systems. Nevertheless, there is less evidence of vital lessons being adopted to help inform and strengthen future policies and policymaking. An important lesson, for example, is the need to reduce the time lapse between the formulation of STI policies and the completion of the implementation framework. Progress in this regard can help maintain momentum between the two policy stages – formulation and implementation. And ensure that implementation activities resume right after formulation.

5. Funding for innovation Funding is essential for innovation and policy implementation. Currently, in terms of Gross Expenditure on R&D (GERD), both countries are below the 1% threshold set in the continent, with South Africa performing comparatively better than Nigeria and many other African countries in this respect. Nevertheless, the target set by the South African government to reach a GERD of 1.5% of GDP by 2019 was not realised, indicating more effort is required in this area. In contrast, the Nigerian government set a target as low as 0.5% of GDP in 2021. Reasons for the low GERD include low BERD, and the absence of a coordinated funding mechanism to help match needs to appropriate funding mechanisms or prevent duplication. Improvements in STI governance can help in addressing the gaps in the quantity and quality of funding for STI.

Significance

Evidence gathered during the stakeholders' workshop indicates that although efforts are being made to address the gaps in fragmentation and coordination mechanisms, challenges in the NSI remain, which effective governance could help address. Relatedly, key stakeholders stressed that innovation governance in the past was focused on centralisation and became too prescriptive. This influenced public funds, which were disbursed in prescriptive ways, resulting in a lack of focus on underdeveloped areas. Addressing these gaps through learning, experimentation, and improved interactions among NSI actors can be made possible by strengthening governance systems. This in turn will improve the prospects of innovation policy to foster long systems change, address the SDGs and Agenda 2063 and contribute to transformative change.

[5069] *Connecting innovation to human capabilities: a case study of township innovators in South Africa*

Alejandra Boni (Universitat Politecnica de Valencia) and Erika Kraemer-Mbula (University of Johannesburg).

Abstract

Introduction

It is conventionally assumed that innovation is inextricably linked to economic development and subsequently, to human development. Although this connection has traditionally been regarded as primarily positive and somewhat natural, recent concepts such as responsible and inclusive innovation highlight the need to be more conscious of the potential and actual adverse impacts of innovation in inclusion and environmental sustainability. Assessing whether innovation processes do lead to the reduction of social inequities and enhance meaning transformations is especially urgent and relevant in Global South contexts.

The concept of “capabilities” has become central to diverse bodies of literature, from production theory to innovation studies and development paradigms. In all these literatures, capabilities are central to transformation, be it production processes, innovation systems, or individual freedoms.

In innovation studies, learning and the subsequent accumulation of capabilities lie at the centre of the process of innovation. In development studies, Amartya Sen's Capability Approach (thereafter, the human capabilities approach) provides us with the conceptual elements (capabilities, functioning and agency) that allow us to scrutinize innovation capabilities and assess whether they are resulting in responsible and inclusive innovation.

This paper aims to integrate the concept of innovation capabilities with that of human capabilities, in order to (1) explore the extent to which innovation capabilities and their underlying learning processes are important in expanding valuable human capabilities and (2) explore if core elements of the human capabilities approach (such human capabilities, functionings and agency) provides an analytical approach to assess the process and the effects of innovation.

We test these ideas through the development of a case study of the eKasiLabs programme in South Africa, which is a network of incubator facilities spread across the populous province of Gauteng, aimed at building a culture of innovation and entrepreneurship in informal settlements (also known as townships). These incubators directly engage with township innovators operating in multiple sectors. The qualitative approach allows for a contribution to both the empirical and conceptual understanding of how innovation capabilities and human capabilities connect in practice in the constrained context of South African townships.

We first present some fundamental concepts of the human capabilities approach and innovation capabilities. Then we briefly describe the context of capabilities in the context of South African townships; later, we describe the methodology and present some preliminary results. Finally, we discuss the implications of using the human capability approach in reframing responsible and inclusive innovation.

The Human Capability Approach

The capability approach constitutes a broad normative and analytical framework for the evaluation and assessment of individual well-being and social arrangements, focusing primarily on what people are effectively able to do and to be; that is, on their capabilities (Robeyns 2005, 94).

Capabilities and functionings are two key concepts in the approach. Capabilities refer to different combinations of functionings which can be achieved, where functionings are "the different things that a person can value doing or being" (Sen 1999, p.3). These beings and doings together constitute what makes a life valuable. Functionings include working, resting, being literate, being healthy, being part of a community, being respected, and so forth. The distinction between functionings and capabilities achieved is a distinction between what has been realized and what is effectively possible; in other words, between achievements, on the one hand, and freedoms or valuable options from which one can choose, on the other. Capabilities, then, are the freedoms to enjoy valuable functions. Sen defines freedom as "the real opportunity that we have to accomplish what we value" (Sen 1992, p.31).

Another central concept in the capability approach is the agency, defined as the ability to act according to what one values or –in Sen's words- "what a person is free to do and achieve in pursuit of whatever goals or values he or she regards as important" (Sen 1985, p. 203). An agent is "someone who acts and brings about change, and whose achievements can be judged in terms of her own values and objectives" (Sen 1999, p. 18). Freedom and agency are mutually interconnected: "wider freedoms allow agents to act and achieve the goals they value, while the exercise of agency leads to a further widening of freedoms" (Ibrahim 2006, p. 400).

Innovation capabilities

There is an extensive literature on innovation capabilities, which has mainly looked at capabilities at the firm level and focused on their connection to productivity and competitiveness (Dutrénit and Vera-Cruz, 2005; Lall, 2005). The connection between capability building and human development or broader social impacts has received less attention.

However, there are concepts such as interactive learning and tacit knowledge, which are both central to the processes of building innovation capabilities and also intimately related to human capabilities. For instance, the articulation of needs, which is an expression of individual freedom, entails a learning process (Tunzelmann and Wang, 2007). Also the exchange of tacit knowledge, which is central to the creation of distinctive innovation capabilities, is the result of complex social interactions and requires people to have social mobility for that flow of knowledge to be realized (human capability).

Innovation capabilities may therefore be a factor in expanding human capabilities, while at the same time, the ability to have social interactions may also be a factor that expands innovation capabilities.

Case study and Methods

We develop a case study around the eKasiLabs programme in South Africa, which is a network of incubator facilities spread across the Gauteng province. These incubators directly engage with township innovators operating in multiple sectors. We will conduct semistructured interviews with innovators and entrepreneurs supported through the eKasiLabs network, which will collect information on the individual entrepreneurs' innovation capabilities as well as their human capabilities.

Preliminary Results

Evidence from the field research conducted in the eKasiLabs programme in South Africa point out that, in general, people considered that individual entrepreneurs expanded their human capabilities in terms of: Education, Health, Economic stability, Social relations, and Spiritual dimensions.

Those statements show that people value different things related to entrepreneurship, which were often not considered by innovation actors. Also, noteworthy is that the capability expansion did not occur equally among men and women. Similarly, agency expansion was different among men and women in the network.

We contend that innovation programmes can be vehicles to expand the freedom of people. They represent the means that allow people to do and achieve whatever goals or values they regard as important (capabilities), enhancing their ability to make changes happen (agency). And, what is more important, people can collectively become agents of change rather than being mere recipients of aid.

Focusing on human capabilities and agency, instead of solely on economic growth, can help to design and implement innovation policy with a broader perspective taking into account social justice dimensions which are extremely relevant in Global South settings.

[7972] *Stronger together: migrant entrepreneurial teams in high-tech industries in Germany*

Maria Karaulova (Fraunhofer ISI), Abdullah Gök (University of Strathclyde), Peter Neuhäusler (Fraunhofer ISI) and Denilton Luiz Darold (Fraunhofer ISI).

Abstract

Introduction The paper combines capital and intersectional approach to entrepreneurship in order to explain the causes of under-representation of entrepreneurs with migrant background (EMBs) in high-tech sectors in Europe. Previous research has consistently found that people with migrant background have higher rates of self-employment than natives. Various positive effects of migrant entrepreneurship on sending and receiving countries' economies were identified, which include establishment of transnational links, job creation, firm efficiency and growth. Culturally and ethnically diverse firms are more likely to introduce innovations, pioneer radical, transformative ideas, bring new technologies to the market. There is also significant societal value of immigrant entrepreneurship as a trajectory of social and economic integration. Under-representation of EMBs in technology-intensive sectors remains a major issue in European countries. In the US, foreign-born constitute around 16% of the population and around 20% of high-tech entrepreneurs. In Europe, immigrant-founded firms tend to be over-represented in low-tech sectors like hospitality and retail, but are under-represented in industry and services. In Germany, migrant-owned firms are also much more represented in low-tech industries, such as trade and construction than in technology- and knowledge-intensive manufacturing than native-owned firms. Previous research on immigrant entrepreneurship concerned itself little with explaining or improving sectoral distribution of migrant-owned firms. Only a few studies, all drawing on the US data, provide relevant insights. Since the institutional dynamics of migrant entrepreneurship in the US differ significantly in comparison with European countries, there is a knowledge gap regarding the factors associated with under-representation of EMBs in high-tech industries. Conceptual Approach High-tech entrepreneurship has several distinctive characteristics: it is typically resource-intensive, is associated with higher level of uncertainty, and takes longer to produce returns on investment. Our conceptual approach builds on the intersectional understanding of minority disadvantage. As entrepreneurship takes place in an institutionalised socio-economic setting embedded in specific local values, various dimensions of social inequality exert critical influence on how minorities experience it. The pressure of these influences is experienced differently by different ethnic groups, and by individuals who are differently positioned within the groups with regard to social dimensions, such as gender, religion, class, education level, prior entrepreneurship experience. As the result of the multiple influences, some of which may appear minor, those who do not fit the mainstream criteria of entrepreneurship accumulate disadvantages and are filtered out of the system. Two barriers are identified in particular: negative entrepreneurial categorisation, which could lead to difficulties with entrepreneurial identity formation; and the lack of social capital whereby people with migrant background have less capital and have access to fewer sources of capital. We argue that entrepreneurial team composition in particular could mitigate these barriers. Homogenous teams could improve their chances of entrepreneurial success by bonding and specialising business strategy to address ethnic communities, while mixed teams could improve performance by harvesting effects of diversity. Previous research found that entrepreneurs with migrant background are more likely to form homogenous teams. Yet we build the case for

mixed-team advantage in high-tech sectors: firms with diverse teams have higher survival rates, and there is robust positive association between diversity and firm innovation. In diverse teams, specific investment and social capital needs can be addressed by tapping into ethnic networks, while for single heritage teams, some of the opportunities remain closed. Summarising: H1. Firms with mixed heritage teams are more associated with high-tech sectors compared to low-tech sectors.

Methodology We investigate team composition in new high-tech firms founded by people with migrant background in Germany in 2013-2020. The data source is Amadeus database provided by Bureau van Dijk. “Migrant background” is the official demographic status, which is assigned to first-generation immigrants and people with at least one first generation immigrant parent. We identify entrepreneurs with migrant background of Turkish and Russian origin, two largest non-EU minorities in Germany, by using surname data to estimate their heritage. Since entrepreneurship is inherently a social process, which depends on resource acquisition and value creation, people’s heritage influences their entrepreneurial opportunities. Our dependent variable is used in different models to differentiate R&D intensive (or high-tech) sectors, from less R&D intensive (or low-tech) manufacturing sectors based on the Eurostat definition. We created two sets of independent variables that use heritage characteristics. Heritage is identified for Directors/Managers (DMs) and Shareholders (SH) in our dataset. Collectively, we describe them as the entrepreneurial team. We run the first set of models to estimate the effect of presence of Russian/Turkish person in the firm. In the second set of models, we estimate the effect of team compositions: for each subset of firms, "no heritage" if there is no person of Russian/Turkish origin in the firm, "Turkish/Russian only" if the entrepreneurial team is homogenous, and "Mixed team" for the rest. We included four variables to control for firm characteristics: Firm independence calculated based on the BvD independence indicator; number of employees; firm age; location in East Germany. Further five control variables control for factors that were previously found important: whether there is an academic in the firm; a female in the firm; median DM age; whether all DMs are shareholders and vice versa; and whether there are multiple DMs/shareholders in the firm who form an entrepreneurial team. In order to test our hypothesis, we regress the heritage variables on the sector assignment of a firm using logistic regressions. Results and Discussion Of 15,748 firms included in the dataset, 659 firms have a Turkish DM (4.18%). The share of firms with Turkish DMs is much lower for High-Tech industry firms (2.75%) and slightly higher for Low-Tech industry firms (4.78%) than the average. 184 firms have a Russian Heritage DM (1.17% of total). This ratio is slightly higher High-Tech industry firms (1.32%) and slightly lower for lower for low-tech industry. Both Russian and Turkish heritage have lower shareholder prevalence than DM. Turkish Heritage DMs form more homogenous teams than Russian Heritage DMs: approximately 73% of firms with Turkish Heritage DMs have only Turkish Heritage DMs. This value is around 44% for Russian Heritage DMs. Mixed teams of both Russian and Turkish heritage are significantly more represented in high-tech firms compared to low-tech firms: only around 28% of high-tech firms have teams consisting of only DMs with Russian Heritage. The value is 62.2% for Turkish-only teams. The distribution of shareholders follows a similar pattern. Our hypothesis is partly supported. In firms with Turkish DMs, mixed team as well as Turkish only DM firms have a lower probability to be in high-tech industries, although the coefficient is not significant in the case of mixed teams. As for the shareholders, we do find a slightly positive coefficient for mixed heritage teams, but a significant negative association between firms with Turkish only shareholders and firm location in high-tech sectors. Firms with mixed Russian heritage DM teams ceteris paribus are more likely to be in high-tech manufacturing industries than firms with “No Russian Heritage” DM team members. For Russian only teams, however, a negative, but not significant coefficient is observed. These results can also be confirmed for the shareholder regressions. The analysis provides a valuable insight into the role of the entrepreneurial team in new high-tech venture formation. Our findings mean that although team composition seems to affect the propensity of new high-tech EMB firm formation, there are likely other factors at play, which leads us to consider the second major contribution of this paper: the differential findings for the firms founded by different migrant groups. The two non-EU immigrant groups selected for our study have different immigration histories in Germany, which influenced their group-based social capital and their entrepreneurial opportunity structure.

[4625] *Scholarly publishing at US federally funded research & development laboratories: influences on public-private science*

Jeffrey Alexander (RTI International), Vincent Lariviere (Universite de Montreal), Yong In Choi (Georgia Institute of Technology) and Cassidy Sugimoto (Georgia Institute of Technology).

Abstract

Background Government investment in basic research produces benefits that counteract the forces that lead the private sector to underinvest in such research (Rosenberg, 2009). Governments differ in how they organize publicly funded scientific research. In general, this spending is divided between funding distributed to performers outside of the government, such as universities and private firms (i.e., extramural R&D), and funding to government research facilities (intramural R&D). Intramural research facilities, often termed “public research institutes” or PRIs, are assumed to undertake research directly relevant to governmental needs that might not be pursued by extramural performers.

However, few studies of PRIs exist in the published literature. The OECD launched a study in 1989 on government research laboratories, with a follow-up study conducted in 2011 (Sanz-Menéndez et al., 2011). In the United States, Bozeman and Crow (1998) published a series of examinations of federal government research laboratories. Cruz-Castro et al. (2020) and Zacharewicz et al. (2017) produced a series of scholarly works looking at organizational and managerial issues in public research organizations, and Hallonsten (2017) recently conducted a review of what he terms the "third sector of R&D" (encompassing government research laboratories but including non-governmental research institutes).

This study focuses on a specific form of PRI in the United States: nationally owned research laboratories operated as federally funded research and development centers (FFRDCs). FFRDCs evolved from their origin in World War II to constitute a significant part of the U.S. public R&D enterprise, accounting for approximately 36 percent of the research performed at federal facilities in 2018. The FFRDC is an organizational form different from most PRIs in other nations. These institutions are typically formed and owned by the U.S. federal government, but operated by academic, industrial, and special-purpose entities under bespoke agreements with specific agencies (known as the FFRDC's "sponsor"). As a result, these PRIs straddle the boundary between intramural and extramural government laboratories. They retain the status of a governmental entity, but with many of the attributes of a non-governmental organization. The current study is limited to a specific subset of FFRDCs, the Research and Development Laboratories (RDLs). Compared to other types of FFRDCs (Study and Analysis Centers and Systems Engineering and Integration Centers), RDLs are major producers of multi-disciplinary scientific knowledge (Hruby et al., 2011).

Key Research Questions Our paper presents descriptive statistics about scientific output from 1981 through 2020. We analyze the publications for all Research and Development Laboratories (RDLs) and for specific subsets of the RDLs (such as laboratories functioning primarily as scientific user facilities) by field of science. We characterize the scientific impact of that output using measures such as the average of relative citations. We also analyze patterns of collaborative research at RDLs (based on co-authorship networks across all scientific papers). Specifically, we examine the following sets of research questions:

RQ1 How has the production of scientific knowledge at RDLs (measured as the number of scholarly articles) varied relative to overall federal basic research funding to FFRDCs? What differences can we observe in scientific productivity and impact at specific RDLs, especially between user facilities and multidisciplinary research centers?

RQ2 As US federal entities, RDLs are expected to focus on national priorities, and their R&D activities are expected to benefit the US science and technology enterprise. We can characterize the "consumption" of RDL input by analyzing the institutional affiliations of authors who cite RDL publications. How does the citation of RDL publications vary across the nations and types of institutions citing those works?

RQ3 US federal R&D funding is concentrated in mission-oriented agencies, such as the Department of Defense, Department of Health and Human Services, and NASA. How has the disciplinary focus of RDLs shifted in relation to the R&D budget priorities of their sponsoring agencies?

Data and Methods This research-in-progress analyzes the place of FFRDCs in the US basic research landscape, primarily through bibliometric analysis of the publication output of the 29 RDLs as designated by the National Center for Science and Engineering Statistics (NCSES). Data for this paper was obtained from the Web of Science (WOS) database, covering the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts and Humanities Citation Index, over the 1973-2021 period. The name variations of each FFRDC analyzed were retrieved from the institution and department fields of the WOS. Each paper was assigned the subfield of the journal in which it is published according to the NSF field and subfield classification of journals (Hamilton, 2003), and this classification scheme was used for the field-normalization of their number of citations (Waltman et al., 2011). Full counting of papers was used—each FFRDC contributing to a paper obtained a whole unit. Networks were created with the UCINET and Netdraw softwares (Borgatti, 2002; Borgatti, Everett & Freeman, 2002).

We also obtained public-use data files and other outputs from two NCSES surveys: the annual FFRDC R&D Survey (the FFRDC Survey), and the Survey of Federal Funds for Research and Development (the Federal Funds Survey). The FFRDC Survey captures measures of R&D spending, and some data on the sources of funding for those R&D expenditures. The Federal Funds survey provides data on overall R&D obligations by specific federal agencies by field of science and engineering, and also R&D obligations to individual FFRDCs.

We use the FFRDC and Federal Funds Surveys to provide information on the resources (funding obligations) and activities (expenditures) for R&D at each RDL, and for their primarily federal government research sponsors. We then set up various models to derive findings on how the FFRDCs' scientific output changes over time in response to shifts in federal agency R&D priorities and in the nature of research conducted at these facilities.

Significance Link and Scott (2021) conducted an analysis of RDL publications for eight laboratories, and used their data to estimate the elasticity in the production of scientific output for those laboratories (the number of additional publications generated from incremental budget increases). Our work goes beyond this foundation by providing a more comprehensive dataset of publications over a longer period of time, so we can detect long-term trends. We also are able to investigate more thoroughly how publication volume and patterns vary based on the nature of the laboratory and the distribution of R&D funding received by agency and field. We will present our findings showing that the RDLs, in general,

produce publications with greater impact than overall U.S.-authored publications (using citation measures). We also show that RDLs are heavily engaged in international collaboration, and that their knowledge outputs are also consumed significantly by nations other than the United States. We also estimate how RDLs, consistent with the literature on PRIs, change their scientific output in response to changes in the R&D priorities of their sponsors and of the U.S. national government.

[3543] *New industrial and innovation policies in the context of recent productive and innovative global transformations*

Marina Szapiro (Economics Institute of Federal University of Rio de Janeiro (UFRJ)).

Abstract

1. Introduction The paper is based on the main results of the research project called "The global dynamics of production and innovation and the role of territory and national states: challenges for the development of the Health Economic Industrial Complex in Brazil" developed under the project "Challenges for the Brazilian Public Health System (SUS) in the national and global context of social, economic and technological transformations". The project was supported by Fiocruz (Oswaldo Cruz Foundation), one of the most important public research institutions in Brazil.

Some of the global transformations in production and innovation in the last twenty years are related to the deepening of the financialization process and the reduction of the world trade and world GDP growth rates. These trends have characterized the global economic scenario since the international crisis of 2007/08 and were exacerbated by the Covid 19 Pandemic crisis. The changes in global production and innovation dynamics have provoked significant impacts on the public policies focused on productive and innovative development of developed countries and China.

In this sense one of the most important change in the role of state since the international crisis of 2007/08 was the increase in protectionism in the industrial and innovation policies of the most developed countries. It was observed that the governments of most countries, especially of the G-20, have significantly increased the use of barriers (tariff and non-tariff) to minimize the impact of changes in the global dynamics of production and innovation and of international crises on productive structures and to protect domestic companies.

Another policy instrument increasingly used by the most advanced countries since 2016, especially since the Covid 19 pandemic, is related to the control of foreign capital in strategic economic activities related to national security. The sectors related to health (pharmaceutical products and medical equipment, for example) are increasingly subject to control of direct foreign investment entry.

While openness to foreign direct investment has not been eliminated outright, in recent years many governments have established or strengthened mechanisms to increase control of foreign direct investment (OECD, 2020). The most common explanation for doing this has been related to national security, but it can be observed that the protection of domestic firms and the strengthening of the domestic productive base have also been stimulating more developed countries to increase control of foreign capital inflows (especially foreign direct investment).

In addition to using trade policy and increasing control over the entry of foreign capital to protect local industry and domestic firms, the different governments of the developed countries have also adopted policies aimed at stimulating innovation, especially since 2016, aimed at the development and diffusion of new digital technologies (the so called Industry 4.0). In these cases, public resources are articulated with the measures to protect local industry and with other mechanisms, such as the use of the public purchasing power. Those policies are mostly restricted to locally owned companies, excluding companies controlled by foreign capital.

Another important change observed in recent years in the industrial and innovation policies of developed countries and in the strategies of multinational companies is related to attempts to stimulate local companies to return to their countries of origin important parts of their productive systems previously re-located for countries with low costs, mostly in the Southeast Asia. This process was part of the globalization of production and expansion of global value chain. Such practices, treated in the literature as "reshoring", were already a policy objective of some countries since the middle of the last decade, but received a greater impulse with the crisis of the pandemic, that demonstrated the importance of local productive and innovative capabilities in some strategic activities.

2. Objectives

The paper has three main objectives:

(i) To analyse the characteristics of industrial and innovation policies of developed countries, with respect to: increase in protectionism, increased in the use of instruments aimed at controlling the entry of foreign capital and stimulus to the generation and incorporation of technologies associated with Industry 4.0. (ii) To analyse the reshoring strategies (mechanisms aimed at the internalization of stages of the production process previously displaced to countries with lower production costs) adopted by multinational companies and governments of some developed countries from the mid-2010s on strengthened after the crisis of the Covid 19 pandemic. (iii) To suggest inputs for the design of an industrial

and innovation policy in developing countries considering the recent transformations in the global dynamics of production and innovation and in the public policies focused on industrial and innovation development of developed countries.

The context of change in the role of the state in the production and innovation dimension of the developed countries has to be considered in the design of industrial and innovation policy in Brazil. Traditionally, international agencies and institutions suggest that developing countries should liberalize their economies and reduce tariff and non-tariff barriers to increase their competitiveness in the global economy.

In this sense, this paper has the objective of contributing with inputs to new designs of industrial and innovation policies in developing countries (especially Brazil), which take into account the new global trends in terms of productive and innovative dynamics and the new characteristics of the industrial and innovation policies from developed countries and contribute to economic and social development.

3. Methodology The paper uses the innovation system approach to analyse the systemic character of the recent innovation policy adopted by developed countries and to reflect upon the design of new industrial and innovation policy in developing countries.

The methodology of the paper is based on two main axes. The first will be based on the mapping of references about the changes in the role of the State since the international crisis of 2007/08, as well as about the main characteristics of the industrial and innovation policies of the most developed countries. In this case, bibliographical research in international information sources was carried out. The main international information sources to be consulted are the Organization for Economic Cooperation and Development (OECD) and the United Nations Conference on Trade and Development (UNCTAD).

The second axis of analysis of this research project is based on the use of databases to analyse in greater detail the use of protectionist instruments (tariff and non-tariff barriers) in industrial and innovation policies of selected developed countries. For this, the Global Trade Alert database will be used (www.globaltradealert.org). This database gathers, since 2009, information on protectionist and liberalizing measures in relation to international trade adopted by a set of developed and developing countries. This information allows an analysis of the growth of protectionism in the context of industrial and innovation policies, as well as the main instruments used to protect domestic industry.

The main expected result of the paper is to suggest analytical inputs and proposals for the design of a new set of public policy for productive and innovative development in developing countries. This new industrial and innovation policy must consider the international context of increasing protectionism for the domestic firms of developed countries and the need of new approaches for industrial and innovation policy. The paper concludes that these new approaches should be focused on solving national challenges and seek to articulate social demand with the economic development in developing countries.

[3048] *Project Roles over the Career Trajectory: The misalignment between performed labor and desired career preparation*

Clara Boothby (Indiana University), Cassidy Sugimoto (Georgia Institute of Technology), Vincent Larivière (EBSI-UdeM) and Nathan Ensmenger (Indiana University).

Abstract

Background and Rationale Team based project organization plays a critical role in the advancement of scientific knowledge, and the allocation of research work within teams affects the training of graduate students and postdoctoral researchers, which has implications for their ability to pursue and success in scientific careers. While a majority of new doctorate holders rate academia as their top choice for a post-PhD career (Woolston, 2019), an increasing number of recent graduates find the pathway inaccessible (Cyranoski et al., 2011; Doctorate Recipients from U.S. Universities: 2018, 2019; Schillebeeckx et al., 2013). This disconnect may be exacerbated by the division of labor on research teams where the supporting research roles that early career researchers occupy may not necessarily be valued during hiring and promotion decisions (Leahey et al., 2010; Milojević et al., 2018; Robinson-Garcia et al., 2020). While the devaluation of supporting research work is well-established, the extent to which scientists' strategic decisions about their next career steps are affected by their ability to dedicate time to more prestigious research tasks is unknown. Do scientists allocate their time based on what they value most or what they feel will advance their career within in academe? We surveyed academic scientists in the fields of Biology and Biomedical research in the United States about their usual and desired roles on project teams, and the extent to which they see their current work as contributing to their desired career. The respondents' perceptions of the roles that they have performed during their training period will shed light on the extent to which researcher expectations and career decisions are affected by their positioning on project teams and seniority. Understanding the distribution of labor on research teams can inform policy decisions that incentivize the types of work that will advance scientific innovation and provide opportunities for early career researchers.

Methods To prepare a list of potential survey takers, we identified a sample of peer-reviewed scientific papers in the Web of Science that were published in the period from 2018 through 2020 in Biology or Biomedical Research according to the paper disciplinary classification that was developed for the National Science Foundation. We focus on these fields due to ubiquity of team-based science in these areas and their discussion of the issues around research training in a team science environment (Alberts et al., 2014; Bourne, 2013). The final sampling frame contained 138,387 unique researchers with email addresses and affiliations in the United States. We emailed each author a link to participate in the survey and a request to forward the survey and message to collaborators who are currently or who had been graduate students or postdocs in the past two years. We collected 5,088 total responses to our survey, with 4,150 fully completed surveys. Our survey asked researchers at different career positions to rank the prominence of 14 different research-related tasks as defined by the CRediT taxonomy (Allen et al., 2019). After parsing the survey responses, we were able to calculate the proportion of researchers who rank each of the 14 CRediT tasks among their top three tasks. We clustered the roles into Lead, Direct Support, and Indirect support based on a previous classification (Xu et al., 2022), and performed a linear regression to identify which factors and project roles were associated with a higher degree of confidence for pursuing desired career, and which roles were associated with higher numbers of publications.

Results Most notably, we found that while publishing higher number of lead publications is weakly associated with greater a sense of preparedness for pursuing an academic career, there is virtually no correlation between publication counts and a sense of preparedness for pursuing a non-academic career. Nonetheless, the number of lead publications is very often a prerequisite for employment in university contexts. 85% of graduate students and postdocs report that that at least one of the top three roles they spend time performing is a lead role; in fact, the most common role for graduate students and postdocs, was “Writing the original draft” (22%), followed by the direct support roles, “Formal Analysis” (21%) and “Investigation” (18%). However, we found that the degree that early career researchers spend time performing lead roles was not associated with higher numbers of lead publications for early career authors. This counterintuitive negative result suggests that for early career researchers, spending more time on lead roles alone may not actually lead to a higher number of lead author papers. We argue that the reason for this may be that the particular lead author tasks that early career researchers perform were the most time-intensive task on a per-paper basis: Writing the original draft of the manuscript. On the other hand, as senior researchers perform lead roles, their most common lead roles were conceptualization and designing methodology, tasks that are less time-intensive on a per paper basis. For researchers targeting non-university settings, receiving credit for conceptualization is positively associated with their sense of preparedness for their intended careers.

Significance A common conception of doctoral training is that it is designed towards preparing for academic careers. The focus on scientific publications reinforces this conceptualization. Furthermore, establishing oneself as a lead author is essential for retention in academic careers (Robinson-Garcia et al., 2020). This work, however, demonstrates a misalignment between lead author labor and output. Furthermore, few doctoral students obtain academic positions. Whether training for these students is appropriate for their career needs is unclear, especially as trainees may have less autonomy to select the roles that most directly prepare them for their career. Senior researchers, policy makers, and academic institutions must take into account their students' future career trajectories (desired and real) in the distribution of labor.

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[5964] *Framing and operationalizing ethical and responsible innovation in AI-driven manufacturing innovation*

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Abstract

Background and rationale

The growing application of artificial intelligence (AI) to manufacturing, particularly when integrated with smart factory robotics, automation, and logistics, promises to transform the sector. AI will generate impacts across all aspects of industrial systems and industrial innovation, including product development and design, manufacturing production, supply-chain management, sustainability, competitiveness, user interaction and workforce training. Impacts will also be generated for employment and job tasks, affecting both shop floor and white-collar occupations. The potential positive impacts of AI in manufacturing have been recognized by industrial and innovation policymakers, with strategies and programs initiated in the US and other leading economies to accelerate the development and diffusion of advanced manufacturing and AI.

Alongside business and policy expectations that AI-driven manufacturing will drive industrial performance, generate innovation, and revitalize national and regional industrial economies, there are also many worries, generating debates about responsible innovation in AI manufacturing. Among these concerns are apprehensions about the displacement of human agency and labor, the rise of new mundane (and less-well paid) tasks that support AI, and the ethical implications associated with bias and privacy, as well as issues related to data security and consequences for small and mid-size enterprises.

While the scale, scope, and directions of impacts associated with AI in manufacturing will vary across sectors, companies, and occupations, strategic choices made early about how AI-driven manufacturing will be designed, implemented, and governed could lead to material differences in avoiding or mitigating adverse effects and risks and ensuring a more equitable balance of benefits and costs. This is a key premise underwriting initiatives to embed attention to ethics and responsible innovation in AI manufacturing. This paper offers a formative assessment of this proposition by drawing on early experiences with a large-scale project to develop and promote AI manufacturing. We reflect on whether and how consideration to ethics and responsible innovation can be framed and operationalized, anticipate future developments, and derive insights for innovation management, university-industry-community partnerships, and innovation policy.

Methods

The case study focus is the Georgia Artificial Intelligence Manufacturing Technology Corridor (GA-AIM) which aims to accelerate research, scale-up, and transfer of AI and related digital technologies in industry in Georgia, USA. Through a university-industry-community partnership, led by the Georgia Institute of Technology, GA-AIM seeks to integrate the deployment of AI technologies in industry with related job training and outreach to underserved communities. The project has received federal funding ($65 million) under the US Economic Development Administration's Build Back Better Regional Challenge.

GA-AIM has an embedded ethics and responsible innovation team (which includes the authors of this paper) which is focused on two key program elements: an AI-manufacturing test-bed facility and AI-manufacturing community engagement. The team is using action-research methods, including targeted studies, and engagement with designers, users, and other stakeholders to facilitate GA-AIM in addressing ethics and responsibility and to foster learning and adjustment that advances the responsible and ethical use of AI-manufacturing technologies.

Results and significance

GA-AIM started in 2022. For the paper, we anticipate findings from targeted initial studies on the use of augmented reality (AR) systems for training and upskilling manufacturing workers and AI technologies for monitoring the health of manufacturing systems. We will highlight key ethical issues that are implicated in the design, development, and use of these systems and how designers are addressing them. These include ethical issues that are commonly discussed in AI ethics – including bias and privacy – and ones that are less commonly discussed, including AI-human interaction. AI-human interaction is a particularly important issue in manufacturing contexts, although it is an issue that is relatively neglected in AI ethics codes and policies. Additional ethical issues we will consider are trust and trustworthiness. Many AI researchers place a lot of emphasis on trust – on the importance of developing AI systems that users trust. Less attention has been given to the question of the criteria that should be met for a system to be worthy of the trust of users, including users of different backgrounds and levels, as is likely in manufacturing environments. We will explore what is changed through attention to ethics and responsible innovation in the design and deployment of these systems, what are the impacts of those changes.

There is some prior work on the involvement of social scientists in responsible research and innovation (RRI) in emerging technology research centers and projects, including in nanotechnology and synthetic biology. There is a critique that RRI to date has focused more on responsible research than responsible innovation. The GA-AIM project not only targets the use of AI innovations but also integration with workforce training and community economic development. This is significant in that it adds new dimensions and challenges related to the framing and operationalization of ethical and responsible innovation for emerging technologies. In addressing this topic, and drawing on action-research findings, we

aim to contribute to scholarly discussion about how responsibility and ethical approaches in AI can be framed, adding considerations related to manufacturing environments and community development which, to date, have been less explored. We will examine important (and often overlooked) issues of the operationalization of attention to ethics and responsible innovation, with the aim of deriving exploratory insights for innovation management, university partnerships, and innovation policy.

[8500] *Faculty Research Productivity in Striving Research Universities*

Quintin Kreth (Georgia Institute of Technology).

Abstract

Background and Rationale Over the last forty years, many institutions in the U.S. higher education ecosystem have changed their institutional strategy and/or identity to place a greater emphasis on research and graduate education (O'Meara, 2007). This widespread phenomenon, often termed "striving," has occurred for many reasons, most notably via strategic efforts by academic leaders to enhance institutional prestige and ensure long-term stability and prosperity (Jaquette, 2013). Although striving behavior can occur at any institution, this paper looks specifically at the case of institutions seeking to become or advance their competitiveness within the ranks of doctoral research universities – the most prestigious and research-oriented of American universities. Importantly, while the striving phenomenon has been examined by a variety of scholars, often overlooked are the experiences of tenure-track faculty, the very people who are expected to increase the research profile of their institution (Gonzales et al., 2014; Jackson et al., 2017; O'Meara & Bloomgarden, 2011). This study examines the differential experiences of faculty at striving research universities to better understand the patterns of workload and academic research productivity that emerge in these transitioning institutions. Faculty at striving institutions are typically expected to enhance their research programmes in furtherance of institutional goals. However, the degree of institutional support and relief from other job duties (teaching and service) they receive in furtherance of these goals varies considerably, sometimes creating intractable time conflicts (Sabagh et al., 2022). Striving institutions also broadly experience a transitional phase in their internal norms, expectations, and logics (Morphew et al., 2018; Morphew & Huisman, 2002), which can lead to ambiguity in evaluation (Jackson et al., 2017; Véliz & Gardner, 2019). Critically, support and reward systems for research are weaker at striving research universities than at established R1 research universities (Griffith & Altinay, 2020; O'Connor et al., 2011). This results in a complex system of institutional policies that both hinder and support faculty research productivity at striving research universities – one which is likely to have disparate effects on faculty at different career stages and from underrepresented groups. In the broader context of studies of academic research productivity in individual faculty, examining striving research universities helps address an important theoretical gap. Most or all of the major inputs into research productivity have been identified by previous studies (Bland et al., 2005, 2007; Toutkoushian & Bellas, 1999). These include individual characteristics (e.g. intrinsic motivation and research skill), characteristics of the employing institution of the researcher (e.g. rewards structures, clear goals and guidance, sufficient time allocation, lack of red tape, doctoral students, and support structures), and social characteristics (e.g. welcoming climate, peer support, peer expectations, and collaboration opportunities). Despite these many factors being well known, their interrelation is complex and remains ambiguous (Gläser et al., 2014). We do not know, for instance, how varying degrees of institutional support for research may disparately affect individuals. Another complication is that understanding the relationship of the factors which support research productivity is particularly challenging because they tend to largely co-occur, leading to multicollinearity, particularly for institutional factors (Bland et al., 2007). Academic work environments typically have either most or few of the characteristics supporting research productivity, with little in-between. In other words, different categories of institutions (e.g., liberal arts colleges) tend to have internally consistent bundles of research supporting and hindering policies, such as teaching loads, rewards structures, and graduate programs. Researchers have thus struggled to determine which institutional factors are most causally important for research productivity. This greatly complicates the interpretation of studies that compare colleges across institutional categories, models, and niches. That is, studies with doctoral research, comprehensive, and primarily undergraduate institutions in their sample. Such studies, unsurprisingly, find that the average productivity of faculty varies across institutional type, due to the strong correlation of institutional type and the presence research-supporting characteristics. It has been known for some time that the strongest predictive factor of a random academic researcher's productivity is the type of institution at which they work (Pellino et al., 1981). In other words, the research productivity of individual faculty tends towards the average research productivity of their employing institution. This, however, does little to enhance our theoretical understanding of research productivity. In particular, cross-sectional comparison creates a risk of conflating the distinctive characteristics of these institutional categories that are cause variation in research productivity with those that are unrelated. That is the core motivation to study research productivity in the striving university setting. Because these universities are undergoing change, we can observe variation in institutional support for research within a broadly similar category of research institutions, particularly in teaching loads. Striving institutions have unusual combinations of characteristics that are both supportive and deleterious for research productivity, due their transitional nature. This will hopefully lead to a greater

understanding of which factors are most important for supporting research productivity. To examine these complex issues, we ask two questions: 1.) In a striving research university environment, how do individual characteristics and institutional factors interact to enhance and inhibit faculty research productivity? 2.) In a striving research university environment, what is the precise relationship between faculty time allocation and research productivity?

Methods This study uses a subset of approximately 800 faculty working at 117 striving research universities from a 2011 national survey of tenure-track faculty in the U.S. The dataset provides a reasonably large sample size along with detailed individual characteristics, work histories, job duties and time allocations, work psychology measurements, and self-reported measures of research productivity. Striving research universities were identified as those that entered into the Research 1 or Research 2 Carnegie Classifications between 2010 and 2021, after having previously been in a lower classification. The survey data were analyzed using descriptive statistics and a combination of regression techniques, including OLS and count regression.

Anticipated Results Although there are many interrelated factors, preliminary findings suggest: First, faculty interest in research is varied and an important factor in research productivity. Next, teaching duties have a more negative impact on research productivity than comparable service loads. Additionally, there is variation in research productivity by race and sex not explained by other factors in the model. Finally, there are diminishing marginal returns to time allocation to research, particularly when research comprises the majority of a tenure-track faculty member's work. More findings are likely to emerge as this study is refined further.

Significance This research helps advance our understanding of the relationship of the many factors that influence research productivity and may inform the decisions of academic leaders and policymakers. Better understanding of the connections between the mechanisms by which research productivity operates could help improve the effectiveness and equity of striving institutions' strategic initiatives. This is particularly relevant as long-term downward trends in both domestic and international enrollment at U.S. colleges suggest that the financial pressures which have helped spur striving behavior are likely to continue. In addition, these insights could help identify ways to assist faculty build research capacity more broadly.

[4971] *Is there gender bias in academic careers? An event history analysis*

Charlie Mom (TMC Research), Peter Van den Besselaar (Vrije Universiteit Amsterdam) and Torger Moller (DZHW).

Abstract

In this paper we contribute to the understanding of what factors influence academic careers, and whether this results in gender bias. Based on a variety of datasets, we create a series of relevant variables that are expected to influence the appointment to full professor. Using an event history analysis, we find that many more women leave the academic system than men do, especially in the early career (the leaky pipeline). Another (preliminary) result is that - after controlling for relevant (merit) variables - men have a much higher probability to become full professor than women. In the version for the conference, several other relevant covariates will be included, such as the multidisciplinarity of the applicants and the level of academic independence. In that new version we will also include a mediation analysis, which enables to decompose the effect of gender on professor appointments in direct and indirect effects, and through that show what underlying mechanisms produce the observed bias.

[3648] *Comparing states' AI capabilities in governance and performances*

Eunji Emily Kim (Georgia Institute of Technology).

Abstract

As the economic value and technological importance of artificial intelligence (AI) have grown, measuring countries' technological capabilities in AI becomes one of the most popular issues in the research field. However, while there have been some elaborating indices and measurements that can cover the wide range of the technology, most of these assessment systems heavily depend on traditional technology development measurements: scientific publications and patents. These two traditional measurements are beneficial to quantify technological development and capabilities, however, focusing too much on these measures can miss another critical part of AI development, AI governance. Given the impact of the technology, consideration of AI governance including ethical issues and accountability of the technology should constitute a state's AI capabilities. This study aims to compare states' AI governance preparedness and their rankings in performance-based assessment. To measure states' AI governance, algorithmic impact assessment (AIA) tools and states' AI-related legislation documents will be used. As "a tool for assessing possible societal impacts of an AI system before the system is in use," AIA provides governance components of the technology. AI governance preparedness will be measured by applying AIA to a state's AI-relation legislation documents. Because there is no one-size-fits-all AIA tool yet, we will combine the currently used AIA tools (Canadian algorithmic impact assessment model, IEEE's AI Standards, UN

Guiding Principles on Business and Human Rights, and European Commission's High-level Expert Group on AI's assessment list for trustworthy AI) using their shared components. After finalizing the critical part of AIAs, states' AI-related legislation documents will be reviewed based on these components. For the performance-based ranking, we will use AI Index by Stanford Institute for Human-Centered Artificial Intelligence (HAI) which is one of the widely accepted states' AI capability assessment reports. Based on their performance ranking and the existence of AI-related legislation, the following 10 countries will be the cases in this research: US, China, India, Canada, UK, South Korea, Germany, Italy, Spain, and France.

[7428] *Implementing Research Impact Assessments: what data, methods and resources do funders need to do this well?*

Rachel Abudu (London School of Hygiene and Tropical Medicine), Kathryn Oliver (London School of Hygiene and Tropical Medicine) and Annette Boaz (London School of Hygiene and Tropical Medicine).

Abstract

Background and rationale: Funder research impact assessments (RIA) are exercises which measure the research outputs, outcomes, and impacts of research projects, portfolios, or programs. They include three key components: (1) activities which funders undertake to assess impact of their investment such as reviewing publications stemming from funded research and asking researchers about their perceptions of project impacts; (2) methods used within these activities such as bibliometric analysis to capture citation data and surveys or interviews to capture data about research impacts from investigators or stakeholders; and (3) frameworks used to guide these activities such as the Payback Framework or the Canadian Academy of Health Sciences (CAHS) Framework. The field of RIA has seen remarkable growth over the past 30 years. Several RIA frameworks have been developed and applied by research funders around the world, new technologies exist to better capture research impacts automatically such as Dimensions.ai or Researchfish, and best practice guidelines have been established to provide researchers and funders with high-level advice about conducting RIAs. Recent literature reviews have found that while RIA is a valid and essential tool to measure the wider benefits of biomedical research, there are clear methodological limitations that may limit the utility of RIA exercises and their potential conclusions.

To usher in the next era of RIA and mature the field, future RIA methodologies need to become more transparent and easily implementable. Current advice for RIA best practices such as those developed by the International School of Research Impact Assessment (ISRIA) provides an important foundation of the fundamentals of impact assessment, and several literature reviews provide an overview of available RIA frameworks for evaluation. However, the current literature falls short of offering practical guidance funders can use to design a RIA, including how to select an appropriate RIA framework and related impact indicators, collect and analyze data, and reflect on post-assessment steps that can be taken to improve RIA culture within their organizations. Our aim in this poster is to understand what data funders are currently collecting when performing their own assessments, how they collect this data, and how they use it to assess their own research portfolios. We draw on a subset of literature from our larger systematic review (Abudu et al. 2022) to understand the steps that funders have taken to implement an indicator-based RIA of a project portfolio.

Methods: Within our systematic review, we identified all published studies (n=21) which funders explicitly identified an assessment or evaluation-based RIA framework to guide their RIA activities. We reviewed these studies to examine: 1) the operational steps funders took to perform their RIA; and 2) the variation in how funders implemented the same RIA frameworks. This process allowed us to explore the varying indicator-based "operational pathways" that funders employed in their analyses and spurred us to organize the methods and approaches funders listed (such as literature reviews, identifying a sample of projects, documentary review, bibliometrics, surveys, and interviews) into a logical series of steps needed to complete a successful RIA. We then applied this series of steps to the papers in our review to understand the areas where funders are succeeding in RIA implementation and where challenges and opportunities for future development lie ahead.

For each paper included in our review, we coded data on the aims of the framework used by the funder and why it was chosen for use; the data collected by the funder to assess the research portfolio; and information the funder provided about staffing needs or requirements, resources used, and lessons learned during the assessment. In addition, we extracted data on seven steps for assessment implementation: Step 1: Setting the Stage for Analysis; Step 2: Framework Selection; Step 3: Metric/Indicator Identification; Step 4: Primary Data Collection; Step 5: Data Synthesis & Analysis; Step 6: Communicating Results; and Step 7: Reflecting on Best Practices/Capacity Building. These steps drew upon existing principles from the 2018 ISRIA Statement, the Reed et al. 2021 Methodological Framework for Evaluating Research Impact, the World Bank's Roadmap for Implementing an Impact Evaluation, and informal conversations with A. Kamenetzky, an experienced RIA implementor at the National Institute of Health Research.

Results: We found that funders are using a wide range of frameworks (n=12) to implement RIAs, and that even when the same framework is used to analyze a research portfolio, funders are using different data sources, methods, and resources to support their analysis. Approximately half (n=10) of studies in the review identified metrics and impact categories that

they planned to measure during their assessments within the methods sections of their papers. Primary data collection activities were the most widely reported activities across papers included in the review, however only thirteen studies reported activities to synthesize or analyze the data they had collected. No studies reported on activities to communicate results of their RIAs beyond the included review paper or included reflections on lessons learned after preforming the RIA.

Building on the analysis from this review, seven essential steps for RIA implementation – from setting up the RIA to data collection to an end-of-assessment reflection of best practices and opportunities for capacity building – were developed to assist funders. These steps may help funders to implement their RIA more practically and rigorously. We encourage funders to: discuss the preparatory activities that they undertook to set up their analyses in greater detail within papers' methods sections (step 1); carefully select an assessment-based RIA framework for their analysis, considering if a legacy framework is applicable to their portfolio (step 2); pre-select indicators for impact measurement and specify them within the methods (step 3); detail all data collection activities undertaken to gather new and existing data for the assessment (step 4), as well as activities undertaken to analyze and synthesize data (step 5); share planned or completed dissemination activities to share results within the papers' discussion section (step 6); and report lessons learned during the assessment process more formally to support knowledge-exchange of best practices across funders (step 7).

Significance: RIA for biomedical research can take many forms. In order to increase transparency and improve methodological quality and reporting of funder RIAs, we recommend that funders follow seven key steps for implementing a RIA. Incorporating the seven implementation steps will help to standardize the RIA evidence base and allow for much-needed future empirical research to determine optimal data sources and methods to best evaluate funders' research impact. We hope that our work, in tandem with future research can inspire funders to feel more confident that their impact assessments are methodologically sound, meaningful to end users of their research, and providing valuable insights for their organizations.

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[5876] *Equitable Energy Transition Problem Framing: A Comprehensive Success Factor Analysis (CSFA) Approach*

Waire Olawolu (Institute for Innovation Science - Purdue University), Romika Kotian (Institute for Innovation Science - Purdue University) and Joseph Sinfield (Institute for Innovation Science - Purdue University).

Abstract

Equitable Energy Transition Problem Framing: A Comprehensive Success Factor Analysis (CSFA) Approach

Background and Rationale

Problem framing is essential to address sociotechnical system challenges because it reduces ambiguity and facilitates a shared understanding of the problem. For large-scale sociotechnical systems challenges like developing an equitable energy transition plan, problem framing becomes more complex, as capturing the subjectivity and nuance of the manyinvolved stakeholders becomes a daunting task. Current approaches to framing energy transitions embrace either a reductionist or holistic lens. Both framing approaches have their limitations in achieving an equitable plan. A reductionist approach fails to capture the complexity within the system, and the subjectivity needed to attain an equitable renewable energy solution. Holistic approaches, on the other hand, do not adequately capture cross-scale, cross-level interactions that occur at different abstraction levels within a system.

To address these limitations, this work employs a holistic approach designed to frame challenges spanning levels of abstraction, plurality, context, and scope, thereby facilitating the development of an equitable energy transition plan in complex sociotechnical systems.

Method

We employ Comprehensive Success Factor Analysis (CSFA), a method for grand challenge problem framing developed at the Institute for Innovation Science at Purdue University. CSFA is a holistic method that helps reduce unknown-

unknowns, identify barriers, mitigate risks, and achieve high-impact through the organized exploration of various elements of a system that are necessary to yield desired outcomes. CSFA encourages systematic exploration of broad framing categories including 'system organization', 'operations', 'users and actors', and 'dynamic properties. In addition, CSFA incorporates perspectives from 9 overarching disciplinary lenses – psychology, physiology, politics, operations, education, environment, economics, technology, and sociology (P^3OE^3TS).

To carry out this analysis we pursue framework-informed systematic exploration of web-derived information on equitable energy system transitions. The energy transition system is analyzed at the national level. Renewable energy, in this work, encompasses solar, wind, bioenergy, hydro-electric, hydrogen, and geothermal energy. To perform CSFA and identify success factors needed for a low carbon, renewable energy transition, we reviewed nearly 400 documents and drew out perspectives on 16 categories of success factors that compose the CSFA framework, namely: infrastructure, equipment and supplies, workforce and talent, capital/finance, practices and mechanisms, awareness and acknowledgement of needs, motivation, enabling strategies, adoption and habit conversion, mechanism for evaluation, mechanisms for sustainability, resilience, security and safety, policies, government/ leadership support, and stakeholder interaction.

Result

Several hundred success factors were identified that are vital to achieving an equitable energy transition. These factors provide a conceptual framework that can guide energy transition policy deliberations towards achieving equity by ensuring that: 1.) individual and collective experiences, identities, backgrounds, and environments are taken into consideration during policy discourse, and, 2.) the dynamics of cross scale and cross level interactions within the sociotechnical system are accounted for. Collectively, these factors highlight that transition interventions must differ by level of abstraction, and are influenced by cross-scale (e.g., jurisdictional, management, and network scale) interactions, calling attention to the need for a portfolio of solutions to achieve widespread transition success.

Significance

This research identifies success factors that need to be addressed by policymakers and other key stakeholders to achieve equitable energy transitions. Our findings, which are location agnostic, provide a user-friendly means to support energy transition planning and discourse that helps reduce unknown unknowns and expert bias (identified in discourse theory) during problem framing, helping to foster more equitable outcomes.

[530] *Understanding the use of innovation-related concepts in enterprises' websites*

Mikaël Héroux-Vaillancourt (École Polytechnique de Montréal), Catherine Beaudry (École Polytechnique de Montréal), Davide Pulizzotto (École Polytechnique de Montréal) and Margaret Dalziel (University of Waterloo).

Abstract

This study explores the use of keyword frequency from corporate websites to build innovation indicators of firms. We used the online data from 2,413 companies that participated in 29 questionnaire-based investigations between 2010 to 2016. We extracted the content of the corresponding websites via snapshots hosted on The Wayback machine and analyzed them based on keywords related to innovation concepts (innovation, collaboration, open innovation, R&D and IP). We built a nominal scale from the questionnaire-based data that categorize firms based on the level of evidence of innovation and on their level of time to market. Then, we produced multinomial logit regressions with the nominal scale indicator as dependent variable to test the contribution of our Web-based indicators to increase the relative risk ratios of being in a group of firms that shares similar evidence of innovation and time to market pattern versus other groups. Our preliminary results show that when one of the web-based indicators is high, our control group (no evidence of innovation while being in the bottom 20% in terms of time to market), does not see any significant positive increase in relative risk ratios when we compare it to any other groups. Other results are consistent with what one would expect from groups with greater evidence of innovation, which show a significant positive increase in relative risk ratios when we compare them to the other lower groups. However, some other significant results seem at first glance to be inconsistent with what would be expected. Indeed, this raises the question of whether we are capturing patterns of market signaling from the mid-lower tier while observing the absence of the need to perform any form of market signaling from the companies in the upper tier. After all, actions still speak louder than words it seems.

[9550] *The value of competitive hires within institutions under audit: A global comparison of university departments in the UK, Italy, Australia, New Zealand, Norway and Hong Kong*

Kristy James (Elsevier) and Gemma Derrick (University of Bristol).

Abstract

The realities of periodic research audit in operation in many research-intensive countries means that HEIs are incentivized to implement policies and mobilize their research workforce towards achieving a high return within these evaluations. This preliminary research uses a global comparative approach using HEI case studies in the United Kingdom, Australia, Norway, New Zealand, Hong Kong and Italy to investigate the productivity and visibility benefit of a competitive hires to university departments. Competitive hires are identified as a mobility event into a department two years prior to an evaluation event (T1), and their value to the department (the extent that the competitive hire was successful) is determined by comparing their productivity and visibility value three years post hire (T2) when the evaluation event is complete. Particular attention was paid to the value-added by international, versus locally based hires, especially in countries with a research workforce that is internationally diverse (UK, Australia & New Zealand). Results show an interesting interplay and conceptualization of the potential benefit of hiring individuals to a department that extend to a consideration of their wider networks. These results provide alternative considerations for research recruitment policies, as well as extend current thinking of the value of an individual vis-à-vis their wider research capacity and existing network.

[9328] *Are Women's Works and Claims Received with More Skepticism?*

Jina Lee (The University of Arizona).

Abstract

BACKGROUND There is a wide body of research on the gender gap in academia, but the gender differences in the content of citations remain underexplored. Additionally, we do not know if social cues like gender would remain relevant to the reception of scientific papers in the midst of a global public health crisis. In the pandemic, there is a higher tradeoff between speed and quality of information. Due to the high-stakes nature of findings, scientists should be cautious to embrace new information. But there is also a high pressure to form a consensus rapidly, so they must make decisions in a short period of time. Thus, this provides a rare opportunity to observe how a new scientific finding is acknowledged and legitimized in the scientific community from its very start to its end. This also provides better data coverage. Old papers are sparsely covered in bibliometric data and more recent findings take a long time to be legitimized. In contrast, the covid-19 started recently, so the data coverage is better, and its legitimization process is expedited due to the urgent nature of relevant research.

HYPOTHESES Past research suggests that stereotypes and bias will be even more impactful under highly uncertain and urgent conditions like the pandemic. The evidence has been shown in research about decision-making in the Great Recessions. Furthermore, in Status Characteristic Theory, gender forms a hierarchy whereby men have higher status than women. Gender is a diffuse status characteristic that influences evaluations of the most task. Men are advantaged as higher-status actors and women are disadvantaged as lower-status actors. There are also empirical studies that support such predictions. As female workers are perceived as less competent and less committed to their work, the legitimacy of female professionals is often questioned. In other words, female professionals are likely to experience pressure to prove their qualifications repeatedly. Gender disparities in the patterns of citations are also prevalent, and female-authored articles are systematically less central than male-authored articles in network positions. This suggests that female-authored articles tend to gain less attention in academia. For these reasons, I hypothesize that (1) female-authored articles will be received with more skepticism. I also theorize the relationship between novelty and the extent of skepticism. Because novel works are likely to be atypical, audiences will be more skeptical of novel offerings. Therefore, (2) when scientists claim that their article is novel, the article will be received with more skepticism. Additionally, as female accomplishments are often received with more skepticism, the effects will be stronger for female-authored articles than for male-authored articles. In other words, (3) the positive effect of claims of novelty on skepticism will be stronger for female-authored articles than for male-authored articles.

METHOD I use citation context data (sentences surrounding in-text citations) in Microsoft Academic Graph (MAG), an open-access database that covers bibliometric data of 225 million publications. I quantify the extent of skepticism in the reception of scientific papers and analyze the gender differences. In doing so, I rely on a text-based measure of uncertainty cues in academic writing developed by Chen et al. (2018). They manually compiled 61 uncertainty cues from academic writings and expanded this set of vocabulary into 2200 uncertainty cues using the word embedding approach. I count the number of uncertainty cues in the citation context to measure the extent of skepticism and then take a mean across the citation context within a cited paper. I construct a sample of covid-19 relevant articles. Articles should be published between December 2019 – December 2021. Articles have relevant keywords in their titles like covid or coronavirus. About 10% of papers are covered by citation context data. The final sample is 9,259 covid-19 papers. The main independent variable of this study is the gender of the author. Gender is coded by using the first names of authors. I rely on Lariviere et al. (2013) and use their gender dictionary. Another independent variable is claims of novelty. I use a novelty dictionary I developed with my collaborators in Leahey et al. (2022). It consists of 16 words that are synonyms of new and novel. This dictionary is applied to 9,259 abstracts of covid-19 papers. I control for a count of uncertainty cues used by authors because it can affect the extent of skepticism by the audience. Other control variables are the number of

authors, months since 2019 December, citation count of an article, citation count of a journal, citation count of a first author, paper count of a first author, citation count of the last author, and paper count of the last author. I also generated a field variable. Life sciences, natural sciences, engineering, social sciences, and humanities. Finally, my method of analysis is Poisson regression because my dependent variable is a count variable and approximately follows the Poisson distribution.

RESULT The results suggest that female last-authored papers are received with more skepticism. Additionally, the number of claims of novelty is inversely related to the extent of skepticism in the reception of the paper. Results also indicate the moderating effect of gender and claims of novelty. As the number of claims of novelty increases, the extent of skepticism decreases, but this effect holds only for male last-authored papers and not for female last-authored papers. In other words, male last-authored articles claiming novelty enjoy the benefits of the lower extent of skepticism.

I conclude with the implications for gender inequality in academia. This study sheds light on the understudied mechanism of the gender gap in academia. In general, the results show that senior women academics who tend to be the last author in the authorship order are disadvantaged.

[4664] *The making of a new technoscience: the contribution of CIFAR databases to the development of deep learning*

Daniel Souza (University of Turin), Aldo Geuna (University of Turin) and Jeff Rodríguez (University of Turin).

Abstract

1 Introduction

Artificial Intelligence (AI) technologies promise to revolutionize the knowledge production process. At the core of this recent AI revolution are machine learning (ML) algorithms: computer programs that improve performance as they are exposed to an increasing amount of data. An example of disruptive technology based on ML is AlphaFold – an AI algorithm developed by Google's offshoot DeepMind, which solved one of the most challenging problems in the field of biology: the prediction of protein's structures based on amino-acid sequences (Jumper et al., 2021; Callaway, 2020). This breakthrough and many others underpinned by developments in deep learning (DL), a subset of machine learning (ML) algorithms that relies on neural networks and manually classified data to solving problems (LeCun et al., 2015). Due to the extremely promising results in wide areas of application, DL has been regarded as a new method of invention and potentially a general-purpose technology in which the next industrial revolution maybe based (Crafts, 2021). Although a growing literature in Science and Innovation Studies has studied the impact of DL in the knowledge production process (Bianchini et al., 2022; Klinger et al., 2021), little attention has been given to its inception and the institutional context in which DL has emerged as a field of study.

It is widely known that the recent developments of DL are intimately linked to the Canadian Institute of Advanced Research (CIFAR), a research organization based in Toronto that finances basic research with a high-risk, high-reward philosophy. Since its foundation in the 1980s, CIFAR has been consistently interested in the advancement of AI and was at the forefront of the recent upsurge of ML technologies. A testament of CIFAR's centrality in the DL field is the fact that two of the most used annotated datasets in DL, CIFAR-10 and CIFAR-100, are named after the Canadian institution. However, the exact nature of the role these datasets and the institution behind them in the blooming of DL as field of research has yet to be explored.

In this paper we analyse the emergence of deep learning as a technoscientific field, that is, a domain in the middle of scientific enquiry and technical problem-solving (Kastenhofer and MolyneuxHodgson, 2021). More specifically, we examine the role played by labelled datasets and the funding institute that supported the birth and growth of deep learning. Within this perspective, we regard annotated datasets as technological artifacts that allow the development of the field. Then we draw on the literature discussing the emergence of new scientific disciplines to provide a picture of the development of DL as the dominant approach in ML & AI, and the role of labelled datasets in that process.

2 Data and Methods

To answer these questions, we perform an analysis that includes both qualitative and quantitative elements. We start with a thorough review of the literature that encompasses the general conceptual framework and some specific historical accounts of the development of CIFAR. Several sources have been consulted both online and physically to better understand the nature and development of CIFAR as an important institution in the Canadian innovation system, and in particular the evolution of the work on AI through different stages.

The literature review has been complemented with semi-structured interviews with relevant actors, including prominent academics working on the field of AI and deep learning, as well as CIFAR personnel linked directly or indirectly to the creation of CIFAR-10/CIFAR-100. Two kinds of interviews were conducted: "general" interviews with academics working on AI, not necessarily related to CIFAR datasets, with the aim of getting an understanding of the field and some general

features that practitioners might look for in a training dataset; and more “specific” interviews with strategic individuals that were directly or indirectly related to the development of the CIFAR datasets.

Finally, to better understand the reasons behind the continuous use of CIFAR-10/CIFAR-100, a survey was developed using Qualtrics and distributed to academics and practitioners who have used those datasets in their work. To find those who have used CIFAR datasets, a query was conducted using the Scopus database by Elsevier to find papers that contained CIFAR-10 or CIFAR-100 in their titles, abstracts or keywords. A total of 5,267 papers were identified in that search. Then, the authors of each paper were identified and individualized, to finally retrieve the email of the corresponding author. A total of 2,535 different emails were collected. The collected papers are then used in a bibliometric analysis focused on citations.

3 Findings

We find that CIFAR datasets were fundamental for the developments which lead to the DL revolution and still shape the trajectory of the field. Specifically, we identify CIFAR-10 as the most important technological artifact used to develop DL architectures. We trace the creation of these dataset to the CIFAR NCAP Summer School in 2008, where the labelling of the datasets was conducted mostly by graduate students over the supervision of George Hinton, a prominent scholar in the field. We also learned through our interviews that CIFAR-10 became a benchmark due to its technical specificities, namely the nature of the images, their size, the number of samples and categories. Moreover, the timing of its release was deemed crucial to the popularity of the datasets, considering that no other similar dataset was available at the period.

The survey confirms the insights taken from the interview and reveals an additional role CIFAR datasets played in the diffusion of deep learning methods. We reveal that CIFAR-10 and CIFAR-100 are used extensively in the training of computer scientists working with ML. Many researchers not only teach courses using CIFAR databases, but also were themselves exposed to the datasets while following graduate programs. This finding highlight teaching as an important channel through which CIFAR-10/CIFAR-100 impacts the field of DL. Finally, we learn from our bibliometric analysis that the CIFAR datasets are still relevant in the scientific production of developing countries, given its easy accesibility and low computational requirements. This suggests that the same technical characteristics that lead to the initial success of datasets are still driving research in DL to this day.

[9494] *Signaling innovation activities within agri-food ecosystems*

Davide Pulizzotto (Polytechnique Montréal), Louise E. Earl (Institute for Science, Society and Policy, University of Ottawa) and Sandra R. Schillo (Telfer School of Management, University of Ottawa).

Abstract

Innovation studies traditionally employ bibliometrics and patent analyses to model ecosystems – methods that are less suited to measuring innovation in industry sectors where patents and publications are not used frequently by innovators. Some such sectors may be quite innovative despite a lack of patents or publications, for example the agriculture and agri-food sector, which is currently undergoing deep transformations relating to digitalization, climate changes and consumer preferences. Studying innovation in these sectors can be challenging due to a lack of accessible data. Official statistical sources often do not provide adequate coverage, and traditional surveying techniques such as personal interviews, focus groups, paper-and-pen or electronic questionnaires are increasingly problematic due to declining response rates or insufficient quality of data. It is crucial to explore alternate data sources and methods in sectors such as agri-food (Gök et al. 2015). Experimenting with webscraping techniques provides a non-intrusive method of collecting the public expressions of organizations with regards to their innovation activities. Previous studies have shown the potential of using text analysis in innovation studies (Antons et al. 2020; Youtie et al. 2021) and some underline the potential of content analysis of organizations’ public communication (Daas et van der Doef 2020). In this context, this study investigates whether innovation activities in sectors such as agri-food can be identified and captured; and what aspects of innovation activities are disclosed using public communications. The case we explore is the Canadian food and beverage processing sector and value chain due to its characteristics (Finco 2018; Vlachopoulou et al. 2021) and we develop a method to detect innovation-related themes conveyed by the sector’s organizations. In brief, the model is able to recognize paragraphs on websites that pertain to "innovation" and classify those, producing a coding scheme that can be used to analyze the agri-food sector. Data We base the analysis on a list of 2,506 organizations belonging to the Canadian agri-food ecosystem for which websites (URLs) have been identified. This agri-food ecosystem contains food and beverage processors, private sector suppliers of services and goods, private and public research and development institutions, government and non-for-profit organizations, and higher education institutions. The list was developed using manual and automated keyword web searches (food and beverage manufacturers by type such as products produced, etc.), and augmented by membership lists from associations of types of food and beverage processors, directories of organizations, and other public sources. Using a proprietary web analyzer tool created for this research, the data employed in this study were retrieved in May 2022. For this project, 47,531 English-only web pages are analyzed. Method

We develop the method in four (4) main steps: 1) pre-processing of text data; 2) selection of paragraphs containing words related to innovation as a topic and vectorization; 3) topic analysis of the contexts in which innovation is used; 4) supervised classification process of select paragraphs related to the topic of innovation in new websites. This fourth step comprises two (2) sub-steps: 4.a) expanding the training corpus with a positive and unlabeled (PU) data classification; and 4.b) testing the model with a test data set. In step 1) pre-processing of text data, we apply classical Natural Language Processing (NLP) steps to prepare unstructured textual data for further analysis. Specifically, we execute morphological analysis and a lemmatization procedure for each word, then filter out stopwords so that only tokens corresponding to nouns, adjectives, and verbs that respect a document frequency threshold of 30 are kept. Next, we identify the most frequent bigrams of words to create a bag-of-words model. In step 2, we select text segments containing at least one of the words from a curated list representing innovation concepts. This results in a Document-Term Matrix with 69,826 segments and 3,879 unique unigrams and bigrams. In the third step, we use the Latent Dirichlet Allocation (LDA) approach to detect key topics across all segments containing on the innovation-related words. Next, a series of parameter tests occur that result in a model with eight (8) topics selected with a topic coherence score of 0.54. The LDA output consists of two matrices that allow us to analyze and interpret each topic and to create latent features for documents that feed the fourth step of our method. Step 4) consists of expanding the training set using supervised classification. The expanding method is based on the contextual modulation phenomenon involving conceptual expressions. This phenomenon describes the semantic process of the text segments where a concept is evoked, but without any standard lexical anchorage. Specifically, we formalized this task as a positive and unlabeled data (PU) classification problem. This type of method aims to expand the set of positive data from unlabeled data. Thus, we label those segments containing innovation-related words as the P dataset (positive dataset), and then we mark the unlabeled dataset U. Then we retrieve an equal number of labels that do not contain the identified words. Next, we apply the previously developed LDA model to retrieve feature vectors for the U dataset. Finally, we train models and select the best model using the F1-measure. This final step leads using the supervised training method on unseen websites to select organizations having more intensive innovation branding. With the help of agri-food experts, we then evaluate the results. Expected results We have implemented all but the final step in the method. We developed a significant topic model that encompasses the main subjects of our corpus well. In our first experiment, the model obtained an F1 score over 0.8. We anticipate that further iterations of the model will lead to improvement and that the model, programming, or methodology will be able to classify unseen websites to identify those organizations communicating about the identified topics, as well as those with higher intensity of such communications. Conclusions This study experiments with machine-learning and using unobtrusive methods to expand knowledge of innovation ecosystems. It provides a model to identify firms with higher innovation intensity in their communications. As next step, research into validation of the technique, for example conducting collaborative research with industry associations representing the main stakeholders of the Canadian agri-food ecosystem would be recommended.

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[2041] *Creation of new indicators with a specialized DeepLearning model for innovation studies – Testing the B Corp Certification*

Pietro Cruciata (Polytechnique Montreal), Davide Pulizzotto (Polytechnique Montreal), Mikaël Héroux-Vaillancourt (Polytechnique Montreal) and Catherine Beaudry (Polytechnique Montreal).

Abstract

This paper proposes a tool that uses web-based data to provide new indicators on numerous innovation dimensions. We built this tool based on recent advances in Natural Language Processing (NLP), in particular the creation of pre-trained language models like BERT that seems to better capture the semantic facets of natural languages. The algorithm and the data allow the tool to have several advantages such as real-time analysis, minimum building cost, granularity and large sample size that make it appealing. Thus, we first develop a specific BERT model, provisionally called InnovBERT, and then we use the tool to create an indicator of the environmental culture of companies. This topic was chosen because the dramatic climatic events of the last years bring a sense of urgency and push the government's need to allocate more funds to further promote environmental protection and the sustainability culture of companies. We test the tool on the

B-CORP dataset which provides scores on the environmental performances of thousands of companies. Our hypothesis is that the environmental indicator provided by the tool is correlated with the score given by the B-Corp organization.

[9576] *Evolution of the co-authorship network in 5G technology: Bibliometrics and network analysis from 2005 to 2021.*

Anas Ramdani (Polytechnique Montreal), Catherine Beaudry (Polytechnique Montreal) and Mario Bourgault (Polytechnique Montreal).

Abstract

Introduction The fifth generation (5G) of mobile communication network (which succeeds 4G) has been accompanied by an increase in the number of connected devices and thus an increasing consumption of mobile data worldwide. In addition to increasing throughput and bandwidth, the introduction of this technology will support future applications that will impose additional requirements, including low connection latency. While the literature abounds with scientific articles addressing 5G, there is a lack of studies exposing a more detailed view of scientific collaboration in this area. To fill this gap, this study aims to answer the following questions: 1. What is the trend in terms of scientific collaboration in 5G? 2. What are the structural properties of the co-authorship network and is there an evolution of this structure over time? 3. What are the marked trends in international and inter-university collaboration? 4. Which countries and universities are most central to the network? Question 1 aims to determine the importance of scientific collaboration in the 5G field by assessing the evolution of links between researchers and comparing the proportion of collaborative versus single-author papers (intensity of collaboration). In other words, this first step will determine who works with whom on 5G. In answering Question 2, the co-authorship network will be analyzed at the structural level to identify the existence of a small-world structure (deemed more efficient in terms of knowledge transmission) within the network and to measure the degree of cohesion over time. Question 3 first aims at determining the intensity of international (between countries) and inter-university collaboration. Second, it will measure the evolution of the countries' collaboration with their main partners. The strong rivalry between Huawei and the other players in the game may not have the same impact in the scientific networks as researchers hedge their bets and play both sides. Question 4 will allow us to identify the most central countries and universities in the network, in other words who have the most influence. In sum, answering all of these questions will brush a broad picture of the evolution of the international network of scientific collaboration in 5G. Literature review Throughout the bibliometric literature on 5G, it is interesting to observe two strong trends. First, several researchers use bibliometrics to paint an international picture of 5G research in general. The idea is to collect all scientific papers on 5G and to focus mainly on the number of papers published, the authors, the countries as well as the most productive and most cited universities (Aslam et al., 2020; Mao, 2021; Semwal et Pande, 2021). The second category of papers focuses solely on a particular aspect of 5G. For example, Farouqi, Arshad, and Khan (2021) review the state of research on security and privacy related to 5G networks. Dixit et al. (2020) focus on papers dealing with the antennas needed to transmit and receive 5G signals. Thus, these studies have paid little attention to the collaboration in this field. To fill this gap, this paper aims a clearer picture of the evolution of the scientific collaboration network related to 5G Data and Methodology All papers were extracted from the Thomson Reuters Web of Science (WoS) database using the term "5G" in the title, abstract or keywords. The choice to restrict ourselves to the term "5G" is due to our desire to eliminate false positives, due for instance to some keywords related to 5G technology components (e.g., milimeter wave, edge-computing, or massive-MIMO) being not exclusively related to 5G. This first search yielded 43 155 scientific articles, from 2000 to 2021 which were then manually examined to eliminate those that did not correspond to the fifth generation of mobile communication. The final database contains 13,561 articles. A series of three-year staggered co-authorship networks was then characterized using SNA packages from R, an open-source statistical software, and Gephi, one of widely used Social Network Analysis software. The methodology therefore comprises two steps: 1. Analyse and understand the evolution of the collaborative structure of 5G co-authorship network the intensity of scientific collaboration, the existence of a small-world structure and the degree of cohesion); 2. Calculate the centrality of countries and institutions in the co-authorship network (degree centrality, betweenness centrality and eigenvector centrality). Preliminary findings Three main findings emerge from this analysis. First, and not surprisingly, 5G research is mostly performed in collaboration (very few articles are published by single authors). For each of the periods under study, more than 96% of the papers are the result of collaboration with an average of four authors per paper. In addition, the network is not highly fragmented since the main component represents more than half of the researchers during the first period (2014 to 2016) until reaching more than 60% in the last period (2019 to 2021). Second, the results indeed show that the co-authorship network possesses the properties of a small world in all periods. Thus, the structure of the 5G co-authorship network indicates an optimal structure for knowledge diffusion and information sharing. This contrasts with the cohesion measures obtained: The results show low density in each of the time periods and a negative trend over time for centralization and centrality by proximity. In other words, there is less and less cohesion around central researchers and it is increasingly difficult for researchers to "reach" others indirectly through the network. Turning now to collaboration, the results show that national collaboration is favored over international collaboration in the 5G domain

and that this trend is increasing over the years. For example, it is noticeable that from the 2017-2019 period, China favors domestic collaboration over international collaboration, where it has been losing ground over the last three periods. This is clearly observable by the relative decrease in collaboration with its main collaborators and in particular with the United States. There are several reasons for this trend. First, the weakening of collaboration during the last periods of this study coincides with the arrival of the COVID-19 pandemic, this cannot be ruled out as a possible root cause. Indeed, entry restrictions imposed by the United States impacted collaboration as most research collaborations usually begin with face-to-face meetings, to establish the necessary trust relationship, rather than by video conferencing. Second, exacerbated political tensions between China and the United States from 2018 onwards may also contribute to explaining our observations. Chinese scientists are reluctant to travel to the United States because of foreign interference investigations. For example, the U.S. Department of Justice under the Trump administration launched the "China Initiative" program in 2018 to investigate alleged Chinese spying in research and industry. However, despite the set of measures instituted by the U.S. government, the trend of collaboration with China from the U.S. perspective is still growing: the results show an increase in U.S. collaboration with China that has stabilized in the last two periods (2018-2020 and 2019-2021). Our results also show an increase in collaboration with China from the points of view of Italy, Spain, the United-Kingdom, and Sweden. However, the political tension between the U.S. and China over Huawei's role in 5G network deployment eventually reached Europe and the rest of the world. This may explain the decrease or stabilization, especially in the last period (2019-2021), of the collaboration between European countries, Japan, South Korea and Canada with China. Finally, with respect to the positioning of countries within the collaborative network, the results show that China, the United States, Great Britain, and France stand out from other countries in all three measures of centrality. Implications This article provides a description of the 5G co-authorship network. The results may be the basis for future work. For example, other studies could investigate in more detail the impact of public policies on collaborative trends at the international level.

[3977] *STI policy and climate change: insights from Uruguay and South Africa*

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Abstract

Science, technology and innovation (STI) are called to play a fundamental role in the quest for overcoming the current global challenges, and deep tensions around the models of economic growth, and the social and planetary unbalances and the aggravated and reinforced dynamics among them (UNDP 2020). We are faced with an increasing inequality in wealth, global unsustainability, child labor, new ways of slavery, political polarization and challenges in human rights (Giuliani 2018). Thus, the call is for urgently rethinking the current development paradigm, to prioritize sustainability and social inclusion, and radical new relationships between humans and nature within the planetary boundaries (Rockström, Steffen et al. 2009).

This very complex scenario leaves open and uncertain questions that require new approaches, methodologies, and frameworks in the search for new practices, institutions, ways of life, guiding principles and ethical standards to define new ways of life within safe planetary boundaries which leave behind a growth paradigm based on the depletion of natural resources and the environment. Science, technology and innovation must be placed at the forefront of this process, as instruments of sustainable and inclusive development. In a different vein, for some decades STI policy have gained an explicit space within the policy concert, particularly in the developing world where this process is lagging behind. In Latin America, countries have defined STI policies and, in some cases, strategic plans, although with diverse emphases, scope, objectives, approaches and guiding principles (Dutrenit, Aguirre-Bastos et al. 2021). In spite of this well established and acknowledged role, its legitimacy is clear at the discursive level, but its intertwinement and embeddedness into crucial development aspects is still missing (Dutrenit and Sutz 2013, Bianchi, Bortagaray et al. 2021, Bortagaray and Aguirre-Bastos 2021). Furthermore, it is not evident what is best governance scheme to better advance in this direction, to foster the necessary changes across the policy spectrum placing STI as a fundamental driver of change. What type of policy space should STI have within the overall policy spectrum? Should it be organized as a discrete policy domain, or should it be designed in a way that cuts across others like agriculture, health, industry, social development? What scope, governance models and systems better serve such transformation, and with what specific policies, institutional arrays, and the extent to which they need to be changed or created? (Sachs, Schmidt-Traub et al. 2019). Current societal challenges are profoundly complex and novel, calling for flexibility, adaptation, experimentation and policy learning. STIP key (new) role is part of a "normative turn" (Daimer, Hufnagl et al. 2012), a paradigm shift in STI policy with growing importance of directionality and normativity in STI, and an instrumental role of STIP for solving societal challenges, and advancing sustainable human development.

This work attempts to analyze such changing scenario, its scope and scale in the context of two very different countries, Uruguay and South Africa, particularly taking into account how STI policy connects with climate change strategies. The work is in its initial stages, and draws on an ongoing collaborative effort in this regard.

Empirically it studies both the STI and the climate change policy spaces on their own, to then analyze (i) the extent to which STI permeates climate change strategy, (ii) how does climate change appears in the STI policy domain, (iii) and their linkages and intersections. It also investigates their connections to other policy domains, such as agriculture, industry, health. The explored hypothesis is that STI policy has evolved in relative isolation of other development arenas and in the particular climate change policy in the case of Uruguay. In South Africa, this trajectory has been different, and STI policy has been more tuned to development problems including climate change. Part of the explanation lays in the different ST policy governance systems these two countries have.

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[3505] *Building an innovation ecosystem: ENCQOR's strategy*

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Abstract

Purpose The deployment and introduction of 5G technology will offer many advantages and distinct features from previous generations not only in the telecom world but also for many vertical sectors. SMEs from different sectors can seize this opportunity to develop new innovative solutions or take advantage of 5G to develop disruptive solutions to target new markets. Since 2018, the ENCQOR 5G project in Canada has raised awareness, mobilized and helped mainly SMEs to prepare for the deployment of 5G in the Quebec-London corridor. This initiative will enable Canada to accelerate the transition to 5G and unlock the potential of smart cities, e-health, autonomous vehicles, and the Internet of Things. ENCQOR's objective is to create, mobilize and consolidate an ecosystem that attracts heterogeneous actors such as SMEs, industrial actors, and universities at both the national and international levels. Since its creation, ENCQOR has attracted more than 800 SMEs working in various fields such as transportation, agriculture, augmented reality, mining, etc. As of March 31, 2021, 15 higher education institutions in Quebec and Ontario were collaborating with ENCQOR in various 5G projects. Positioned as the starting point of the 5G ecosystem in Canada, the ENCQOR 5G project is an ideal case study to analyze the construction of a new ecosystem. This study aims to answer the following research question: What are the factors that enable the emergence of an innovation ecosystem? The general objective of this research is therefore to develop a better understanding of the dynamics, mechanisms and challenges concerning the emergence of an innovation ecosystem based on the ENCQOR 5G project. Literature review This study is based on the model developed by Cohendet, Grandadam and Simon (2010) to analyze the ENCQOR ecosystem. According to the authors, local innovation dynamics are based on interactions between three levels: - Upperground: Creative firms and other organizations: research laboratories, universities, cultural and artistic centers as formal organizations contribute to the creative process through their ability to finance and unite different ideas, and to test new forms of creativity on the market. - Underground: Includes creative, scientific, technological, artistic and cultural activities taking place outside of any formal organization or institution based on production, exploitation or dissemination. - Middleground: Provides the necessary soil for the informal structures of the Underground to be born and develop, as well as for the trust necessary to transfer ideas from the Underground to the formal organizations of the Upperground. Methodology The methodology employed for this article is a case study based on semi-structured interviews of the various stakeholders involved in the ENCQOR 5G project. These interviews allow for an in-depth analysis of the existing dynamics within the ENCQOR project through key testimonies from the various participants. A total of 26 semi-structured interviews were conducted: 11 interviews with the founding and mobilizing organizations of ENCQOR and 15 interviews with businesses and SMEs that participated in

one of the program components. The interviews (lasting from 40 min to 130 min) were recorded, transcribed, coded and then analyzed using InVivo. We participated in several formal and informal events and meetings organized by ENCQOR to gain a more in-depth understanding of the project and the program participants. We also relied on other secondary data sources such as ENCOQR's annual reports, partner websites, documents shared by partners, and media articles to complement and provide context for the interview analysis. In analyzing the interviews, we focused on understanding the roles and interactions of the upperground organizations, particularly the founding partners and the engagement partners. Subsequently, we identified and analyzed projects, places, spaces, and events at the middleground level that benefit underground actors. For each of the three strata of the model, we identified the challenges constraining the emergence of the 5G ecosystem. Findings Upperground or Rebuilding and expanding the existing network – The emergence of a 5G ecosystem did not start from scratch as several ENCQOR founding partners had already collaborated before the arrival of 5G. This highlights the importance of using the existing network of organizations to build a "new" ecosystem. The success of their collaboration on past project motivated them to continue their partnership in the field of disruptive technologies such as 5G. Government funding played a key role in the creation and development of the ecosystem: their contribution was not limited to project funding, but ensured, through the establishment of KPIs, the smooth running of the project/ecosystem. For instance, the ecosystem faced several challenges: Slow program set-ups with governments; Legal issues and contract-based challenges; Complex governance. Building an attractive middleground – An innovation ecosystem must attract several organizations to emerge and last over time. To fulfill this mission, the construction of a middleground capable of attracting a wide range of organizations is necessary. ENCQOR's attraction mechanisms for SMEs that want to test or develop their 5G products are summarized below: • Free access to an iPaaS platform; • Funding for stand-alone and co-development projects with core partners; • Technical and human capital whose mandate is to provide free technical support to new members; • Appropriate governance and IP management to create a climate of trust between the multinationals (main partners) and the SMEs, by setting up an NPO whose mandate is to ensure that the SMEs keep their intellectual property when using the platform; • Project selection committees that are independent of multinationals to ensure a fair and transparent distribution of government funds; • Events, projects and activities to raise awareness and attract organizations to the platform (Bootcamp, discovery tours, challenges, etc.) These mechanisms remain insufficient to attract, engage and retain the larger number of organizations needed to create an ecosystem. Among the several challenges highlighted in this regard, our results found identifying organizations likely to use 5G is difficult especially in non-telecom verticals, keeping SMEs in the ecosystem and encouraging them to collaborate with new players to have a snowball effect that will expand the 5G ecosystem, KPIs not adapted to the innovation ecosystem concept, or the lack of 5G specialists in non-telecom SMEs Implications Thus, the creation of the ENCQOR 5G project was the result of the mobilization of an existing network with the addition of the business ecosystems of the founding members with the help of the three layers of governments. The results could help companies, governments and managers understand the key factors for building an innovation ecosystem

[3717] *Innovation-Led Oriented Policies: Investigating the Development of Low-Carbon Hydrogen Technologies*

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Abstract

Background and rationale: Recent literature has focused on the importance and many potentials of innovation or mission-led policies to respond to social, environmental, and economic challenges (Mazzucato, 2018). This framework recently gained attention by defending the role of governments in setting the direction of technical change, promoting innovation, and the diffusion of new technologies. Thus, mission policies help create and shape new markets via targeted innovation-led oriented policies and can be considered an opportunity for countries with less mature R&I systems to accelerate the development of their capacities (Fisher et al., 2018). The main differences between mission-oriented policies (MOPs) and other typical innovation and industrial policies may be in terms of "scale (bigger), scope (broader) and target (more specific)" (Alves, Vonortas & Zawislak, 2021, p.81). MOPs often use a mix of policy instruments going beyond the mere realm of R&I policies and require horizontal policies cutting across governance levels (Fisher et al., 2018). Ultimately, mission-led policies are seen as a helpful way to employ a policy direction that is smart, inclusive, and green (Mazzucato & Perez, 2014). In fact, scholars do consider that "green growth" is the ultimate goal and the next big technological and market opportunity that can stimulate private and public investments (Mazzucato & Perez, 2014). A promising technology that falls under the umbrella of "green growth" is the production and adoption of low-carbon hydrogen. Producing hydrogen from renewable sources is seen as a global alternative for decarbonizing energy production and economic activities by 2050. In an attempt to close the gap between rhetoric and action, the International Energy Agency (IEA) has set a roadmap that establishes pathways to reach net zero emissions by 2050 that highlights the importance of hydrogen as an energy vector (2021). Similarly, governments from advanced and developing countries launched ambitious hydrogen strategies and directed economic stimulus funds to this area. Based on this

background, we can consider that producing low-carbon hydrogen is one goal of a set of global policies that target green growth. Although MOPs have a major part to play in delivering better quality growth while addressing grand sustainable challenges, they can also face their own challenges in their design, implementation, and assessments. Alves, Vonortas and Zawislak (2021), emphasize that the mismatch between the expected goal and what is actually feasible (based on the available technological capabilities) creates what the authors call "a fuzzy boundary" that often leads to the unsuccessful implementation of missions. Another important aspect to consider is that, while setting goals and determining pathways, missions will hardly be reduced to a single development path or by a single technology. The establishment of a goal or a mission should consider the available innovation capabilities in order to promote a successful regime change or shape and create markets. We consider that MOPs may create an institutional incentive for regime change, catching-up, capability building, and eventually for market creation, but we must also consider that a MOP approach should acknowledge the many stages of development and diffusion of still immature technologies. Geels' (2002) approach is helpful to understand the dynamics of regime change, the emergence of new technologies and their diffusion processes, and how they interact with extant sociotechnical regimes that are crucial for the societal sustainable transformation. One can consider that MOPs cannot be successful without the understanding and mastering of innovation capabilities and the characteristics of their technological path. A full understanding of these dynamics can directly impact the success of the implementation of the MOP framework for sustainable innovation.

Objective: In this article, we aim to analyze and discuss the effectiveness of applying the MOP framework in the context of innovation and diffusion of new technologies applied to low-carbon hydrogen and present a historical approach to the development of this sustainable innovation.

Methodology: We conducted an in-depth literature review of the recent history of the technological development of low-carbon hydrogen as an energy vector. A detailed mapping of global policies that are part of the mission approach applied to this topic was developed. This review covered papers, international reports, recommendations, and cooperation agreements related to low-hydrogen technologies. Significance of the study: This study contributes to academic research and literature by providing a detailed study that enhances the potential and limitations of the MOPs framework applied to the technological development of sustainable technologies. Our analysis demonstrates that MOPs can be helpful tools for addressing important societal problems and can also stimulate government and private actions that could not have happened otherwise. However, the detailed comprehension of the technological regimes and capabilities of a technology, which is the central discussion of a mission, is essential as this influences the implementation and the success of a MOP.

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[3093] *Using Zero Robotics as a study case for Intersectional Antiracist Technology Framework*

Yiyun Zhang (Massachusetts Institute of Technology) and Danielle Wood (Massachusetts Institute of Technology).

Abstract

Background and rationale: A novel theoretical framework named "Intersectional Antiracist Technology Framework" is developed by Dr. Danielle Wood and Dr. Katlyn Turner. This framework uses Systems Architecture to explain, evaluate and design approaches to incorporate Intersectional Antiracism within the Definition, Design and Distribution lifecycle phases of technology. The framework defines technology across four levels of scale including Concept, Artifact, Complex Product System and Complex Sociotechnical System. The framework seeks to demonstrate methods at each phase in the lifecycle of technology to employ an intersectional antiracist mindset and act towards promoting equity.

In this work, Zero Robotics (ZR) is used as a study case in STEM outreach activities to implement the Intersectional Antiracist Technology Framework. The framework provides a method to evaluate how the Zero Robotics program applies antiracist principles to the program design and execution. New insights and visions to the program design and distribution phases are being explored using the framework. Zero Robotics, an education outreach program led by Prof Wood at MIT, is the first U.S. space robotics competition since 2009. The program aims to engage young students from

secondary schools in computer science and space technologies and prepare them for the future STEM workforce. Over 20,000 students and 4,500 educators across 15 countries have participated in the program.

Every year, there is a game challenge being designed for students to gain hands-on experience in engineering and coding. During the program, students learn about the fundamentals of science and robotics and practice their coding skills in the online simulation called the ZR Integrated Development Environment (IDE). The final competition is livestreamed from the International Space Station (ISS) and students interact with the astronauts and watch their code running in space. The program uses the space free flyer robots aboard the ISS called Astrobee, and it seeks a social impact in promoting STEM education and education equality. The ZR program lies at the intersection of Complex Product System and Complex Sociotechnical System scales in the framework which means that both technical and social factors should be considered when asking how the program can be designed with sensitivity to the identity of the program beneficiaries. Continuous development of the program is being made to broaden the participation of underrepresented groups and overcome the technical challenges from the transition to a new robot system.

Methods: New collaborations with Minority Serving Institutions, as defined by the U.S. Department of Education, Navajo Technical University (NTU) and California State University Long Beach (CSULB), are established to promote the participation of Hispanic and Indigenous communities. MIT, the founder of the ZR program, is committed to provide training to college students at NTU and CSULB on the IDE and ZR online simulation tools. NTU and CSULB serve as regional hubs for communities nearby and are responsible for outreach activities and local community support. Based on the principles in the Antiracist Technology Framework, this approach seeks to apply culturally sensitive implementation to ZR customized to the concerns of urban Hispanic students and rural Indigenous students. MIT learns from the experts at NTU and CSULB who are familiar with each local context.

In summer 2022, the first ZR Middle School (MS) competition using the new Astrobee system was held successfully after the transition to a new generation of space robots. It is also the first time for NTU and CSULB students to mentor and support middle school students in the space robotics program. The game challenge is an imagined story that motivates the code activities called “The Great Astro-Spelling-Bee”.

This tournament is a 5-week program and was conducted from June 27th to July 29th, 2022, with a final event live streamed from the ISS on August 3rd. Field days and local workshops are conducted in CSULB and MIT with campus tours and laboratory visits. The program experienced the design and distribution lifecycle phases as defined in the Intersectional Antiracist Technology Framework. Pre-program and post-program surveys from students and educators in the program are collected to evaluate the participation, design, and operation of the program. The method with respect to Indigenous data sovereignty to collect data from Native American students is in development.

Results: The presentation presents a graphical summary of the Zero Robotics program using the Systems Architecture Framework with an emphasis on Antiracist Technology Design. The graphical summary highlights the Context, Stakeholders, Objectives, Functions and Forms of the Zero Robotics Programs and shows how these system elements interact with identity-based features. By using the Systems Architecture framework, the MIT team leading Zero Robotics can identify gaps that need to be improved to increase the cultural relevance of Zero Robotics for the Hispanic and Native American communities. This includes providing language-relevant materials and asking survey questions in a manner that fits community culture. Responses to these findings are ongoing.

20 teams with 178 middle school students participated in the 2022 MS program, and 6 US states (California, Massachusetts, Illinois, Minnesota, Arizona, and New Jersey) and 3 Tribal Nations (Navajo, Hopi and Zuni) are involved. 40 of the middle school students are from Long Beach, Los Angeles, and Paramount Unified Districts. This improvement in diversity and inclusion is made from community outreach conducted by CSULB. Sixty-seven adults have supported the program operations in the summer, including 37 educators and 30 college students.

The pre-program survey with responses from 124 students shows that 60.5% of them in the program are male and 32.3.% are female. Moreover, 52.9% are Asian, 14.7% are Hispanic or Latino, 10% are Black or African American, 9.4% are White or Caucasian (using identity labels aligned with US Census conventions). The fact that females are underrepresented in the program is consistent with observation from the U.S. Census Bureau 2019 American Community Survey (ACS). In the survey, women only constituted 34% of the STEM workforce while 52% of the non-STEM workforce. Moreover, 91% of students expressed that they plan to go to college and concentrate in STEM majors, and 70.2% of students said they participate in the ZR program because of the programming aspect it offers. This implies that the majority of the students who come to the program already have some background in STEM fields.

The post-program survey to students has 31 responses. 77.4% of the students think the 2022 game is interesting, 71% expressed their desire to return next year and 77% would recommend ZR to their friends. The post-program survey to educators has 13 responses. On average, educators ranked ZR 8.7 out of 10 in terms of the impacts on students’ summer learning. 100% of educators thought the game was interesting and fun. 61.5% of educators would run ZR again and 76.9% would recommend it to their colleagues. These results give positive signals on the program impacts on students’ learning experience and the game challenge designs.

Significance: The “Intersectional Antiracist Technology Framework” incorporates aspects from science and technology studies, critical theory, design research, and systems engineering. Zero Robotics, as an impactful STEM education

outreach program, is used as a study case to define and evaluate the framework. This framework is also used to explore solutions in the design and distribution lifecycle phases to improve social justice in education. Historical discriminations and inequalities in socioeconomic resources create barriers for certain groups to be engaged in STEM activities. These barriers shall be minimized to involve minority groups and equal opportunities should be provided to promote future workforce diversity. The outcome of this work is an evaluation of the current phase of the ZR program and an analysis of defining and applying the Intersectional Antiracist Technology Framework.

[8310] *Societal impact of research and public policy: a bibliometric assessment*

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Abstract

Suggested topic area: Societal impact

Background and rationale: The literature on societal impact of research has been pointing to a diverse range of ways to identify, analyze, and measure how scientific knowledge flows from its production spaces to engage with and influence society (Viana-Lora & Nel-lo-Andreu, 2021; Smit & Hessels, 2020; Bornmann, 2013). Part of this debate is related to the impact of research on public policy design, implementation, and evaluation processes (Boaz et al., 2009; Newson et al., 2018). In general, such studies adopt a diversity of theoretical and methodological approaches that basically follow two paths, which are not mutually exclusive: forward tracking, starting from research to identify its impact on policy; and/or backward tracking, starting from policy to identify the use of scientific research. In both paths, one of the possible approaches refers to the use of bibliometrics and altmetrics techniques to capture and analyze the use of research in policies and measure its impacts (Tahamtan & Bornmann, 2020). In addition, the debate on the societal impact of research - in its various social dimensions and spaces, including policy - allows us to put into perspective and debate the role of stakeholders directly involved in the production of scientific knowledge, especially universities and funding agencies.

Objective: Considering this debate, our study aims to explore the potential of bibliometrics to identify and analyze, in an exploratory way, how policy documents have been created based on research funded and promoted by the São Paulo Research Foundation (FAPESP) in two main areas: society and environment. We assume herein the inseparability between the social and environmental spheres. Considering the environment and society as elements that mutually affect each other, it is common for research funding institutions to include the analysis of environmental impact within the social scope. The Higher Education Funding Council for England (2019), for instance, considers that health and environment are part of the definition of social impact by affirming that it means “[a]n effect on, change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia” (HEFCE, 2019: 118). Regarding FAPESP's financial support for projects, in the field of life sciences, which accounted for 45% of the disbursement made by the institution in 2020, the health area was responsible for more than 25% of this investment, totaling more than BRL 247 million that year. Thus, as for societal impact, we have decided to focus on health-related research funded by FAPESP. Likewise, amongst the several projects supported by FAPESP in the environmental field, climate change-related research has been receiving most of the grants, which reflects the global trend of counteracting the emission of greenhouse gas and warming of the earth’s surface. In other words, we will seek to understand how policy organizations have been using research funded by FAPESP in these two major socio-environmental problem areas, namely health and climate change. This study answers the following research question: to what extent is it possible to measure the impact of research funded by FAPESP in the areas of health and climate change by exploring bibliometric resources?

Methodology: Here we make use of Overton, considered the largest and most comprehensive database that tracks how research (papers) are cited in policy documents produced by government agencies, think tanks, nongovernmental organizations, and intergovernmental organizations in 182 countries (Fang et al., 2020). The research explores the following path: from the policy documents found under the umbrella of "health" and "climate change", we have identified the papers written by authors from Brazilian research institutions. After this initial screening, we have selected only the research funded by FAPESP. Such procedure allows bibliometric data to be obtained from both the funding-related articles and the policy documents that use them. Afterwards, an exploratory analysis was conducted, focusing on four aspects: (i) the characterization and type of political organization that cited research funded by FAPESP, including country of origin; (ii) the sub themes of impact within health and climate change most related to research funded by the agency; (iii) how the research is being used, considering the debate about political appropriation and mobilization of research; (iv) and basic bibliometric analysis of the identified papers. Although the study cannot be considered comparative in nature, the methodology enables the establishment of similarities and differences between the impacts considered (health and climate change).

Significance of the study: By using Overton, this study explores ways to connect funding to the impact of research on public policy, attempting to dialogue with the literature on the social impact of research, as well as empirically bringing about novel analyses on one of the main Brazilian research and innovation funding agencies. On the one hand, the focus on the funding agency is justified by its prominent and influential role in stimulating the societal impact of research within the scientific community; on the other, funding agencies are embedded in a context of political and social pressures to demonstrate the societal impact of funded research, also seeking for political and societal legitimization (Curry et al., 2020; Watermeyer, 2019). Moreover, FAPESP is considered one of the most important research and innovation funding institutions in Brazil. Regarding the chosen impact themes, it is known that health and environment are fruitful fields for the dialogue between research and public policies (Newson et al., 2018; Bornmann et al., 2016), as well as relevant themes to society, closely related to the Development Sustainable Goals (SDGs). Thus, we discuss herein, from the data and analyses carried out, the role of funding agencies in promoting studies capable of politically impacting health and the environment.

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[6373] *What Does Equitable Co-production Entail? Three Perspectives*

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Abstract

Background and rationale Unlike basic science, studies conducted for the purpose of societal decisions, sometimes referred to as “Mode 2” research, require the involvement of broad publics. The U.S. Global Change Research Program (USGCRP), mandated by Congress in 1990 to provide decision-relevant climate science, spurred the establishment of some of the longest-running and most geographically diverse programs to conduct these types of research, among them the National Oceanic and Atmospheric Administration (NOAA) Climate Adaptation Partnerships (CAP) program, Department of Interior (DOI) Climate Adaptation Science Centers (CASCs), and U.S. Department of Agriculture (USDA) Climate Hubs. These federal programs may shed light on an issue that is increasingly recognized as a significant challenge to decision-relevant scientific research: involvement of people who historically have been underserved by government programs and/or have experienced discrimination and exclusion. Public administration scholars have long warned that

conditions of social inequity and inequality may worsen when the quality of governance and public services is dependent on community participation. This raises the question, what does equitable co-production entail? This question is increasingly pertinent as federal funding agencies expect that researchers will conduct science that has societal impact.

Climate research has been one of the areas in which co-production academic literature has grown rapidly. Climate change represents the epitome of "post-normal" science in which the uncertainties and decision stakes are both high, requiring the involvement of "extended peer communities." The manifold nature of collective action for climate change—creating knowledge or information, building connections/networks, amassing influence, and implementing responses—requires stakeholder, cross-sectoral, and transdisciplinary efforts, including expertise from a broad range of practitioners and publics. Given the diversity of actors, climate risks, and governance structures across the United States, solutions often need to be place-based. Further, resources serve as a crucial constraint on local responses to climate change. But aligning various forms of knowledge, priorities, values, and users and ensuring "useful, usable, and used" information for the purpose of societal action poses a significant challenge.

Methods The research was conducted in a series of four stages between July 2021 and May 2022: 1) interviews with the directors of the three regional climate programs to identify potential projects with both co-production and equity dimensions; 2) interviews with participants in three federally funded projects to identify a range of statements about what constitutes equitable co-production (n=18); 3) an online rank-order survey of the interviewees and other participants in co-production to quantitatively determine how the perceived requirements of equitable co-production processes vary across groups (n=32); and 4) a workshop to vet and discuss the perspectives, assess areas of consensus across the perspectives, and determine what types of associated activities would support more equitable co-production, in which all of the participants in Steps 2 and 3 were invited (n=40). Q methodology was used to evaluate differences in viewpoints between small sub-groups of individuals using principal components analysis.

Results We abstracted a list of dimensions about equitable co-production by coding statements from the interview transcripts. The criteria of exhaustiveness and mutually exclusiveness guided the identification of five categories: 1. Outcomes (OC): What are the project outcomes, both intended and achieved? 2. Power (PWR): Which people and forms of knowledge have the power to influence the project across different stages, including preparatory work and planning? 3. Audiences & participation (AUD): Who does or doesn't participate and how, or reasons they choose not to; audiences for information; access to information, decision-making spaces, and resources to participate. 4. Place-based, community rights & respect (PBD): Place-based focus; what community experiences, challenges, expertise, knowledge, and rights are, or are not, recognized. 5. Interactions (INT): Characteristics of the process: language, communication, process and outcome clarity, longer time periods, and interpersonal contact or relationships.

Two researchers independently coded each of the interview statements into the categories and resolved all coding discrepancies. From the aggregated list of interview statements within each category, representative examples, exhaustive of those coded from the interviews, were chosen for the final concourse of statements to be used in the ranking. The final concourse is comprised of 50 statements across the five dimensions. It attempts to capture a diversity of viewpoints from the interviewees on what constitutes equitable co-production. Based on a principle components analysis of Q-sorts (i.e. participant rankings), we found three perspectives of equitable co-production that are descriptively titled: Ways of Knowing & Power (P1), Participants & Interactions (P2), and Science as Capacity Building (P3). The analysis was performed using qmethod in R. We examined up to 7-factor solutions using principal components analysis with varimax rotation. Only in the 2- and 3-factor solutions did all participants cleanly fall into one of the perspectives with none loading negatively. The three-factor solution accounted for more total explained variance than the two-factor solution (42.8% vs. 36.2%). Further, each of the three factors accounted for a roughly equal proportion of the total. Solutions that explain more than 35-40% of the total variance are considered satisfactory. Interpretation of the perspectives was conducted both through analysis of the Q-sorts and the discussions of workshop participants. Notably, the perspectives are not aligned with the case studies from which the interview statements were taken. Interviewees from the same case study fell into differing perspectives. Nor is there necessarily a relationship with organizational affiliation; individuals from government, academia, and non-governmental organizations ranked across all three perspectives. The perspectives are described below.

Ways of Knowing & Power (P1). This perspective focuses on two dimensions of participation in co-production by communities who are affected by the project. First, the co-production process should respect different knowledge systems and ways of knowing. Not only should communities have the right to give—or withhold—consent to any project that would affect them, their lands, or resources, but they should be in the driver's seat in creating project goals and outcomes from the outset.

Participants & Interactions (P2). This perspective emphasizes the participatory, communicative, and interactive dimensions of equitable co-production, while honoring the expertise and experiences of communities and their rights to consent. Local groups should be involved, and community members provided with the information, resources, and technological tools they need to participate and multiple ways to engage.

Science as Capacity Building (P3). Co-production outcomes factor more strongly in this perspective than the others: 1) to help people use science and help make science useful to individuals, 2) to build connections within and external to

communities, and 3) to empower and build capacity for collective action. Boundary organizations play a core role as partners on the project team with power over decisions, and with community buy-in and participation from the outset.

Significance Without any clear consensus on the necessary components of equitable co-production that align across differing perspectives, there can be few assumptions about how others may view them when starting to build new partnerships. Contemplating the varying ways that co-production may be perceived may bring some measure of clarity. Understanding potential perspectives can assist participants in co-production efforts in communicating with each other and considering rules of engagement in co-production that may satisfy holders of different perspectives. Within this capacity for imagination and flexibility lies perhaps the greatest potential for success.

[7613] *Use of Science in Government Decision-making: An Analysis of Regulatory Impact Analysis*

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Abstract

The design and implementation of regulations is a core government function. Regulatory impact assessment and related cost-benefit analysis procedures are used worldwide as a tool for setting efficient and effective standards. In the U.S., major federal regulations undergo a Regulatory Impact Analysis (RIA). By executive order, the rulemaking agency must develop an RIA to justify a proposed rule based on scientific evidence and supporting research. Thus, the content of RIAs provides a window into how different government agencies use scientific products and data for decision-making.

This study evaluates how and what types of scientific research and data are used in RIAs. The study analyzes all available RIAs between 1981 and 2022, around 18,000 documents in total. RIA documents and metadata are collected using web scraping. Then, we use a series of natural language processing and automated classification methods to extract and disambiguate references from this corpus. Extracted citations are classified by category (e.g., academic sources versus government reports), and matched to the OpenAlex scientific works database. Matching to the OpenAlex database allows observed references to be linked to extensive metadata about individual publications (e.g., citation count, keywords, abstract), journals (e.g., impact factor, tagged concepts), and authors (e.g., institutional home, authorship teams). Collectively, this allows us to develop a comprehensive, quantitative representation of how agencies use science in rulemaking decisions.

We use these data to address three core questions: (1) what types and forms of research are most directly connected to regulatory policy decisions?; (2) how does the use of science differ by agency and organizational attributes?; and (3) to what extent are methodological and topical innovations (e.g., open-access, machine learning, artificial intelligence) growing in academic contexts being picked up by regulatory agencies, and where is such innovation occurring. Answering these questions is relevant for both scientists and policymakers alike. For scientists, understanding the characteristics of scientific publications that get used in policy decisions can help scientists design, implement, and report work in a fashion that supports use and dissemination. For policymakers, better understanding the landscape of science used in government decisions can support targeted investments, science and innovation policies that better support research-to-practice, and identify organizational strategies and processes that appear to support scientific innovation in the public sector.

[9355] *Literature review and scientific mapping on the economic, policy, and societal impact of research*

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Abstract

Background and rationale Over the past years, research funding agencies have demanded studies on the impact of the research financially supported by them to verify how the creation of knowledge relates to improvements in economic, social, and policy-related areas (Aiello et al., 2021; Sandes-Guimarães, Velho & Plonski, 2022; Milat, Bauman & Redman, 2015). More importantly, research funding agencies are concerned about demonstrating the relevance of scientific research and studies to address societal problems, i.e., about producing evidence of the impact of the funded research. This movement is important because it promotes higher accountability and advocacy directed to different types of stakeholders and it demonstrates the effects of investing in research. This is also part of a larger discussion that investigates the science of science, or research on research, that aims to identify how scientific research can be made more open, inclusive, and impactful. Considering the above, through a brief literature review, we have come across multiple impacts deriving from research. In order to conduct our study, we decided to group them into three clusters,

namely, economic, policy, and societal. This division allows us to identify similarities and differences between the many impacts of investing in research according to their specific contexts. In addition to understanding aspects related to the literature on research impact, thinking of the societal impact of research is increasingly connected with discussions on Equity, Diversity and Inclusion (EDI) in academia. In this sense, we consider that incorporating EDI indicators in the literature review together with traditional bibliometric indicators is relevant as it sheds light on aspects that are often neglected when discussing the state of the art of a certain topic. In other words, this research approach allows us to identify the status quo and marginalized discussions of relevant topics by including indicators of genre, race, location, and language.

Objective This study aims to show an overview of the economic, policy and societal impact of scientific research from 2015 to 2022 through the elaboration of a scientific mapping, as well as critically discussing it. This scientific mapping considers four main areas: a) thematic evolution, b) methodological approach, c) performance based on traditional bibliometric indicators; and d) performance based on new bibliometric indicators (EDI). It is important to note that this study is part of a larger project to investigate and develop research impact indicators for several initiatives carried out by the São Paulo Research Foundation (a.k.a. Fapesp) in Brazil.

Methodology Through a bibliometric analysis carried out in the Web of Science and Scopus databases, we provide the scientific mapping concerning the three broader impacts mentioned herein, namely economic, policy, and societal. It is important to clarify that to all impacts considered, basic bibliometric and literature review techniques will be applied. Common to all impacts is the inclusion of EDI metrics, as well as the identification of articles that address the role of funding or funding agencies in impact evaluation. However, considering the vastness of sub-themes implicit in each of these impacts, we resorted to a few methods to delve deeper and focus on each more effectively. The economic impacts will be evaluated based on three pillars, namely: university-industry collaboration, focusing specifically on an output indicator of university-industry co-authorship in scientific articles; the relevance of funding for the development of innovation and entrepreneurship ecosystems; and the importance of funding for the creation and development of small business programs, such as the SBIR. Regarding policy, we intend to identify how the literature on policy impact of research addresses the flows of knowledge from academia to policy (forward tracing method) and the use of scientific knowledge by policymakers (backward tracing method). Taking into account the research objectives, the following aspects will be emphasized: methodologies for evaluating the different flows and use of knowledge between science and policy-making; the debate on the role of funding and funding agencies in promoting the impact of research on policy and ways to assess and evaluate this, including the incorporation of new bibliometric and altimetric methods to measure impact; and the thematic dimension (public policy area reached) of the articles identified, looking for trends in knowledge areas that present greater predominance on the impact of policy research. As for the societal impact, we had to make a more delimited cut, as the literature informs that the social impacts encompass several fields, like health, the environment, public policies, and education. However, it is important to state that the social and environmental areas are relevant and frequently cited when it comes to the societal impact of research. Thus, by assessing the main thematic projects supported by Fapesp, we found that the health area is the social field that has received the highest financial support in recent years, which emphasizes its relevance as a field of research and project development. On the other hand, considering the relevance of environmental issues, we verified that the environmental-related area that receives the most funding from Fapesp is climate change, which reflects the general concern with global warming, expressed and emphasized by reports like those by the Intergovernmental Panel on Climate Change (IPCC). For these reasons, we chose health and climate change as the societal impacts to be further assessed in this study.

Significance of the study The analytical exercise of identifying and developing a scientific mapping of the economic, policy, and societal impact of research allow us to identify similarities and differences between recently developed impact assessments. The intercambiation of methodological approaches is a rich contribution of this study as new ways of assessing a certain impact could be limited to a field of knowledge and have not yet overcome the disciplinary barrier; this may be useful when applied to other areas of knowledge. Another relevant contribution of this study is that the scientific mapping provides us with an outlook on research opportunities and points out where contributions can be made to the field. In addition, evaluating the state of the art in each dimension based on traditional performance indicators gives us an overview of the status quo of a topic of academic interest which is a well established way of providing information and evidence of how impacts are being assessed in recent literature. However, as we previously outlined, funding agencies are concerned about ways to make research practices more open, inclusive and impactful and an effective way of addressing and investigating this topic is to consider alternative indicators while performing a literature review. In that sense, we provide a relevant contribution by stimulating the incorporation of EDI indicators when conceptualizing a study, and also by developing new bibliometric indicators based on EDI.

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[5898] *Connectivity, Networks, and Policy: Broadband and Urban Workforce Development*

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Abstract

Background and rationale While infrastructure has traditionally be thought of in a concrete manner (e.g. roads, railways, water systems, etc.), access to broadband, has become a 21st century factor in technological innovation, and economic growth. Beyond basic access, robust broadband connectivity is a key component in technological innovation and workforce preparation. In the U.S., while broadband access is generally available, there are still notable gaps in accessibility and uptake in both rural, and urban areas. Some 15 million urban households are without broadband access, but of additional concern, from a policy perspective are key non-technological barriers. These include digital literacy and education, and as well as awareness of the application of access on the part of both workers and enterprise. Recognizing this need, several interlinked approaches have been proposed: 1) connectivity efforts, 2) workforce enhancement, 3) economic development initiatives, and more broadly, 4) innovation network activities, involving a variety of actors, including the public sector, the private sector, and assorted combinations thereof – with varying degrees of efficacy. With this in mind, the present project focuses on exploring the interaction between local level broadband access policy, and local enterprise and industry innovation networks in advancing connectivity driven skilled worker preparation and workforce development. While basic access and connectivity has been seen as critical on an individual basis for social, community, and economic participation, at a broader, metropolitan level, it impacts the success of community, business, and other institutions. Urban digital divides, coupled with shortages of appropriately skilled workforces, represent a "soft" infrastructure gap to industrial and economic innovation, ancillary to the traditional urban infrastructure noted above. In short, "technological access" to the internet is necessary but not sufficient to provide connectivity - which requires, optimally, both individual competences, skills, education, partnered with the efforts of intermediary organizations. Connectivity here is used to suggest a more nuanced construct encompassing application and use of information flows, training, and preparation of skilled workers, and understanding of the economic and community impact of access to information. In short, a focus on the outcomes and utility of broadband connectivity. Effectively designing approaches to address workforce preparation requires consideration of a range of questions to help assess contextual factors. This research explores the impact of technology, infrastructure, data, actor engagement, and public funding to enhance understandings of connectivity and deployment in urban settings. While the fundamentals of urban broadband supply and demand are fairly well understood with respect to basic access, a relatively understudied area is the role of, and potential contributions that could be made by, proactively engaging institutional intermediaries in policy design and deployment directed at education, digital literacy, and demonstrating the internet's relevance and benefits. Enhancing broadband adoption and awareness can be critical to improving the pool of information savvy, skilled workforces. Preliminary findings of previous research indicate that the adoption of policy approaches and associated instruments need to be responsive to contextual realities that reflect the diversity and needs of the community and is critical to fostering the deployment and long-term sustainability of urban broadband soft-infrastructure connectivity. In urban areas with low adoption, a mix of implementation approaches (e.g., public sector, public/private and non-profit) and engagement of intermediaries can be effective tools to address digital inclusion challenges. Research Approach In urban and metropolitan areas, it is useful to consider: 1) the technological "how" of connectivity deployment, 2) the "who" facilitating/supporting the design and deployment approaches, and 3) the "why" or objectives/policy outcomes of the initiatives, including the interplay between state/provincial policies and local policy/initiatives, and the role innovation intermediaries play. The paper presents the results of a comparative case analysis of a set of 10 representative U.S. cities that can be classified as most or least as "innovative" using an approach such as the WalletHub index, along with 6 representative Canadian cities using a comparable innovation index. These are compiled into a matrix capturing local connectivity related policy approaches and comparatively analyzed using the following perspectives: - Context of, and associated data available for the connectivity analysis. This takes into account data related to physical geographic parameters, as well as demographic, social and cultural community variables. Assessment of a specific use case – here the dimensions of connectivity, workforce and associated industrial sector development, is impacted by selection of a given set of data used to inform the problem. - Access/System technologies – The specific technologies and technological based solutions available to stakeholders in a given locale. - Actors/Stakeholders have different interests and objectives, which underscores the need of any model or set of tools, including policy alternatives for advancing city connectivity to address priorities and barriers. This includes examination of the various network intermediaries (trade groups, professional societies, NGOs, advocacy and economic development groups, institutions of higher education, etc.,) who could be involved in the crafting and supplying of solutions. - Objectives/Outcomes/Impacts, relate to the particular aspect of the problem being solved. Does one solution (e.g. local government provision of broadband) "break" another (subsidized competition with an incumbent carrier)? Does a focus on community participation and "retail connectivity" take a back seat to economic development of large industry needs? - Identification of the specific policy approaches present in the selected cases, including the array of possible solutions, both technological and policy oriented to

enhancing regional connectivity. In the US, these range from public sector initiatives at Federal, State and Local levels, to public private partnerships, to NGO/Advocacy related activities, to purely private sector initiatives

We explore the issue of municipal connectivity from a multidimensional perspective – the components of the problem, and then examine the types of policy approaches that are generated by actors using an approach presented in a paper (Gaspard and Baker, 2022). We catalog different perspectives and conditions of the problem, and identify the specific policy approaches present in the selected cases, including the array of possible solutions, both technological and policy oriented to enhancing local/urban connectivity. Preliminary Observations Work in progress based on Canada and the U.S. cases, suggest that adoption of policy approaches and associated instruments responsive to contextual realities, and that reflect the diversity and needs of the community, are critical to fostering the deployment and long-term sustainability of broadband-based connectivity initiatives. Local policy impacting connectivity—be they policy/regulatory, economic, financial, or technological—are most effective when designed to consider contextual conditions, the diversity of the target communities, and the specific orientation of intermediaries. Mapping existing connectivity policy, and community and industry needs is essential for actors and intermediaries. Developing an understanding of what works and how would add to the literature, as well as provide insight for policy and decision makers. Effective uptake and impact of broadband infrastructure connectivity is impacted by policy approaches and associated instruments that is targeted to address the contextual realities inherent in the diversity and needs of the community as well as other key stakeholders

[1508] *Using Granular Start-up and Project Data to Analyze Global Scaling of Novel Climate and Energy Technologies*

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Abstract

Background and Rationale: Accelerating technological innovation is essential for meeting long-term decarbonization goals and for supporting economic development and employment by expanding emerging green industries. Currently mature technologies will meet only a quarter of long-term sustainable energy goals according to the International Energy Agency. Addressing this challenge therefore requires ensuring that new climate technologies scale up rapidly and can be deployed cost effectively. Energy innovation systems research suggests that various actors—especially governments, start-ups, large firms, and private investors—and their interactions will be involved in scaling up innovation to a commercially ready product. However, currently, there is no systematic approach for connecting empirical data on commercially viable, early-stage technologies and the various actors involved, with systems models that investigate large-scale deployment and inform energy and climate policy decisions.

Standard methods of developing learning curves require a track record of deployment that new technologies lack, and expert elicitations are resource-intensive and may be less amenable to analyzing commercial breakthroughs. Linking realistic, bottom-up empirical evidence on technologies such as start-up investment data, project databases, and historical technology analogues with macro-level energy systems models can help overcome these difficulties to inform scaling trajectories for emerging technologies. Here, we propose a framework for integrating such granular real-world data into an open-source integrated assessment model, i.e., the Global Change Assessment Model (GCAM), and use direct air capture and aviation as examples of how this framework can support analysis of technology development and just energy transitions.

Methods: The technologies selected are based on the following criteria: (a) technologies in early development stages that will be important for deep decarbonization pathways (b) technologies developed by start-ups with substantial investment records, particularly from private investors (especially strategically and financially motivated corporations), (c) technologies with new model developments in GCAM (often related to previously understudied areas, indicating a strong potential for high-impact results).

We examine two case studies. Our assessment of direct air capture (DAC) technologies draws on publicly available investment data on commercial purchase agreements for carbon dioxide removal, as reported by Stripe and www.cdr.fyi, and plant capture rates from IEA project data and announcements from company websites. Our examination of aviation utilizes ICAO records of sustainable aviation fuel (SAF) offtake agreements and novel aircraft design timelines to investigate decarbonization trajectories in the US and EU that would limit the need for offsetting emissions in net-zero pathways.

We use these two cases to estimate variations in technology diffusion through projected changes in the S-curve. An S-curve has three degrees of freedom: the inflection point, the growth rate, and the maximum value. The inflection point and growth rate are derived from historical technology analogues by fitting an S-curve to historical capacity data for those technologies. The maximum value is calculated using investment data and publicly available purchase agreements or plant operation announcements.

We implement the changes in S-curves in GCAM. GCAM is a technology rich model with detailed regional representation of energy production, transformation, distribution, and end use. GCAM projects systems outcomes through 2100 at five-year intervals, including energy supply and demand by technology and vintage, regional prices for goods and services (e.g., electricity, agricultural commodities, etc.), emissions of greenhouse gasses and short-lived species, and climate outcomes. For each five-year time step, GCAM solves for a set of market prices such that supply equals demand for all markets and sectors and across all regions (32 geopolitical regions, 384 land-water regions).

In the DAC case study, we use purchase agreements and plant announcements for 16 DAC start-ups which report the amount of carbon a company plans to capture in the near future. Assuming a start year of 2010, the first year of operation for a DAC plant according to IEA, we project the next ninety years of DAC assuming a growth rate and inflection year identical to different historical analogues. We specify the exact capacity of DAC for which GCAM should solve at every five-year time step, using the S-curve parametrization calculated with historical technology analogues and near-term DAC projections.

For aviation, we use global data on SAF offtake agreements through 2035 to project scaling pathways for SAF using a similar approach with historical analogues. We also use granular data on novel aircraft deployment timelines to determine the potential speed of a transition to electric and hydrogen fueled planes, accounting for fleet turnover rates. We specify these pathways in GCAM to determine how these technology innovations can contribute to 2050 net-zero goals.

Anticipated Results: Preliminary results suggest that, if DAC adoption follows historical analogues, the timing, growth, and market saturation of DAC technologies differ significantly from what is typically observed in models that currently inform global, national, and sub-national climate policy. The median logistic growth of technologies in our dataset (measured in cumulative capacity) is 17%, but with a wide range of growth (2% - 200%). This result suggests that technologies grow at vastly different rates, impacting the cumulative capacity of the technology as well as the time it takes for the technology to scale up to its eventual steady state.

Preliminary analysis of aviation in the US and EU suggest that the sector can deliver emissions reductions that limit the need for offsetting in net-zero pathways. Full decarbonization of the aviation sector will likely place additional burdens on biofuel production and scaling of clean electricity generation uncless coupled with demand reduction policies such as mode shifting.

Significance To reach a net-zero world, rapid development and deployment of pre-commercial technologies is essential. In order for researchers and policymakers to accurately assess the potential contributions of these technologies to decarbonization pathways, new methods of analysis are needed to determine realistic scaling pathways. Here, we demonstrate two case studies of how such analysis can be developed, and the resulting implications for ambition for carbon dioxide removal, negative emissions, and decarbonization of the aviation sector.

[7423] *Impact of Institutional Design and Funding Mix of Research Funding Programs*

Takayuki Hayashi (National Graduate Institute for Policy Studies).

Abstract

BACKGROUND: Public R&D funding does not merely provide money for research activities; its institutional design of funding influences the characteristics of the research activities carried out. As diverse types of funding programs are being formed, not only traditional project funds but also, for example, large funds for outstanding researchers, centers/networks of excellence, and mission-oriented programs tackling social issues, it has become important to identify what institutional elements of program have what effect on research activities (Gläser & Velarde, 2018; Laudel & Gläser, 2014; Ramos-Vielba et al, 2022). In addition, researchers are now receiving multiple funding sources to carry out their research activities (Aagaard et al., 2021). As block grants/core funding to universities decreased and shifted to competitive funding, activities and infrastructure for which block grants have been used in the past must be funded with competitive funds. For example, hiring young faculty, purchasing and maintaining research facilities and equipment, networking with outside parties, etc. Therefore, ministries and agencies need to design a “funding mix” in which funding programs with different characteristics can be synergistically effective (Cocos & Lepori, 2020). Different patterns of this combination are expected to lead to different ways of developing research fields at the national level (Nedeva et al., 2022). However, empirical analyses of research are scarce, and few studies have identified what is currently occurring. In this study, we analyze the following research questions: 1) does the institutional design of individual funding program

actually change research activity? 2) what is the state of the funding mix? and 3) how do funding design and funding mix affect the characteristics of a country's research field at the macro level?

Case: As a case of funding program which intended to create a new research paradigm, the “Elements Strategy Initiative” (2013-2020) in Japan is the subject of this empirical analysis. This program is to integrate materials engineering research, which has traditionally been experimental development research, with element-level theories, calculations, and simulations in physics and chemistry, as well as with advanced analytical technologies such as large synchrotron radiation facilities and high-intensity proton accelerator facilities. This aimed to form a new paradigm in material science, and was also intended to have a social impact in the development of materials that could replace the functions of rare earth, which is often difficult to obtain due to geopolitics. For this purpose, different types of funding programs were formed first, including a team-based project fund, young researchers fund, and an industry-academia collaboration fund. A few years later, funding program for the formation of four research centers to serve as focal points. There are institutional conditions for the creation of the centers. Each center was to have groups in three different research areas (theoretical research in physics and chemistry, materials creation engineering, and advanced analysis and evaluaiton), with the condition that the research be integrated among them.

Methods: We use the difference-in-differences method to analyze how the funding institutional requirements of the research centers affected the researchers' activities. After identifying the researchers' primary discipline from their records of obtaining funding in the past, we compared researchers who received the Elements Strategy Center Program with those who received a most popular grant in Japan, Grants-in-Aid for Scientific Research, for researchers in the same discipline. The analysis compares the differences of increase in co-authored papers between researchers in different disciplines, publications in journals in fields that are not a major discipline for that researcher, and the percentage of highly-cited papers. With regard to the funding mix, we analyze the joint receipt relationship of the funding using the acknowledgments of the articles. For the analysis of macro-level effects, the nanoscience/nanotechnology field is used as an overarching area (Wang et al. 2019), and an international comparison of the differences among the fields that comprise nanoscience is conducted.

Results: As a result, the Elements Strategy Center program showed co-authoring relationships between researchers in physics and chemistry and those in materials engineering, which were not seen in the Grants-in-Aid for Scientific Research. In particular, there was a statistically significant formation of new collaborations between materials engineering and researchers in condensed matter physics who use large analytical instruments. Furthermore, we found that physicists began to publish more papers in materials engineering journals, and materials engineering researchers began to publish more papers in physics journals. However, while this increased the number of highly cited papers by materials engineering researchers, it had no such effect on physics researchers. With regard to the funding mix, there was a co-occurrence of acknowledgments for young investigator fellowships, inter-university experimental equipment sharing funds, and large experimental facility funds with center program. The results indicate that even researchers who receive flagship center-based funds acquire the necessary elements for their research through a combination of other funding programs. At the macro level, a country-by-country comparison of the fields that comprise the nanoscience/technology field shows that Japan has a relatively high percentage of highly cited papers in the field of physics than other countries, and the Elements Strategy Center program contributes to this percentage at 14%. This is higher than the contribution to other fields, indicating that the Elements Strategy Center program is building the characteristics of the nanoscience field in Japan.

Discussion: The results show that although individual funding has a direct impact on research activity, the current funding environment nevertheless necessitates the design of a funding mix. We suggest that this design will facilitate the formation of a new research paradigm and will allow for qualitative differentiation of research content from that of other countries.

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[8124] *The Evolving Role of White House Science Advice: An Assessment of the Membership Balance and Policy Impact of the President’s Council of Advisors on Science and Technology (PCAST)*

Kenneth Evans (Rice University's Baker Institute for Public Policy) and Kirstin Matthews (Rice University's Baker Institute for Public Policy).

Abstract

Overview This presentation offers a comparative analysis of the President's Council of Advisors on Science and Technology (PCAST) across presidential administrations, beginning with President George H.W. Bush through the first two years of the Biden administration. PCAST – a federal science advisory committee appointed by and advising the president – will be assessed for its changing balance of member social and professional perspectives and its role and impact in federal policymaking over the last thirty years. The goal is to understand the changing balance of PCAST's expertise and the evolution of its advisory role and across time, as well as to employ this analysis to develop recommendations for PCAST's organization and operations in future administrations.

Background and Rationale PCAST was created by President George H.W. Bush in 1990, although its origins date back to the Truman administration and the early Cold War. PCAST is co-chaired by the president's "science advisor," its only federal member, and consists of roughly 30 independent scientists, engineers, industry leaders, and other research professionals. PCAST is charged to advise the president – either directly or through the science advisor – on all matters related to science, technology, and innovation (STI).

While PCAST's function has not changed significantly since its creation, its membership demographics, policy areas of focus, and influence on White House policymaking has shifted considerably with each presidential administration. Most recent research studying scientific experts in U.S. government decision-making focuses on "science for policy" technical advisory bodies within federal regulatory agencies. PCAST, however, is "policy for science" presidential committee responsible for guiding White House policy development and implementation across a broad range of issues that rely on STI data and analysis, including national security, public health, industrial competitiveness, environment and energy policy, and science education. PCAST's proximity to the president, its high-profile membership, and the historical influence of its predecessors make it a unique case study for examining the role of scientists and other research experts working at the nexus of science, policy, and politics. Empirically evaluating scientific advice remains a challenging research question. This presentation offers data and a preliminary analysis of PCAST's changing member perspectives and its evolving role and impact in White House STI policy decision-making. The goal is to understand how and why professional or social groups were represented on PCAST's roster across time and how PCAST policy recommendations are developed and implemented in broader STI ecosystem through time.

Methods This research employs two analytical frameworks to understand PCAST's membership demographics and the nature of its advisory function over time, from 1990 through 2022. The first framework establishes a measure of PCAST's diversity in the context of its governing legislation, the Federal Advisory Committee Act (FACA). FACA mandates certain transparency requirements for committee operations, as well as guiding language for ensuring committee membership is "fairly balanced" in represented interests and technical expertise to address its intended function. As PCAST members are appointed based on both their scientific knowledge and personal achievements, member demographics are categorized into "professional perspectives" and "social perspectives." PCAST membership will be compiled from the Federal Register and each individual will be coded by their professional (i.e., scientific expertise and career experience) and social perspectives (i.e. race or ethnicity, gender, and geographic location) to be collected from public biographical records. Data will be supplemented with public statements from PCAST members—such as oral history interviews and public statement from current and former White House officials—to provide comprehensive picture of how each president and their science advisor approached membership balance and if that balance is representative of the national STI workforce at the time of service.

The second analytical framework offers a methodology for examining PCAST's intended function and its impact in White House policy development and implementation. Although FACA ensures PCAST's formal independence from the administration, PCAST remains responsive to White House policy priorities through the leadership of the science advisor and sometimes direct engagement with the president. PCAST, in its alignment with administration priorities, could possess an "instrumental" role, providing substantive policy analysis that advances the public interest, or a "symbolic" role, legitimizing or otherwise supporting administration decisions – or a combination of both. To make this determination, each president's PCAST will be analyzed based on four criteria: its leadership structure (e.g., Does the science advisor serve as its sole chair or co-chair?); its process for consensus building (e.g., How are policy recommendations vetted and agree upon?); the long-term impact of policy products (e.g., Do PCAST studies translate into concrete policy actions?); and the image of PCAST presented through official government press releases and its reception in national media (e.g., How and how often are PCAST members and their work represented in news outlets?). Anticipated Results

The two frameworks will help to provide a complete picture of PCAST's shifting membership balance and its role in White House STI policymaking beginning with the George H.W. Bush presidency. With respect PCAST's diversity, the council's exceedingly broad charge to address all policy related to STI raises the question of how best design a representative council membership inclusive of all individual and career backgrounds and scientific disciplines. An initial analysis of PCAST membership demographics demonstrates a trend toward increased inclusion of both professional and social perspectives with time. However, the data indicate a persistent underrepresentation of both categories with respect to the national STI workforce and overall U.S. population. In particular, women and minoritized racial and ethnic groups are

underrepresented in PCAST in most administrations. Notably, individuals of Asian descent were significantly underrepresented with respect to that group's increasing participation in the national STI workforce. Additionally, individuals with expertise in the social sciences, while consistently represented in most PCASTs, are not included in PCAST at the level of active U.S. STI professionals.

Tracking the trajectory of PCAST research products from ideation, to development, dissemination, and implementation on downstream policy decisions is a challenging task. The second framework will provide a method for beginning to understand how PCAST has interfaced with high-level stakeholders in the STI community to deliver policy recommendations, and how those recommendations translated into actions or informed government decision-making. The analysis will allow for a deeper understanding of the de facto nature of PCAST's independence and the limits of working within both FACA and the highly political context of the White House.

Significance This study presents the first longitudinal analysis of PCAST membership and policy products. PCAST stands as one of the U.S.'s most visible scientific bodies, unique in both its position within the federal STI policymaking apparatus and the preeminence of its membership. The anticipated results will offer an empirical basis for developing best practices for PCAST's membership selection and operations. As PCAST is involved in high-level development of federal STI policy, optimizing its activities and policy products to increase its future impact will in turn work to advance the overall health of the U.S. national STI enterprise.

[7562] *Quantifying hierarchy and dynamics in US faculty hiring and retention*

K. Hunter Wapman (University of Colorado Boulder), Sam Zhang (University of Colorado Boulder), Aaron Clauset (University of Colorado Boulder) and Daniel Larremore (University of Colorado Boulder).

Abstract

see attached paper

[9800] *Transformative innovation capabilities in practice: insights from the Living Catchments policy experiment in South Africa*

Andrew Roberts Cummings (NITLAPAN development research institute, UCA Nicaragua), Il-haam Peterson (Science, Technology and Innovation Indicators, Human Sciences Research Council, South Africa) and Mahlodi Tau (Centre for Science, Technology and Innovation Indicators, Human Sciences Research Council, South Africa).

Abstract

The emergence of the transformative innovation policy (TIP) approach is disrupting the systems of innovation for development landscape of academic discourse and engagement with policy practice. It draws on multi-level systems theory to advance a theoretical and methodological framework, a 'transformative' theory of change (TToC) that hinges on the achievement of 'transformative outcomes'. We address a gap in understanding relate to the capabilities – that is the 'transformative innovation capabilities' – required to design, implement, and evaluate TToC through experimental interactive practice. Although, there is no clear conceptualization of "transformative innovation capabilities" as such, in the TIP related literature (personal communication with Johan Schot, 2022, Carolina et al, 2022), we build off the work of Penna, Schot, Velasco and Molas-Gallart (2022) on institutional capacities and capabilities for 'transformative mission-oriented' policies. The object of our analysis is the emergence and evolution of the "transformative innovation capabilities" of a coalition of actors in South Africa, aimed at co-creating and strengthening transformative innovation policy initiatives. We aim to understand what transformative innovation capabilities are and how these are being strengthened. What do the coalitions of actors need to know and have the power to do to achieve transformative innovation outcomes? What are the principal structural, systemic, landscape and regime level forces that are directly enabling or conditioning the expression of their innovation capabilities in practice?

[7054] *Changing landscape of global science funding*

Lili Miao (Indiana University Bloomington), Feifei Wang (Beijing University of Technology), Vincent Larivière (University of Montreal), Yong-Yeol Ahn (Indiana University Bloomington) and Cassidy Sugimoto (Georgia Institute of Technology).

Abstract

Financial investments are instrumental to national scientific competitiveness. Cutting-edge scientific research is resource-intensive—e.g., facilities, equipment, materials, and labor—and investments in science are key drivers of scientific activity. However, scientific investments are not distributed equally across the world. Three regions—North America, East

and Southeast Asia, and the EU—account for more than 85% of global Research and Development (R&D) expenditures. Meanwhile, national scientific investment has been primarily investigated through R&D expenditures which include a huge range of institutions and activities that go beyond basic scientific research. In this study, we investigate how countries fund national and international research by tracking research grants disclosed in funding acknowledgement sections of scholarly publications. Our results suggest that, although China is rising as the dominant scientific funder to global science, it has limited influence on other countries from a research investment point of view. The U.S. is the leader in international funded publications that, on average, countries experience the largest lost if the U.S. stops co-funding activity. Furthermore, science in African countries are heavily underfunded and scientific system of developing countries are more fragile in the global funding perturbation.

[5808] *What drives wastewater reuse policy adoption and reinvention? A policy diffusion analysis*

Aline Banboukian (Georgia Institute of Technology), Valerie Thomas (Georgia Institute of Technology) and Kaye Husbands Fealing (Georgia Institute of Technology).

Abstract

Reuse of water has the potential to alleviate water shortages, reduce wastewater treatment costs, reduce water system energy consumption, and recycle nutrients. Many states have their own guidelines for water reuse. These guidelines include but are not limited to: guidelines for treating and reusing water, design and operation of reuse facilities, and water rights. States make their regulations within nationwide guidelines. Some states allow surface irrigation of food crops where there is no contact between edible portions and reused water, and some states do not allow food crops irrigation. Wastewater reuse has great potential to contribute to sustainably managing water to combat water scarcity and even help support a transition to a circular economy. Studies to date have not investigated the characteristics that influence the type of guidelines adopted and reinvented. In this study, we address this gap. We hypothesize (1) that physical characteristics such as drought in the region, population density, and the importance of the sector the reused water is being applied in have a large impact on water reuse policy adoption. We also hypothesize that (2) political and social characteristics such as governance ideology, and geographical neighbor status have a significant impact on the adoption of the guidelines. And, (3), we hypothesize that circular economy initiatives increase the adoption of wastewater reuse policies. We test these hypotheses in the US based on US EPA data. The findings explain the diffusion of wastewater policy and the relations between states. Moreover, this study enriches our understanding of environmental policy diffusion.

[643] *Using Hierarchical Stochastic Blockmodels to Examine Synthetic Biology Discourse on Twitter*

Brandon Sepulvado (NORC at the University of Chicago).

Abstract

Background and Rationale

Synthetic biology is a recently established field in which practitioners re-design and engineer organisms or parts of organisms with the intention of changing their behaviors or characteristics. The hope is that such genetically modified organisms or components can help address pressing societal challenges, such as pandemics, global warming, pollution, and food security. Synthetic biology, for example, was integral in the development of mRNA vaccines to combat COVID-19.

Synthetic biology, however, is not only practically consequential; it is also theoretically interesting. Theoretical frameworks, such as the Triple Helix model and Pierre Bourdieu's field theory, treat social life as composed of different domains with varying levels of dependence between them, for example the government, academia, and industry in the Triple Helix model. Some researchers might be more focused on producing research to be consumed primarily by individuals in the same field, whereas researchers in other fields often target their research at solving problems in areas unrelated to their field of study, e.g., how to make more pest resistant crops or how to inform policy decisions about the allocation of funds to social welfare programs. Synthetic biology is positioned at the nexus of many fields: seeking to solve myriad societal problems identified by policy makers and other researchers and often relying upon the private sector to support and implement research products.

Social media studies of science encourages researchers to focus on more than scientists and scholarly objects on social media and suggests that this would be important for synthetic biology, where non-academic communication is particularly important in bringing together a variety of stakeholders. Such communication occurring between fields and sectors frequently occurs on social media, and synthetic biology is no different. This study poses the following question:

in a social media environment where diverse stakeholders discuss synthetic biology as well as its applications and implications, what specifically is discussed? Answering this question is essential not only to developing a more encompassing study of synthetic biology, beyond traditional bibliometric and even altmetric data, but also to understanding more generally how the interdependence of certain scientific fields with other fields, businesses, and even sectors impacts the approaches needed to study them.

Data and Methods

Data used in the following analyses come from Twitter, a common platform for synthetic biologists and other actors who communicate about synthetic biology. The Twitter Application Programming Interface (API) allows users to programmatically query the full history of tweets. Because research indicates that synthetic biology stabilized as a research field around 2010, the data in this paper consist of tweets from 1 January 2010 through 30 September 2022.

The following query was used to obtain relevant tweets during this period: #synbio OR #syntheticbiology OR "synthetic biology" OR synbio OR (iGEM -igemcity) OR (#iGEM -(#igemcity)). Hashtags are a feature of social media platforms that allow users to connect their posts with ongoing conversations without having to respond to specific individuals. Querying phrases that are not hashtags identifies relevant posts, even if they are unconnected to broader conversations identified through hashtags. Synbio is a common label used as shorthand for synthetic biology. iGEM stands for the International Genetically Engineered Machines competition, which brings together teams of high school students, college students, postgraduates, and community lab members from across the globe. Manual review of synthetic biology Twitter content and discussions with subject matter experts indicated that iGEM constitutes a significant part of the synthetic biology discourse on Twitter. Tweets were preprocessed by removing emojis, numbers, URLs, hashtags, account mentions, retweets, and non-English tweets and by making all text lowercase. There are 396,154 tweets in this corpus.

Hierarchical stochastic blockmodels (hSBMs) were used to analyze the content of this tweet corpus. hSBMs may be considered an unsupervised method because they help users understand—without specifying any prior knowledge or thematic structure—the different topics discussed in a set of texts. hSBMs represent tweets as a bipartite network in which tweets and the words used within them are connected and then uses statistical approaches to community detection to uncover topics. Topics are conceived as communities in which words are densely connected to each other because they frequently co-occur in tweets. hSBMs do not require the user to specify beforehand a given number of topics, which is usually required for methods like topic models despite being a quantity of interest, and can represent topics as hierarchically nested.

Results

The hSBM identifies four “levels” of topics. The most abstract level contains 25 topics, and the most concrete level contains 924 topics. The second and third most abstract levels contain 84 and 230 topics, respectively. The most abstract level has topics about the iGEM competition, biotech startups, global markets, genomics research, major news stories, molecular engineering research, and popular science writing, among others. Topics at the most concrete level are very specific. One example topic is specifically about sustainability and research containing specific organisms (e.g., pseudomonas), and another is about sustainability specifically regarding biofuels. A final example of a very focused topic mentions the market performance of certain synthetic biology companies. The intermediary levels unsurprisingly present topics that are less focused or concrete but still not as abstract as at the highest level. One finding common to all topic levels is that non-academic content is much more common than academic content.

Conclusion

The fact that many topics do not pertain to academic research and/or research objects (e.g., article DOIs) reinforces the call of social media studies of science to expand the scope of studies on social media beyond scientists and their immediate activities. Synthetic biologists, for example, rely upon tooling and equipment from industry, and companies often work closely with professors to launch new products. Crucially, social media discourse surrounding synthetic biology also includes attention to ethical, legal, and societal issues, like sustainability and dual-use research. Theoretically, this means that domains in which scientists’ activities are oriented toward other types of actors (e.g., businesses, policy makers) or solving applied problems cannot be fully understood by studying only scientific output. On a more practical level, this means that studies often need more than extant compiled data sources, e.g., altmetric statistics, because such sources do not contain data necessary to understand science-society dynamics.

[1516] *Do scientific knowledge flows inspire exploratory innovation? Evidence from US biomedical and life sciences firms*

Ying Guo (China University of Political Science and Law), Jiali Sun (China University of Political Science and Law) and Xiangpeng Lian (Tsinghua University).

Abstract

Exploratory innovation relies heavily on a constant stream of new external knowledge that can be combined and recombined with the knowledge one already holds. As such, scientific knowledge flows, which result from searching for knowledge in scientific research articles, provide the necessary external knowledge elements for exploratory innovation. However, few studies explore the role that scientific knowledge flows play in exploratory innovation. Hence, in this study, we test how several characteristics of knowledge flows impact exploratory innovation in the private sector using firms in the field of biomedicine and the life sciences as our sample. The characteristics include the intensity, breadth, and novelty of scientific knowledge flows. In addition, we examine the moderating role diversity might play in these relationships. Our results indicate that intensive scientific knowledge flows characterized by novel knowledge elements tend to generate greater levels of exploratory innovation, while broad scientific knowledge flows typically have a negative influence on this type of innovation. Additionally, the diversity of the firm's internal knowledge base also has a negative moderating effect on the relationship between scientific knowledge flows and exploratory innovation, no matter how the knowledge flows are characterized.

[7960] *Academic Skill Variety Among Scientists and Engineers*

Briana Stenard (Mercer University).

Abstract

Background and Rationale:

When pursuing graduate education at the Master's degree level, students with Bachelor's degrees in STEM fields can make the choice to return for a Master's degree in their field of education, or pursue a Master's degree outside of their field of study which may include a business degree. This choice is becoming more popular. In 2022, looking at the entrance into top MBA Programs on their corresponding websites by undergraduate majors showed that 41% of Harvard's incoming class into their MBA program had a Bachelor's degree in a STEM field. 42% of Georgia Tech's, 45% of MIT's, 33% of University of Pennsylvania's, and 37% of Stanford's MBA class had a Bachelor's degree in a STEM field. This is becoming a common phenomenon.

Companies large and small have started requiring more diverse entrepreneurial skill sets among their engineers (Nichols & Armstrong, 2003; Rover, 2005). Mixing knowledge from the STEM disciplines with leadership, communication, and business skills can be very valuable for graduates for use in a variety of career paths (Winkler et al., 2015). Employers in engineering fields are wanting engineers with deep knowledge in their discipline who also have a broad array of cross-disciplinary knowledge (Mohd-Yusof et al., 2015).

Giving students a broad skillset helps them to be able to solve problems innovatively (Bodnar & Hixson, 2018; London et al., 2018; Wheadon & Duval-Couetil, 2016). STEM graduates need business skills to be able to take ideas from the ideation stage to actual innovation/production, whether they start their own businesses or not (Atkinson & Mayo, 2010). It has been found to be a valuable ability in engineering to be able to mix opportunity recognition skills with technical engineering skills (Bekki et al., 2018, Hixson & Paretti, 2018). Commercialization of innovation needs multidisciplinary skill bases (Boni et al., 2009).

In the sciences, multiple studies of skill disparities between education and needs of the workplace have found that graduates often lack skills in communication, project management, teamwork, problem-solving, critical thinking, and interpersonal skills (Jang, 2016; Lu et al., 1999; Radermacher & Walia, 2013; Tang et al., 2001). Verzat et al. (2009) highlighted the problem that while the STEM community is looking for "bilingual" graduates who have both technical and business capabilities, most STEM programs fall short of offering what industry is demanding (Dym et al., 2005; Eskandari et al., 2007). According to Atkinson and Mayo (2010): "Few business schools teach design. Few engineering schools teach market engagement. So, business majors lack engineering design, engineering majors lack market context, and science majors lack both." In a study of 99,000 STEAM workers, Stenard (2021) found that STEAM workers regardless of entering wage workers or entrepreneurship reported "management or supervising people or projects" as their primary work activity. The activity of sales, purchasing and marketing was also found to be a top skill used by STEAM workers in their everyday jobs.

There is large body of research that suggests that individuals who have diverse skills and experiences are more likely to enter self-employment (Astebro & Thompson, 2011; Dobrev & Barnett, 2005; Lazear, 2004, 2005). However, there is mixed results as to how the skills are developed and whether skill diversity leads to successful self-employment or not. Lazear (2004, 2005) argues that it is a purposeful investment of skills, while Astebro and Thompson (2011) argue that those who have a taste for variety and enjoy doing many different things in their experiences often become entrepreneurs.

In a study of the literature on skill variety, Krieger et al. (2018) found that while Lazear is often cited with starting the research on skill variety using the diversity of coursework by students, only a few studies have considered academic skill variety (Cho and Orazem, 2014; Hsieh et al., 2017; Lazear, 2004; Orazem et al., 2015). A majority of the current research focuses on work-related measures of skill variety instead of academic measures. This paper answers the call from Krieger

et al. (2018) for more studies on academic skill variety by studying the outcomes of those who diversify their degree field between their undergraduate and graduate degrees.

Based on prior findings that human capital and skill variety in particular impact self-employment outcomes (Stenard and Sauermann, 2016), this study looks into whether academic skill variety at the degree level impacts career outcomes, including self-employment outcomes.

Methods and Results:

This study uses data from the National Science Foundation's (NSF) Scientists and Engineers Statistical Data System (SESTAT). The sample used includes 15,000 scientists and engineers with Master's degrees, to examine the relationship between academic skill variety, career choices, and salary. In doing so the author distinguishes between the different reasons why people pursued their degrees in the first place to analyze whether it was a purposeful investment in skills or if it was for a taste for variety, such as a career change. The field an individual studied for their Bachelor's degree and then the field they chose to pursue their Master's degree in is observed. Therefore, one can see whether someone who had a technical undergraduate training switched and pursued a Master's degree in business or if they continued to pursue more technical skills. This allows a new way to analyze academic skill diversity that has not been done in previous studies. The data also allows the analysis of variables that are usually unobservable. In addition to looking at skill diversity and particularly the types of skill variety, the data also allows an analysis of the intentions for obtaining the Master's degree, whether it is for skill development or change in career interest reasons, etc. This allows the creation of a proxy for jack-of-all-trades via skill development intentions and taste for variety at the same time via a change in career interests. In addition, self-employed wage outcomes are compared between those who pursued additional specialized skills with those who pursued additional diverse skills.

This research finds that those who are pursuing a Master's degree for career advancement or a change in their field are more likely to attain a Bachelor's degree outside of their field of Bachelor's degree education, while pursuing the degree for skill attainment is negatively and significantly related to pursuing a degree outside of the field of their Bachelor's degree. Academic skill variety is not found to be significantly related to self-employment. Academic skill variety is positively related to salary generally for scientists and engineers, but not for those in self-employment.

This research contributes to the literature on STEM careers and human capital by providing new insights into the nature and implications of academic skill variety. This paper highlights that academic skill variety can occur for different reasons. Academic skill variety also has implications for work outcomes such as wages for workers in the STEM fields.

[8439] *Quantitative Methods for Assessing the Use of Research Evidence in Legislatures*

Afagh Mulazadeh (University College London).

Abstract

Research on the conditions under which evidence use is most likely to occur in legislatures has historically been hindered by limitations in available data and relevant metrics. Without formal systems for the citation of evidence within legislatures, tracing the policy impact of engagement between the scientific and legislative communities can be challenging. However, new methodologies may offer the opportunity to address these deficits and, in turn, build scholarship on evidence-based policymaking processes and reveal ways to bolster institutional capacity for decision-making on complex scientific and technological issues. Four interdisciplinary studies from the United States, United Kingdom, Germany, and an international dataset illustrate the development of potentially transformative quantitative methodologies for the study of evidence use: machine learning, natural language processing (NLP), and behavioral modeling. K. L. Akerlof and colleagues employ data analytics and machine learning to explore institutional patterns in citation and quotation from the U.S. Congress and National Academies of Sciences, Engineering, and Medicine (NASEM). Similarly, Afagh Mulazadeh's study identifies and analyses the explicit sources of scientific knowledge on AMR used in UK parliamentary scrutiny by applying NLP across two corpuses she is building using open UK parliamentary data and Elsevier's International Center for the Study of Research (ICSR) lab database. Combining Elsevier's ICSR Lab and Overton databases, Basil Mahfouz analysed over 15,000 education policies published by governments throughout the COVID-19 pandemic to evaluate if decision makers used the 'best' available scholarly knowledge. In contrast, Henriette Ruhrmann from the Technical University Berlin applied quantitative behavioural modelling based on psychometrically validated survey data from 1,115 researchers and 162 legislators in Germany to predict science-policy engagement. These techniques from the computational and quantitative social sciences offer the potential to shed new light on how legislatures use evidence, what types of evidence, and what drives researcher engagement and its use by legislators. Focusing on legislatures is a highly relevant extension of the existing body of research that predominantly focuses on the executive branch of governments. Further, the methods enable researchers to evaluate the effectiveness of legislatures at using scholarly research, at scale and with the potential to replicate the studies in different geographic contexts. The panelists will also describe current challenges in using bulk data compiled by legislatures, and the creation of new

datasets, such as the Elsevier ICSR Lab database, Overton, and a large-scale psychometrically validated survey of German legislators and researchers.

[8776] *Innovation capabilities for transformative change: opening a critical knowledge dialogue*

Andrew Roberts Cummings (NITLAPAN UCA Nicaragua), Johan Schot (Utrecht University, The Netherlands), Matthias Weber (AIT Austrian Institute of Technology & Université Gustave Eiffel) and Chux Daniels (SPRU, University of Sussex Business School, UK).

Abstract

After five years of operating the Transformative Innovation Policy Consortium (TIPC), a global research network involving researchers, policymakers and funders from 12 countries, a second phase of TIPC is about to be launched in 2023. The second phase will draw on the research, experimentation, policy engagements and lessons learned over the past few years and the research agenda developed. A key lesson from the first phase of TIPC is the need to better understand what capabilities are needed to design, implement and evaluate Transformative Innovation Policies (TIP). In response to this lesson, several of the TIP research activities involved the development of new tools, such as transformative theories of change guided by a framemwork of transformative outcomes and set within a formative evaluation framework for TIP projects and programmes. The insights reveal that researchers and policymakers working on TIP need certain sets of capabilities (we refer to these as "TIP capabilities", for clarity in this context). Although some capabilities may be shared, others may be specific to researchers (who are active facilitators of TIP policy experiments), or to policymakers or funders (who connect experiments to other political initiatives). Therefore, it is not entirely clear, yet, what the full range of these capabilities entails, hence the importance of this panel session to help unpack the issue with inputs from a wider audience. To this end, the session will feature researchers who have been involved in TIP experiments that cover Africa, Europe and Latin America, to reflect on their experience of working with policymakers and other researchers in TIP projects. Reviews of the relevant literature reveal a gap in the conceptualization and empirical research on the issue of the types of innovation capabilities required for transformative change and the specific nature of what could be understood as transformative innovation capabilities. Each of the speakers has taken up this issue specifically in their work, and through dialogue around the following questions, we will bring these ideas together in a synergistic way.

[1800] *Quantifying science in policy : applying govscienceuseR research software to describe the science of Environmental Impact Statements*

Tyler Scott (UC Davis) and Liza Wood (UC Davis).

Abstract

Motivation: In policy discourse, it is common to hear phrases such as "listen to the science" as a way for agencies to solve policy problems. But to build stronger connections between science and policy it is first necessary to understand current patterns of scientific information use in practice. How can we quantify the kinds of science that are used to support policy decisions? And what can these quantifications of science tell us about the process of policymaking?

Approach: This paper makes two contributions to research on the science-policy interface. Methodologically, we debut the open-source R package collection 'govscienceuseR' as a method for quantifying the scientific information referenced in policy documents. Policy documents are typically published as PDFs, and do not follow common structures or indexing rules. Thus, existing tools and software widely used for academic bibliometric analysis do not work for most policy documents.

In brief, govscienceuseR is a set of computational tools for extracting and indexing references from policy documents and other unstructured texts. These tools provide an accessible workflow for policy researchers to input documents and get an output of references classified into a general grouping (e.g. academic journal, government report, conference paper) and predicted matches to an index of journal articles and reports. Empirically, we run this tool using Environmental Impact Statement (EIS) documents filed between 2013 and 2020. Starting from the EPA's 'E-NEPA' repository, we scraped project metadata and downloaded over 11,000 available documents prepared from 2013 to 2021.

Using the EIS documents, we implemented the protocol for extracting, classifying, and matching references defined in the govscienceuseR packages. First, using the referenceExtract package, we extracted potential references with the help of the anystyle.io bibliography parser. Using the referenceClassify package, we removed misidentified portions of text, identified which references refer to different publication sources, and disambiguated different tags that refer to identical features (e.g., PNAS and Proceedings of the National Academy of Sciences). Using this package we also employed a pre-trained (on a sample of extracted references) artificial neural network classifier to probabilistically tag references by category (academic journals, government agencies, and conference proceedings). Finally, using the referenceSearch package, we matched extracted references to records in a global bibliometric database (Open Alex, the successor to

Microsoft Academic Graph) to disambiguate the references and link to metadata such as reference counts, journal attributions, and institutional sources.

Preliminary results: Across the 11,000+ documents and over 1.5 million extracted potential, govscienceuseR tools helped pare these data down to approximately 500,000 classified references. Of these, around ~13.5% are from an academic journal, while ~86.5% are from grey literature sources such as public agencies and policy research institutes. Our ongoing analysis will summarize the distribution of scientific references observed in policy documents on multiple dimensions including: (1) scientific prestige; (2) journal format and focus; (3) organizational producers; and (4) topics and methods. Answering these questions in the context of EIS projects, helps us better understand the kinds of science that are used to justify environmental policy decisions.

[7994] *Is Korean research council system good fit for innovation?*

Yong-Nam Jung (Hallym University).

Abstract

In South Korea, Government Supported Research Institutes (GSRIs) have played a significant role in the science and technology innovation system. The current research council system was created in 1999 by mimicking the German research council system from a public reform perspective. However, resistance from research institutes during the legislative process resulted in the distortion of the German-style research council. Over time, the three research councils were reduced to two, and now only one integrated research council system remains. The effectiveness of the roles played by the GSRIs and the research council remains a concern.

This study aims to examine ways to improve the GSRIs and the research council system from an innovation policy perspective. GSRIs need to play a crucial role as a knowledge producer, mission performer, intermediary within the innovation system, and a means to solve problems related to Grand Challenges.

The analysis indicates that Korea's research council system emphasizes the autonomy of the scientific community and has a supply-oriented perspective. The research council does not function properly due to the maintenance of the separate corporate personality of individual research institutes and the existence of separate R&D funding agencies for each ministry. From an innovation policy perspective, the current governance is suitable for conducting knowledge production and narrow mission-centered research but is not suitable to play the required role from a transformative innovation perspective.

At the national innovation policy level, it is necessary to have overall STI related goal setting, coordination between ministries and agencies, and various stakeholder participation in policy processes by the government. These aspects could also be applied to the research council system. If the research council system is to continue to operate, it is necessary to consider reorganizing it into the original German-style research council rather than maintaining the current single research council. Additionally, there is a need to add comprehensive planning and resource allocation functions to the research council and to consider abolishing the corporate personality of GSRIs to effectively respond to significant challenges.

[8919] *Quantifying biomedical firms' basic research*

Chao Min (Nanjing University), Chenjiao Gong (Nanjing University), Haotian Lin (Fudan University), Jiping Gao (Institute of Scientific and Technical Information of China) and Minglu Li (National Natural Science Foundation of China).

Abstract

Background and rationale Basic research is the catalyst for promoting the growth of high-tech firms that are the main driving force of technological innovation. As society progresses, the link between science and technology gets closer. The development of high-tech industries has an increasing demand for original knowledge and innovationse, making basic research even more important nowadays. Therefore, understanding how basic research influences the development of firms becomes a significant issue. Identifying and measuring basic research accurately is fundamental to investigating its influencing mechanism. However, it seems that a standard measurement method has not yet been determined, because of the abstraction of the concept basic research. For now, there still remains limitations in existing methods in current empirical research. For example, most methods are either indirect to basic research or too coarse-grained to measure the basic research intensity. Such measures include overall R&D expenses and the number of scientific papers, which would lead to the inaccuracy and even incorrectness of findings and policy suggestions. High-tech firms, as one of the main bodies in research investment, assume important responsibilities in R&D activities. Encouraging firms to invest in basic research is a crucial means for a country to enhance the competitiveness of science and technology. Therefore, it is particularly important to study firm's basic research, especially whne the empirical research on this topic is still lacking. Biomedicine is a research-intensive industry in both China and abroad. Its progress and development is closely related to

basic research, especially the high-level basic research. In this study, we measure the basic research in biomedical firms by applying an indicator, Level Score, that can quantitatively reflect the basicness of an individual paper.

Method “Level Score”, a quantitative index that Ke (2019) proposed, can well measure the basic level of a research paper. By establishing the occurrence network of MeSH terms and using the LINE network representation learning algorithm, we can obtain the translational axis in a vector space, pointing from the center of basic type MeSH terms to the center of applied type MeSH terms. Then we can calculate the appliedness score of each MeSH term, which is the cosine similarity between the translational axis and the MeSH term. The Level Score of a research paper is the average appliedness score of all its MeSH terms, ranging from -1 to 1. The smaller the score is, the more basic the research paper is. Based on this indicator, we then quantify the basic research of biomedical firms in the biomedicine industry. We derive a list of all biomedical firms from 2015 to 2017 according to the Standard Industrial Classification (SIC) from Compustat database. Using the method of keyword matching, more than 20,000 firm papers published from 2015 to 2017 are successfully identified from MEDLINE database. Their reference papers are obtained from Microsoft Academic Graph (MAG) using doi as an intermediary. We then calculate the Level Score of all firm papers and their reference papers. We observe the distribution of the basic level of firm papers and their references, investigate the dependence between firm’s basic input and output, and come to some valuable conclusions.

Results The preliminary results of our study show that: (1) In the biomedical industry, there is an obvious binary distribution of "basic research-applied research" in firm papers. That is, firms clearly publish scientific papers of both basic research and applied research. In the meanwhile, papers’ basic level increases along the path of “MEDLINE papers - firm papers - firm reference papers”, revealing a hierarchical supporting mechanism of basic research. (2) Biomedical firms adopt diversified R&D strategies. There is also a binary division of "basic-applied" in firm’s research preference. But this reference deflects more to basic research, as basic type papers accounts for 60%-80% in most biomedical firms. Further, the R&D strategy adopted by biomedical firms is related with firm size. Our results show that, small and medium-sized firms are more likely to choose only one of the research type, a relatively extreme strategy. Yet large firms appear to be more conservative, carrying out both basic and applied research at the same time. (3) Basic research is important for biomedical firms in terms of the relationship between research input and output. We find that biomedical firms cite more papers of basic research more than those of applied attributes, and that some firms even only cite basic papers. Regarding references as a kind of knowledge input and papers as an output, we find that the basic type knowledge input can produce both basic and applied output. But it is more difficult to obtain basic type output from applied input than to get applied output from basic input.

Significance First, by applying the Level Score index in biomedicine industry, we further verify its feasibility in measuring basic research in this study. According to the results and the conclusions, we believe that this index has the potential to be further promoted in both theoretical and empirical research of science and technology assessment. In this way, our study can provide new ideas for the relevant empirical research in the future in terms of measuring basic research. Second, we find some interesting preliminary results regarding the status and rules of basic research in biomedical firms, through measuring the basic level of more than 20,000 firm papers and more than 1 million reference papers. The results of our study reflect the important role that basic research plays in the development of biomedical firms. The conclusions will help improve the measurement methods of basic research and provide more empirical evidence for the field of biomedicine. Third, based on the results of our study, we tentatively propose some suggestions for firm basic research. Theoretical support will be provided for government to formulate relevant policies. An implications will also be provided for firms to strengthen the efforts in basic research to improve R&D and innovation capabilities, which is of great significance to achieve the long-term development of firms.

[6479] *The Technological Convergence of Emerging Intelligent Technology Ecosystem*

Shihhsin Chen (Institute of Management of Technology, National YangMing Chiao Tung University), Hungchi Chang (Institute of Management of Technology, National YangMing Chiao Tung University) and Duenkai Chen (Department of Computer Science and Information Engineering (English-Taught Program)).

Abstract

This paper is submitted to the panel entitled "The Dynamics of Science and Technology Governance in Emerging Sectors" (submission 6247)

Abstract This paper aims to study the emergence of emerging innovation ecosystem with focus on three selective intelligent technologies, including artificial intelligence (AI), Internet of things (IOT), and intelligent manufacture. The key research question this talk try to answer is how to form and develop the innovation ecosystem of emerging technology industries? How does the institutional factor influence the evolution of innovation ecosystem during the development process of science and technology? As emerging technology is constantly developing rapidly, its definition, scope, application, and technology governance approaches align with the emergence of emerging technologies. This paper considers the current development status of various industries and the recent policy content of emerging technology

industries mostly aims to promote smart technologies such as artificial intelligence, the Internet of Things and smart manufacturing. Though, establishing innovation policy framework to enhance the governance of the emerging technology are important, but the empirical studies focusing on the convergence of various emerging sectors and social impacts on the technology emergence process are still less clear. This paper will therefore explore the formation of the innovation ecosystem base on the multilevel prospective, taking academic research, technological development, commercialization process, and social impact on the three emerging intelligent technologies. In addition, we will focus on the interplay between multilevel prospective on emerging sectors. Finally, the main focus of this panel will move onto macro level with focus on the interactions between emerging sectors and the institutions. Combining social network analysis and multilevel analysis, this research will analyze the innovation ecosystems of various emerging sectors. Ultimately, this project will propose tailor-made policy recommendations to further promote the developments of emerging sectors.

[603] *The latent structure of global scientific development*

Lili Miao (Indiana University Bloomington), Dakota Murray (Digital Science), Woo-Sung Jung (POSTECH), Vincent Larivière (University of Montreal), Cassidy Sugimoto (Georgia Institute of Technology) and Yong-Yeol Ahn (Indiana University Bloomington).

Abstract

Science is essential to innovation and economic prosperity. Although studies have shown that national scientific development is affected by geographic, historic, and economic factors, it remains unclear whether there are universal structures and trajectories of national scientific development that can inform forecasting and policymaking. Here, by examining countries' scientific 'exports'—publications that are indexed in international databases—we reveal a three-cluster structure in the relatedness network of disciplines that underpin national scientific development and the organization of global science. Tracing the evolution of national research portfolios reveals that while nations are proceeding to more diverse research profiles individually, scientific production is increasingly specialized in global science over the past decades. By uncovering the underlying structure of scientific development and connecting it with economic development, our results may offer a new perspective on the evolution of global science.

[2249] *Building Innovative Medical Device Sector and the Convergence of the Emerging Technologies in Small Emerging Economy*

Wenhsin Chi (Institute of Management of Technology, National YangMing Chiao Tung University), Hungchi Chang (Institute of Management of Technology, National YangMing Chiao Tung University), Shihhsin Chen (Institute of Management of Technology, National YangMing Chiao Tung University) and Huei-Chen Yen (Institute of Management of Technology, National YangMing Chiao Tung University).

Abstract

This paper is submitted to the panel entitled "The Dynamics of Science and Technology Governance in Emerging Sectors" (submission 6247)

This study explores how the innovation ecosystem of emerging technology industries are formed and developed and how does the evolution of the innovation ecosystem in the course of technological progress depend on institutional factors? Taiwan has long experience in the ICT field and the technology of wheelchair assistive device manufacturing has led to the rapid development of smart medical devices by introducing smart technology. In this empirical study, 7 elite group interviews and 10 multi-criteria decision-making questionnaires are conducted an in-depth study to understand the formation of the medical device industry innovation ecosystem. In Taiwan, however, there is no significant growth trend, though the medical device firms adopted intelligent technologies in their product developments in recent years. we have found the medical device industries in Taiwan have gradually developed over the past 20 years, and has established its own international partners, mostly from the U.S. and Japan. Therefore, we hope that this joint research will open up opportunities for international research collaboration of in the medical device sector.

[169] *The Effects of Chinese Investments in Digital Infrastructures on Data Policies and Regulations in Host Countries: A Case Study on New Clark City, Philippines*

Timothy Joseph Henares (The Hong Kong University of Science and Technology) and Masaru Yarime (The Hong Kong University of Science and Technology).

Abstract

Background and Rationale

China's Digital Silk Road (DSR) is a strategy template for Chinese technology companies to invest in digital infrastructures in the Belt and Road Initiative (BRI) signatory countries. Launched in 2015, the DSR is reminiscent of the ancient Silk Road, with trade routes connecting Asia to Europe. Today, the same idea applies; this time, digital infrastructures connect these continents where "solar panels and smartphones have replaced silk, and trains and aeroplanes have superseded camels"(Huadong, 2018, p. 25). RWR Advisory Group found that Chinese investments in digital infrastructures amounted to US$ 79 billion globally as of 2019 (Prasso, 2019). These investments include e-commerce, fiber-optic cables, telecommunications equipment, internet-capable appliances, and surveillance systems.

There is, however, little research about the scale and impact of Chinese-funded digital infrastructures towards these BRI countries. In this study, we look at the effects of Chinese investments in digital infrastructures on data policies and regulations in host countries, particularly smart cities in Southeast Asia. We use New Clark City as a case study. Previously the site of an American airbase in the early 20th century in the Philippines, New Clark City (NCC) is perceived to be the country's "first smart, resilient, and green metropolis" (Global Future Cities Programme, n.d.). The smart city will comprise a residential-industrial hub that will host 1.2 million residents, including a variety of light industries and technology companies (Muggah & Khanna, 2018; Siu, 2018). Equipped with green building standards and Internet of Things (IoT) technology, NCC is also viewed to offload the population-dense Metro Manila.

As of 2022, we find four Chinese companies – China Gezhouba Group Company Limited, Huawei Technologies, China Development Bank, and Dito Telecommunity (a local firm backed by China Telecom) – having a stake in New Clark City. We make two implications. First, the transnational flow of ideas, expertise, capital, and technologies involving data provided by Chinese companies influence the Philippines to adopt Chinese data policies and regulations. Second, the same adoption of these technical standards spillovers or shapes local environmental and energy standards. All these could mean that the data governance regimes of Southeast Asian smart cities receiving Chinese investments in digital infrastructures, like New Clark City, have their data policies and regulations containing Chinese characteristics.

Methods

We apply a mixed methods approach to data collection. Primary data will be collected through at least ten key informant interviews from November 2022 to February 2023. Each interview is expected to last an hour. Key informants will include state and non-state actors, including representatives from the Philippine government, non-government organizations, civil society groups, technology companies, think tanks, and academia. The criteria for choosing key informants will begin with a purposive sampling approach by utilizing known contacts, followed by a snowball sampling method where we ask our interviewees for suggestions or recommendations on individuals who could be valuable resource persons for our research. After transcribing the interviews, we will code and analyze the data using MAXQDA. The interviews aim to gather information not publicly available. The secondary data source used in this study consists of policy documents, government websites, media reports, and company project profiles and reports.

We will also utilize the "Beijing Effect" theory. Coined by Erie and Streinz (2022), the theory states that China's increasing influence in transnational data governance is due to a collection of "push" and "pull" factors that convince host countries to gravitate to Chinese data policies and regulations. The Beijing Effect can be seen in the light of China exporting digital infrastructures to assist emerging economies in building their smart cities. China relies on its companies to provide physical components such as telecommunication devices, data centers, and cell towers. However, as smart cities of host countries utilize Chinese digital infrastructures, this technology transfer, in turn, makes the host countries adopt Chinese technical standards, affecting the data governance regimes of host countries.

Preliminary Results

Our preliminary results show that it takes the world to build a smart city, as multiple foreign stakeholders are involved. Smart cities need expertise, integration, and a lot of capital where, in the case of New Clark City, one country alone cannot afford nor perform the whole project from planning to implementation.

This scenario raises two questions regarding data governance. First, which country's data policies and regulations come first, given that several stakeholders from different countries have a stake in New Clark City? Countries such as China (found to manage telecommunications) and Japan (found to manage the smart grid and power distribution utilities) deal with interconnected digital infrastructures. The data from smart grids and telecommunication devices must travel to a specific data center or source. We are uncertain whether the Philippines or another country is storing, processing, and utilizing the data. Second, concerning the first question, are we seeing one set of data policies and regulations of a specific country or a group of countries pooling and combining their data standards? For example, an energy project in the Philippines, a coal-fired power plant, had four reactors divided among foreign and independent stakeholders, particularly China, Japan, France, and the United States. These reactors still function in silos. A smart city, however, lives on integrated IoT technologies for it to thrive.

The preliminary results also put forth two knowledge gaps. First is the extent of Chinese investments in digital infrastructures in New Clark City. We are unsure as to what scale and depth the Dito Telecommunity, a local telecom company with China Telecom having a 40 percent stake, has a role in shaping the data policies and regulations of New

Clark City. Moreover, we are interested to know if Chinese companies previously listed in building New Clark City – namely China Gezhouba Group Company Limited, Huawei Technologies, and China Development Bank – still play a role. Second, given Japan's substantial involvement in the smart city project within the same space with China, is there competition, cooperation, or coopetition (combination of both) between the two investors? As this is the first paper on the topic, the answers are unclear. We believe the key informant interviews to be conducted will aid us in answering these questions and gaps.

Significance

It is crucial to study Chinese investments in digital infrastructures at a time when China is promoting its data governance model along the Digital Silk Road. The integrated nature of technological installation and policy adoption would be essential as a policy transfer mechanism in digital policy. Compared with more conventional areas, such as economic policy or environmental policy, digital policy transfer is an understudied field. Smart cities, moreover, are cities of the future. They are considered essential structures for economic growth and sustainable development in urban areas (Thuzar, 2011, p. 96). The significance of smart cities comes at a time when a United Nations (2018) report stated that by 2050, two out of three people worldwide would live in cities. In the same year, 507 million people will live in cities located in the Association of Southeast Asian Nations (ASEAN), making the regional bloc "one of the world's largest middle-income emerging markets after China and India" (United Nations, 2018). The project has implications not only for data governance and digital policy but also for public policy and international relations.

[9532] *Imprinting or Learning? Charting the Organizational Evolution of Scientific Laboratories*

Vincent Yung (Northwestern University) and Jeannette Colyvas (Northwestern University).

Abstract

1. Question

How do scientific laboratories vary in how they operate, and do they change over time? A legacy of scholarship in the study of scientific productivity has established the demographic, career, and resource factors that explain scientific production. A notable pattern in this work is a preeminent focus on individual investigators.

Whereas some scholars underscore that this focus on individual investigators is an artifact of the availability of data, an emphasis on individuals is especially problematic in the context of scientific productivity because labs are known to exhibit considerable heterogeneity. Science and technology studies demonstrates that how labs assemble people, technologies, and resources varies substantially and meaningfully in ways that are consequential to productivity and innovation. Furthermore, organizational studies further attests to the fact that organizational heterogeneity is significant for explaining differences in performance, innovation, and turnover. Organizations embrace ideologies, logics, "blueprints," or models for organizing which is instantiated in how they operate and can guide subsequent organizational evolution.

Therefore, we ask, how do lab models vary among scientific labs across organizations and over time?

2. Theoretical Framework

From the literature on organizational emergence, persistence, and change, we establish two tenets on how organizations evolve. First, organizations are reflections of their time and are imprinted with the characteristics at the time of their founding. In this view, the features adopted by organizations during founding are highly stable and persist over long periods of time. Second, organizations can learn, adapting to new experiences or developing new forms of knowledge through sensemaking and the enactment of new patterns of cognitive associations. In this view, organizations may change with the experience of success and failure, changes in networks, the incorporation of new information, ambiguity, or by random chance.

Drawing on and comparing the literatures on organizational imprinting and organizational learning, we compare two competing sets of propositions, notably:

1. Imprinting: Scientific labs express an organizational model established at time of founding that persists over time.
2.Learning: Scientific labs express an organizational model that changes and adapts over time that increasingly differs from its time of founding.

We evaluate these competing propositions in the field of academic scientific labs across over 30 American universities using a combination of statistical models and machine learning.

3. Data

The data we use to examine the organization of scientific labs comes from the Institute for Research on Innovation & Science (IRIS) UMETRICS (Universities: Measuring the Impacts of Research on Innovation, Competitiveness and Science) research dataset. The 2020 UMETRICS release consists of data provided by 33 universities over a time frame of 1 to 19 years. UMETRICS captures expenditure data, including data on awards, wage payments to individuals, and vendor transactions resolved at the month level.

To identify labs, we associate each faculty member to his/her/their set of awards. For each faculty member, we generate nonoverlapping, 1-year windows that represent "snapshots" derived from monthly expenditures. For each faculty-window, we construct manifest variables derived from expenditure activity. These measures provide a window into the variety of ways labs search for support, spend their money, and assemble personnel. As such, we use these measures to identify lab models.

4. Methods

To characterize the heterogeneity of lab models, we exploit two independent clustering methods: a model-based method, latent class analysis (LCA), and an unsupervised machine learning method, k-medoid clustering based on Gower's distance. A fundamental analytical decision involves specifying the appropriate number of clusters to represent the data. Thus, we utilize both clustering strategies to assess the extent to which clusters derived from both methods overlap. To assess the extent to which lab models persist or change over time, we sort lab windows into clusters and track the trajectory of a lab across its windows over time.

5. Results

5-1. Lab Models

Our interpretation of the latent classes and a k-medoid clustering analysis of a sample of the UMETRICS data suggest a 6-class solution represents the most parsimonious solution.

Most labs employ what we term a small venture lab model: these labs are unexceptional when it comes to expenditures, number of federally funded projects, and personnel, yet nonetheless make use of competitive federal funds to conduct research.

In contrast, a subset of labs employs models that are characterized by relatively big spending and the lion's share of federal awards. Two of these have a strong association with medical schools and include the Medical Research Facility and the Specialized Medical Boutique: the former is notable for its employment of postgraduate research staff, while the latter is notable for being helmed by an English PI. The Productive Powerhouse, while associated with a medical school, holds multiple administrative affiliations across the university. It employs relatively more graduate and postgraduate employees, and these employees are constituted by relatively more women, ethnically English individuals, and individuals on multiple awards (i.e., their funding is split across different award accounts).

The two remaining lab models are unexceptional when it comes to expenditures and awards yet pull their weight in the employment of graduate students. The Engineering Factory is a leaner version of the Productive Powerhouse and is strongly associated with a school of engineering. The Doctoral Factory is associated with a greater number of graduate employees and graduate employees with split funding.

5-2. Lab Models Over Time

To characterize the persistence and change of lab models over time, we estimate the posterior probability that a particular faculty-year "belongs" to a particular latent class and assign each to one and only one class. Next, we assemble each faculty-year for each faculty member (N = 64,733) to construct a chronological account of each faculty's lab model.

We find that a slim majority of faculty employ the same lab model throughout the course of their career on record (27,565) compared to those who make at least one switch (25,114). However, the number of switches a faculty member incurs appears to correlate with the length of their recorded career. Furthermore, faculty who begin their careers with certain lab models are less likely to make a switch later in their career.

Thus, we find strong evidence for organizational imprinting, i.e., that scientific labs express a model established at time of founding that persists over time. However, we also find evidence for organizational learning, i.e., that scientific labs express a model that changes and adapts over time that increasingly differs from its time of founding.

6. Significance

Our analysis advances our understanding of scientific production and the organization of scientific laboratories in three ways. First, our study addresses the persistent call to study the evolution of organizational populations beyond the rarified set of Fortune 500 companies. Second, our study offers an operationalization for the organization of scientific labs that enhances the fit between our understanding of science as a social system with our actual measurement. While data platforms like UMETRICS improve our capacity to analyze the value of American research and development, our conceptual tools for utilizing such platforms in service of theorizing scientific production require attention. Finally, we shift the spotlight away from individual investigators to laboratories that propel the frontier of scientific knowledge, participate across multiple networks of activity, and produce graduates who go on to populate the scientific and engineering workforce.

[8022] *Innovative Funding Mechanisms to Enhance Federal Technology Transfer and Public Private Partnerships*

Vanessa Pena (U.S. Department of Energy, Office of Technology Transitions).

Abstract

The Federal Government spends more than $150 billion on research and development. This funding has fueled the innovations and technologies that have transformed our societies. However, the pathways from research to impact can be arduous and complex. Way to effectively engage, work with, and leverage resources from the private sector, including small businesses, for example through public private partnerships, continue to be critical to the maturation and commercialization of new technologies and the supply chains necessary in their development.

The Federal Government continues to look for innovative mechanisms to engage with non-Federal stakeholders to enable and improve engagement and opportunities with the private sector. DOE has been working to better understand the lessons learned and identify ways to enhance the use of a few of these mechanisms--including 1) establishing an agency-affiliated foundation, 2) using the other transactions authority (OTA); and 3) using the partnership intermediary agreement (PIA) authority. This presentation will discuss cumulative lessons learned for planning and implementation of these mechanisms and how they inter-relate to complement and build technology transfer pathways from one another. Currently, there is a dearth of published information regarding the use of these mechanisms specifically to enhance Federal research and development, technology transfer, and commercialization goals. This presentation will build on prior studies that analyze process and outcomes of specific mechanisms published by various research institutes, including IDA, ITIF, and NAPA, among others.

[2113] *Mobility of U.S.-Trained Foreign-Born S&E PhDs – a study of evidence building for science policy research*

Christina Freyman (National Science Foundation), Wan-Ying Chang (National Science Foundation) and Haoyi Wei (National Science Foundation).

Abstract

Background and rationale The Chips Act of 2022 highlights topics of critical importance, including the “cyber workforce”, microelectronics workforce, bioeconomy, and artificial intelligence. It is widely known, as the National Science Board has stated, that “foreign-born individuals have long been major contributors to science and engineering (S&E) in the United States”. For example, the Center for Security and Emerging Technology states that “approximately 40% of high-skilled semiconductor workers in the United States were born abroad”. Nationally representative surveys can quantify the share and movement of foreign-born individuals as they move through the U.S. S&E education and training system to the S&E workforce in various fields of interest. For example, most U.S. S&E doctorates who are non-U.S. citizens at graduation expect to remain in the United States after graduation according to the Survey of Earned Doctorates conducted by the National Center for Science and Engineering Statistics within the National Science Foundation; however, when surveyed later, a considerable proportion of foreign-born U.S. S&E PhD recipients have left the United States to pursue future research and employment. This has a significant impact on the S&E ecosystem and empirical evidence can inform various levers employed by government, industry, and academia.

This work aims to quantify the movement of foreign-born U.S. S&E PhD recipients and investigate correlates using nationally representative surveys and bibliometric data in effort to produce high quality evidence related to the participation of foreign-born U.S. S&E research PhD recipients in the U.S. S&E ecosystem.

Initial results The proportion of foreign-born S&E workers in the United States has steadily increased in the past decade, representing 24% of the U.S. S&E workforce in 2019. Among the highly trained U.S. S&E research doctorate holders, the share of foreign-born is larger. It has increased from 25% of the 1971-1975 cohort to 48% of those who graduated in the period of 2016-2020. For the field of semiconductors, foreign-born individuals accounted for more than 50% of S&E research doctorate graduates since the late 1980s, reaching 66% in the latest cohort of graduates from 2016-2020. About 27% of foreign-born U.S. S&E PhD recipients who were on a temporary U.S. visa when graduating resided abroad in 2015, representing a significant amount of talent flow from the United States to other countries.

Methods and further analysis Mobility is studied through the use of nationally representative surveys of science, engineering, and health research PhD recipients. The NCSES Survey of Earned Doctorates, a census of all research PhDs from U.S. institutions, provides respondent-reported demographics and educational history, including birthplace, citizenship status, doctorate field of study, the 2005 Carnegie classification of the doctoral institution, post-graduation employment, sex, race, ethnicity, and type of support for graduate study. It is linked to the NCSES Survey of Doctorate Recipients (SDR), which provides respondent-reported employment outcomes, including occupation, sector of employment, job activities, and location information for the survey reference year. The longitudinal data file of the SDR (2015-19) provides longitudinal data on mobility (geographical and employment) over the period of the surveys. The respondents to the cross-sectional SDR 2015 are linked to the bibliometric database Scopus, providing information on publication history. The author affiliation, co-author networks, and citation topic information contained in the metadata of publications provide unique longitudinal data to explore the mobility of PhD scientists and engineers throughout their

publication careers. These datasets will be used to produce analyses of characteristics of U.S. Ph.D. recipients with regards to country of origin, mobility, and various correlates. Multi-variate regression will explore the significance of the correlates between those who remain in the United States after graduation and those who do not.

Significance A fundamental belief of government investment in higher education and training is that U.S. universities play a critical role in training the future workforce in key industries. This data set provides descriptive information about training, publication, and employment as well as self-reported demographics. These rich, detailed data sources allow policymakers to develop evidence for interventions that support critical fields, such as those listed in the CHIPS Act of 2022.

[7274] *Democratic Governance and International Research Collaboration: A Longitudinal Analysis of the Global Science Network*

Travis Whetsell (Georgia Institute of Technology).

Abstract

The democracy-science relationship has traditionally been examined through philosophical conjecture and single country case studies. There remains limited global scale empirical research on the topic. This study explores country level factors related to the dynamics of the global scientific research collaboration network, focusing on structural associations between democratic governance and the formation, persistence, and strength of international research collaboration ties. This study combines longitudinal data between 2008 and 2017 from the Varieties of Democracy Institute, World Bank Indicators, Scopus, and Web of Science bibliometric data. Methods of analysis include temporal and weighted exponential random graph models (ERGM). The results suggest positive significant effects of both democratic governance on international research collaboration and homophily between countries with similar levels of democratic governance. The results also show the importance of exogenous economic, population, and geo-political factors, as well as endogenous network factors including preferential attachment and transitivity.

[3566] *Greening manufacturing: Technology intensity and carbon dioxide emissions in developing countries*

Elvis Korku Avenyo (University of Johannesburg) and Fiona Tregenna (University of Johannesburg).

Abstract

Industrialisation is an important engine of growth and 'catch up', but also associated with harmful carbon dioxide emissions and hence with climate change. This poses a challenge for sustainable industrial development, particularly for late industrialisers on how to industrialise while also mitigating carbon dioxide emissions. This paper investigates the effect of technology intensity across manufacturing industries on carbon dioxide emissions: are medium- and high-technology manufacturing industries less emissions-intensive than low-technology manufacturing industries in developing countries? The paper analyses this relationship for a panel of 68 developing and emerging economies over the period 1990-2016, by adapting the environmental Kuznets curve and the stochastic effect by regression on population, affluence and technology approaches. Using two alternative measures of emissions and estimating generalised method of moments model, the results show that medium- and high-technology manufacturing industries are associated with lower carbon dioxide emissions than low-technology manufacturing industries. The results also show that these differences vary by the income levels of countries. These findings have important policy implications, suggesting that a shift towards more technology-intensive manufacturing production processes may be a more environmentally sustainable industrialisation path for developing countries.

[6285] *Digital tools for tracing policy action through COVID-19 - Exploring the innovation strategies of 24 countries with natural language processing*

Hunter McGuire (OECD), Hunter McGuire (OECD), Jan Einhoff (OECD) and Caroline Paunov (OECD).

Abstract

Session title: Teaching a virtual dog new tricks – Drawing intelligence from science, technology, innovation and policy documents Session organiser: Catherine Beaudry Number: 8082

This paper applies natural language processing (NLP) to understanding how countries' vision for science, technology and innovation (STI) priorities has evolved through COVID-19. The analysis was conducted on a sample of 313 STI strategy documents from 24 countries that were released between 2013 and 2021. Structural topic modelling, an NLP technique

for exploratory text analysis, is used to analyse these documents across a variety of thematic topics. This approach finds that STI strategy documents issued after the COVID-19 pandemic have not substantively changed the topics that they discuss. It also suggests that environmental sustainability, while an important overall priority, has a considerable variety of meanings in different national contexts, that competitiveness remains a goal both before and after the pandemic began, that employment is an important goal in STI strategy, and that digital technology, infrastructure, and data are all treated as important tools for innovation in the future.

[417] *Panel: The Challenges of Measuring and Governing Global Science*

Caroline Wagner (The Ohio State University), Travis Whetsell (Georgia Institute of Technology), Lili Miao (Indiana University) and Fei Shu (McGill University).

Abstract

Much scholarship has reported on the growth of international collaboration in science. Recent breakthrough scholarship explores necessary conditions at the national level (Whetsell, forthcoming), structures within the global system (Miao et al., 2022), and ways in which national science policy may be better aligned to take advantage of the global system (Shu et al., 2022). Each of these scholarly works wrestles with the deep uncertainty tied to understanding and governing the global system of science. That system has been shown to have network properties (Wagner, 2019), but one which also responds to national policy actions, alternatively directed at the global and ignorant of it. The panel will begin with a theoretical construct of the system of global science from Wagner (2019) and the role of policy in influencing it (Thomas & Mohrman, 2011), and then discuss how each of the presented papers reveals aspects of global science. Further reflection by the panel and during audience discussions will uncover gaps in understanding the global system and where future measurement may help reveal dynamics that will aid policymakers in planning for engagement.

[4075] *Institutional capacities and capabilities for Transformative Innovation. Learnings from diverse experimental policy engagements*

Diana Velasco (Ingenio), Caetano Penna (Uniersity of Delft), Jordi Molas-Gallart (Ingenio (CSIC-UPV)) and Johan Schot (Uniersity of Utrecht).

Abstract

The Transformative Innovation Policy (TIP) is an emerging framework that advocates for an innovation policy that focuses on environmental and social challenges beyond economic growth, that opens up transformation pathways to a diverse set of solutions to complex challenges, is highly inclusive and embraces conflict by acknowledging power struggles, has learning as a fundamental trigger to change practices, norms and institutions, and fosters systemic change (Schot and Steinmueller, 2018). TIP has been gaining more track in the innovation policy narrative in the last decade, gaining theoretical and practical depth through experimental policy engagements (EPE) between researchers, policymakers and practitioners that are part of the Transformative Innovation Policy Consortium (TIPC – more information in www.tipconsortium.net) for the last five years. Being part of different engagements in Sweden, South Africa, Colombia, and Catalonia, we reflect on the required capabilities for advancing transformative innovation from different levels (individual, collective) and groups (researchers, policymakers, practitioners, and social groups). The discussion will have two blocks. The first looks into innovation capacities and capabilities based on a paper in progress related to the (EPE) developed with Vinnova, the Swedish Innovation Agency, related to adding a formative evaluation layer to their mission-oriented innovation policies methodology. The second block takes the capacities and capabilities framework and discusses both sets from the process developed by the core groups part of EPEs in Colombia, South Africa and Catalonia. The mission-oriented innovation policy (MOIP) approach is based on the establishment of clearly defined goals – i.e. missions – within a specific timeframe to direct cross-sector innovation (Janssen et al. 2021; Mazzucato 2018b, 2018a). Transformative innovation policy (TIP) (Diercks et al. 2019; Schot and Steinmueller 2018; Weber and Rohracher 2012) moves away from clearly defined cross-sectorial missions to focus on emergent, open-ended transformations in 'socio-technical systems' (Geels 2004), as conceptualized in the research field of sustainability transitions (Köhler et al. 2019). In contrast to the emphasis on measurable, pre-defined outcomes and state-led governance processes of the MOIP framework, the TIP framework emphasizes the need for policy to engage with ongoing transformations, through the participation of new ('niche') agents and civil society at large, to open multiple directionalities for innovation. The Vinnova paper argues that the two approaches can be treated as complementary by advancing a capacity/capability-based Transformative Mission-Oriented Innovation Policy (TMOIP) framework. The paper aims to identify the types of institutional capacities and capabilities needed to design and implement transformative missions. In line with Diercks et al.'s (2019) typology of challenge-led policies, we argue that TMOIP can address a particular type of societal 'missions': those with multiple (open-ended) goals that cannot be unequivocally anticipated or defined. We first provide a synthesis of the MOIP and TIP approaches to outline the differential characteristics of TMOIPs in terms of the capacities and

capabilities needed to define and implement them. We then review how the mission-oriented innovation policy literature discusses the importance of institutional capacities and capabilities using concepts drawn from business administration, public administration and policy, and human development to identify different types of capacities and capabilities needed for transformative missions, which are formalised into our analytical framework. The resulting TMOIP framework is then applied to an explorative case study of the Swedish innovation agency Vinnova, a frontrunner organization currently experimenting with methodologies to design mission-oriented programmes following transformative innovation policy principles. Complementing the theoretical and practical findings from the Vinnova case, in the second block we discuss the type of capabilities required by the core groups in the EPE, which are usually composed of researchers and policymakers. We extrapolate the capabilities to group dynamics and the specific skills facilitators require to build and nurture transdisciplinary spaces with a base of epistemic capabilities coming from the human development capabilities approach (Velasco and Boni, 2020; Fricker, 2015; Medina, 2017). We discuss how a human development view of transitions, in general, and of innovation capabilities, in particular, can strengthen the concept and practice of just transitions (Velasco et al., 2021). We base our arguments on EPEs developed with the Ministry of Science, Technology and Innovation of Colombia, particularly with the team leading a social appropriation of science national programme called “A Ciencia Cierta”; the “Living Catchment Project” EPE developed as part of the South African National Water Roadmap strategy, funded and sponsored by the Department of Science and Innovation and the Water Research Commission of South Africa and implemented by the South African National Biodiversity Institute; and the process developed with the Shared Agendas in Catalonia, as an expression of TIP in practice. We expect to provoke a discussion with other panel members and session assistants to further develop the meaning of value from Sen’s definition of capabilities as the real possibilities and opportunities of leading a life that a person has reasons to value (Sen, 1999) when discussed from the notion of innovation capabilities. References Diercks, Gijs, Larsen, Henrik, and Steward, Fred (2019), 'Transformative innovation policy: Addressing variety in an emerging policy paradigm', Research Policy, 48 (4), 880-94. Fricker, M. (2015) Epistemic contribution as a central human capability. In G. Hull (ed.), The Equal Society (pp. 73–90). Cape Town: UCT Press. Geels, Frank W. (2004), 'From sectoral systems of innovation to socio-technical systems - Insights about dynamics and change from sociology and institutional theory', Research Policy, 33 (6-7), 897-920. Janssen, Matthijs J, et al. (2021), 'The promises and premises of mission-oriented innovation policy—A reflection and ways forward', Science and Public Policy, 48 (3), 438-44. Köhler, Jonathan, et al. (2019), 'An agenda for sustainability transitions research: State of the art and future directions', Environmental Innovation and Societal Transitions, 31, 1-32. Mazzucato, Mariana (2018a), 'Mission-Oriented Research & Innovation in the European Union: A Problem-Solving Approach to Fuel Innovation-Led Growth', Mission-Oriented Research & Innovation in the European Union. --- (2018b), 'Mission-oriented innovation policies: Challenges and opportunities', Industrial and Corporate Change, 27 (5), 803-15. Medina J (2017) Varieties of Hermeneutical Injust. In Kidd I, Medina J and Pohlhaus G Jr. (eds.) The Routledge Handbook of Epistemic Injustice. Routledge: 41–52. Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. Research Policy, 47(9), 1554–1567. Sen, A. (1999) Development as freedom. Oxford: Oxford University Press. Velasco, D., & Boni, A. (2020). Expanding epistemic capability in participatory decision-making processes: The Universidad de Ibagué capabilities list. In Participatory Research, Capabilities and Epistemic Justice (pp. 27–57). Palgrave Macmillan. Velasco, D., Boni, A., Delgado, C., & Rojas-Forero, G. D. (2021). Exploring the Role of a Colombian University to Promote Just Transitions. An Analysis from the Human Development and the Regional Transition Pathways to Sustainability. Sustainability, 13(11), 6014. Weber, K. Matthias and Rohracher, Harald (2012), 'Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive ‘failures’ framework', Research Policy, 41 (6), 1037-47.

[6773] *Balancing work and family: Differential experiences of foreign-born and U.S.-born faculty in academic science*

Luyu Du (Arizona State University), Julia Melkers (Arizona State University) and Mayra M. Tirado (Arizona State University).

Abstract

Background and Rationale

In the era of globalization, U.S. higher education institutions have become increasingly diversified with the growing presence of foreign-born faculty (NSF, 2022). As of 2021, foreign-born faculty account for around 33% of science and engineering faculty members employed in U.S. universities, increasing from 12% in 1973 (NCSES, 2021). Recruiting foreign-born faculty is also a crucial institutional strategy of U.S. universities to enhance their competitiveness in the global production of knowledge (Lawrence et al., 2014).

As the scholarly community grows more diverse, the importance of foreign-born faculty in U.S. science enterprise has been recognized more than ever before. However, a paradox is emerging. Studies have consistently found foreign-born faculty to be more productive in publications, grants, and patents than their U.S.-born counterparts (Corley & Sabharwal, 2007; Kim et al., 2011; Mamiseishvili & Rosser, 2010). Yet, foreign-born faculty have also reported lower work satisfaction

(Sabharwal, 2011a) and fewer career advancement opportunities (Kim et al., 2020; Sabharwal, 2011b) than U.S.-born faculty. These disparities require further examination: despite high productivity, what other factors diminish the work experience and satisfaction of foreign-born faculty?

Like many immigrants, foreign-born faculty face multiple challenges in integrating professionally and personally in a new cultural setting (Feeney et al., 2023; Kim et al., 2020). Specific to faculty experiences, how one balances home and work life, and the challenges in each setting, matters for a range of personal and professional experiences (Fox et al., 2011). As foreign-born faculty establish their professional lives in the U.S., they also establish their personal lives with the support of U.S. immigration policy, which often sponsors their families to come to the U.S. (Batalova, 2012). Like any working professional, academic scientists may experience work-family conflicts due to the interplay and interference between their work and family roles (Greenhaus & Beutell, 1985). While work-family conflict can negatively affect the work satisfaction of faculty members (Sarwar et al., 2021), particularly women (Carr et al., 1998), how this functions for foreign-born faculty has not been explored. Therefore, drawing upon demand-resource theory and social identity theory, this exploratory study addresses the following research questions:

1) How and why does work-family conflict function differently for foreign-born faculty and U.S.-born faculty?

2) Given the known gender disparities of work-family conflict in general, are foreign-born women more likely to experience work-family conflicts than their male counterparts?

Data and Methods

This study uses data from the 2011 NETWISE II project, an NSF-funded national survey of academic scientists and engineers in four STEM fields: biology, biochemistry, mathematics, and civil engineering. The survey was designed to focus on female and underrepresented minorities in STEM fields and explore their careers, work environments, and professional networks. The stratified sample includes 9,925 academic faculty members from 521 academic institutions: all Carnegie-classified research-extensive and research-intensive universities, and selective teaching institutions (NETWISE, 2012). The survey had a total of 4,196 valid responses (40.4% response rate). The final sample used for this study includes 1,917 responses from 259 doctoral-serving institutions, of which 29% are foreign-born.

As we are interested in the factors predicting the work-family conflict of foreign-born and U.S.-born faculty, this study uses logistic regression models with interaction terms of foreign-born status and key variables. The binary dependent variable indicates reported work-family conflict, which is generated from a scale developed by Netemeyer et al. (1996) (Cronbach's alpha = .93). The two main variables of interest for this study are foreign-born status and gender. Moreover, based on the demand-resource theory, the key explanatory variables include those related to academics' job demands (workload, work stress), job resources (supportive work climate, faculty perceptions of reward and tenure), and family demands (marital status, the presence of children). Additionally, several variables that may affect work-family conflict are controlled, including race/ethnicity, academic rank, discipline, and institutional types.

Preliminary Findings

Our findings suggest that foreign-born identity interacts with work and family demands to influence work-family conflict among academic scientists. Controlling for other factors, being foreign-born predicts a higher likelihood of work-family conflict, though no significant difference is found between female and male foreign-born. Moreover, work demands are more likely to cause work-family conflict issues for foreign-born faculty than U.S.-born faculty, but not for family demands. This can be attributed to the strong work commitment of foreign-born faculty as well as the different family culture between U.S.-born and foreign-born faculty (i.e., individualist culture vs. collectivist culture) (Sallee & Hart, 2015).

Surprisingly, although a supportive work climate is negatively related to work-family conflict, foreign-born faculty who work in a more supportive work climate are more likely to experience work-family conflict compared to their U.S.-born counterparts. How might we account for this pattern? A possible explanation is that foreign-born faculty, in this case, are more willing to stay in the workplace rather than spend more time at home and caring for family, thus leading to work-family conflict. Further, while faculty's perception of rewards is not significantly linked to work-family conflict, foreign-born faculty who are more satisfied with rewards and tenure are less likely to experience work-family conflict, as compared with their U.S.-born counterparts. This suggests that the perception of fairness in the workplace matters for academics' well-being, especially for foreign-born faculty who often have fewer career advancement opportunities.

Significance

Work-family balance is known to matter for a range of work-related experiences and the overall well-being of academic scientists, including job dissatisfaction, burnout, and turnover intentions (Post et al., 2009; Sarwar et al., 2021). In particular, foreign-born faculty often face considerable challenges in relocating and adapting to what is often a very different social and workplace setting. This study makes contributions to the work-family literature by exploring how the relationship between work and family experiences figures into foreign-born experiences.

Overall, the study sheds light on why foreign-born faculty are more productive but less satisfied with work. Their high productivity may come at the expense of their family, which would lead to work-family conflict and in turn affect their work satisfaction. Further, the study provides implications for U.S. higher education institutions to manage diversity in academic science. It is not enough to simply create a representative workforce. More importantly, university leaders and

policymakers should better understand the unique needs of faculty members with different identities and backgrounds, creating an inclusive work environment for improving the support and retention of these scientists.

Acknowledgments

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[6049] *Technology Transfer and Commercialisation in Nigerian Universities: Motivation, Barriers and Policy Options*

Caleb Muyiwa Adelowo (North-West University).

Abstract

Technology Transfer and Commercialisation in Nigerian Universities: Motivation, Barriers and Policy Options Background and Rationale Transitioning from resource-based to knowledge economy has placed premium responsibilities on the knowledge institutions to support innovation (Adelowo, Olaopa and Akinwale, 2017; Adelowo, 2018; Adelowo and Surujlal, 2020). New knowledge creation and dissemination are fundamental roles of higher educational institutions (HEIs) and research organisations (ROs) (knowledge institutions), although some large corporations sometimes establish research base. The core mandates of these institutions have consistently undergone changes over time to reflect different levels of economic and technological development. For instance, educational institutions are set up to supply critical human capital needs at all levels to provide leadership and appropriate governance to both administrative and technical systems in the society. Later, research and development (R&D) activities was added given the substantial knowledge pool existing in the institutions. Translating R&D outputs to useful products, processes and services in the industry has become parts of the mandates of knowledge institutions in the last few decades, and for this to happen, these institutions have to be entrepreneurial in their approach. The arguments for knowledge institutions to become entrepreneurial in their engagements was clearly articulated in the knowledge spill-over theory of entrepreneurship (KSTE) (Acs et al. (2013) and the need for universities to be responsive to societal challenges (Etzkowitz (1998). This implies that knowledge institutions possess talents and tangible research results that are capable of transforming the society or an economy. This argument becomes more obvious when economies with most innovative firms and regions, including global leaders in high-tech are considered. For instance, most of the top twenty leading innovative companies globally emerged from the developed and newly industrialising economies that have not only invested heavily in knowledge creation but also created a channels through which those knowledge outputs are transferred for economic renewal and societal benefits (BCG, 2019). These economies are also home to top ranked universities and research institutions, supplying critical skills and knowledge inputs to the industries in a coordinated manner. Therefore, for developing countries in Africa, particularly Nigeria to harness knowledge outputs for development, there is the need for the knowledge institutions to embrace entrepreneurship and innovation as parts of coherent policy to achieve both institutional and developmental goals. Parts of the process to embrace innovation and entrepreneurship include the creation of and, or strengthening existing mechanisms for knowledge transfer in these institutions, including technology transfer offices, technology incubators, knowledge parks, innovation hubs and other innovation infrastructure. Nigeria has since 2006 started establishing technology transfer offices in its knowledge institutions to serve as a collation hub for R&D outputs and to foster linkages with industry for the purpose of technology commercialisation among others. To date, about forty-three intellectual property and technology transfer offices (IPTTOs) have been created/established in different institutions across the country. Despite its existence for more than a decade, the performance of few of them have been recently assessed, suggesting improvement in the patenting activities among the scientists and researchers (NOTAP, 2019). Also, institutions without the IPTTOs have also demonstrated great potentials in creating commercialisable research results but without any documented (known) mechanisms for its management. Data and Methodology Therefore, this article x-rays the strategic approach(es) adopted to sensitize stakeholders and manage research outputs in Nigerian universities and research institutes using primary data collected through cross sectional survey conducted among thirty-one (31) intellectual property and technology transfer offices and one hundred and sixty-seven patentees. For the institutions without the IPTTOs, we also established the mechanisms adopted to manage tangible research outputs within them. The motivation and barriers to patenting and commercialisation were examined among scientists and researchers in the selected universities. Preliminary Results The results show weak management capabilities in the TTOs, as most of the managers and staff do not have adequate knowledge and training in IP management. Most of the staff (67%) of the TTOs, including the directors regarded themselves as permanent staff, however many of them have primary department or faculty they are affiliated to in the same university. The basic office infrastructure in the TTOs are fairly adequate while only few of them have automated their IP database. On major activities of the TTOs, IP sensitisation and training for faculty members, industry collaboration, facilitation of inter/intra departmental linkages and collation of R&D outputs are reported as the dominant ones. The TTOs are majorly financed by the host institutions and sometimes by the internally generated revenue. Financing TTOs from the institutions' budgetary allocations is perceived as additional financial burden, given that universities and research institutes are not adequately funded. The Offices hardly receive funding from the National office for Technology acquisition and Promotion, an Agency of government that is responsible for establishing and funding IPTTOs in the country. The major challenges confronting the offices are inadequate funding, personnel, training opportunities and inability to sufficiently foster industry collaboration for research uptakes. Few of the TTOs have assisted their institution to develop robust IP policy at the time of data collection. From the inventors' perspectives, key motivations reported for filling patents are promotion, prior knowledge of IP, expected monetary returns, career advancement and recognition/award/fame that is associated with it. Only a handful of inventors have commercialised their inventions, and that was done through private arrangements. Major barriers to inventions commercialisation are lack of industry collaboration, poor funding, inadequate innovation infrastructure, and lack of IP policy or incentives. The paper concludes with policy recommendations to improve innovation ecosystems in the universities.

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[387] *A Tale of Two Faculty: Differences in Career Experiences of First-Generation Faculty and Faculty with PhD parents*

Victoria Pham (Arizona State University) and Julia Melkers (Arizona State University).

Abstract

Though first-generation status has been studied in undergraduate student populations, little attention has been paid to first-generation faculty even though 16% of individuals who earned STEM doctorates in 2020 were first-generation (NCSES, 2020). Despite facing barriers typically associated with first-generation status (e.g., less material resources, lower cultural capital), a significant number of first-generation students are successful in becoming faculty members themselves. Conversely, recent studies have found high proportions of faculty with PhD parents suggesting that parental education provides significant advantages to accessing academia. Because parental education is often used as a proxy variable for socioeconomic status, this suggests that social background variables play a large role in shaping faculty careers. Using a nationwide sample of academic scientists in the United States from four STEM disciplines, we examine the extent to which socioeconomic status offers advantage (or disadvantage) to faculty as they advance their careers. We find that faculty with PhD parents are one and a half times more likely to work at higher-ranked and more competitive universities, while first-generation faculty are three times more likely to work in lower-ranked and non-doctoral-serving institutions. We find that first-generation scholars are especially disadvantaged in navigating the competitive work environment of research-intensive institutions.

[5967] *Institutional reproduction of intersectional inequalities in science*

Diego Kozlowski (EBSI-UdeM), Thema Monroe-White (Berry College), Cassidy Sugimoto (Georgia Institute of Technology) and Vincent Larivière (EBSI-UdeM).

Abstract

Introduction Universities play a key role in shaping the social structure in which scientific activities are performed. Wapman et al. (2022) showed that graduates from the 20% most U.S. prestigious universities occupied 80% of the faculty positions in the country. This is due to the fact that authors from top universities benefit from an environment that gives them higher productivity and recognition (Way et al. 2019). Such inequalities at the individual level influence the research priorities of the country, as it allows those top institutions to have a fundamental role in setting the research priorities within the scientific community (Clauset et al. 2015). In tandem, research has shown a strong alignment between an author's sociodemographic characteristics and the topics they study (Kozlowski et al. 2022a). However, little research has studied the intersection of these intersectional inequalities and how they might be mediated through institutional prestige. In this project, we focus on how prestige relates with the socio-demographic representation of authors, of research topics and research impact. Also, we will analyze the role of mission-driven institutions, such as Historically Black Colleges and Universities (HBCU) and Women's Colleges (WC). Two main research questions drive the analysis. First, we want to assess whether those types of institutions have a specific topical profile, and how it varies as a function of authors' intersectional identities. Second, while it has been widely studied that institutional prestige drives impact (Way et al. 2019), it is important to acknowledge how this relates with race and gender inequality. How, if at all, does the citation bias against marginalized groups—women, Black and Latinx authors— vary by the prestige of the institutions in which they work?

Methods To answer these questions, we use more than 4.5 million articles from more than 800 US universities published between 2008 and 2020 and indexed in the Web of Science (WOS). Following the method developed by Kozlowski, Murray et al. (2022b), authors of the selected papers were assigned a probability over each racial group based on the association between their family names and racial categories found in the 2010 US Census (USBC 2016). Gender was inferred using authors' given names, based on Larivière et al. (2013). We consider a researcher's identity as the combination of four racial categories —Black, Latinx, Asian, White—and gender, considered in a binary way. Given the limitations of the data and inference algorithms, it is not possible to automatically classify authors into Census categories "Native Americans" and "Two or more races", and gender outside the women-men binary, which further highlights the

importance of studied based on surveys and self-identification of authors as complements to large-scale secondary analytical studies. We used historical WOS data to compute the average number of citations of US universities between 1980 and 2019. We use three different classifications as complementary indicators of prestige, as proxies for perceived prestige (US News & World Report), research prestige (average citations) and selectivity prestige (Carnegie Selectivity Index). Each of these three rankings is divided into three groups: 'high,' 'middle' and 'low'. We also consider mission-driven classifications: HBCU and WC. We used topic modeling (Blei et al. 2003) to infer the research topics of articles based on their titles, abstracts and keywords. We define the topical profile of a group as the proportion of papers this group contributes on each topic with respect to the total number of publications in the topic. Topical profile can be applied both to groups of researchers' identities and institutional categories. To compare two topical profiles, we use the Spearman rank correlation, as the relation between topical profiles is not linear. We focus on the correlation between the topical profiles of institutional categories and authors' identities. If the correlation between those groups is high, it means that they tend to publish on similar topics. We also build a linear model to predict the effect of author's identities on impact (citations and Impact Factor). By splitting articles by their institutional prestige groups and running the linear model for each, we show the differential effect of race and gender by institutional prestige.

Results and discussion There is an increasing debate around the role of elite institutions in the reproduction of systemic inequalities in science (Clauset et al. 2015; Wapman et al. 2022). These institutions do not only have a higher accumulated economic capital—as exemplified by their endowment—but also of symbolic capital. A handful of institutions produce a large proportion of research articles, and those attract an even larger impact (Way et al. 2019). This study provided an intersectional perspective on the role of institutions. It provided evidence that institutions are key to the stratification process of science and that, across different institutional tiers, the experiences of racialized and women authors is qualitatively different from that of White men. Aligned with their missions, HBCUs and WCs occupy a topical space that is closely related with that of Black and Latinx, and White women (respectively). In previous works we found that thesetopical profiles relate with the lived experiences of these populations, and have a larger focus on issues such as racial discrimination, migration, and gender-based violence (Kozlowski et al. 2022a). However, as we climb the ladder of institutional prestige, we observe a sharp decline of participation in those topics. Far from being a simple consequence of the composition of their faculty, this reflects on a more nuanced phenomenon: authors from marginalized groups in top institutions have a topical profile that differs from the one of their institutions, but also differs from that of their own identity in other institutions. Top institutions are failing to leverage topics that are relevant to marginalized populations. We have also found that the impact gap by race and gender is affected by institutions. Articles from top institutions gather more citations and are published in higher impact journals. But within institutions the gap persists, and the highest impact gap is found on top institutions, even after controlling by topic and other relevant covariables. These results demonstrate the strong role that institutions play in shaping the research profile of a nation. Initiatives that serve to diversify hiring may serve to expand the topical profile of an institution, but only if other mechanisms are in place to ensure that scholars are free to pursue the full landscape of research questions. Our work suggests a penalty for this deviation that is borne particularly by minoritized populations.

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[7496] *Assessing Organizational Capabilities and Effectiveness of Digital Transformation Implementation Agencies: A Case of the National IT Industry Promotion Agency (NIPA) of South Korea*

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Abstract

Background and Rationale: Although studies have examined the benefits of digital transformation and the effectiveness of certain policy instruments for digitization, the policy implementation capabilities of public agencies have received little attention despite their critical importance in the effective delivery of support programs. Using a new framework developed by the World Bank for assessing the organizational effectiveness of innovation agencies, this

research aims to address this knowledge gap with a case study of a Korean implementation agency tasked with supporting firms' adoption of digital technologies. This study analyzes the effectiveness of the Korean agency in four key dimensions–delivery of goals, stakeholder satisfaction, processes and functionality, and resources–of organizational effectiveness and draws lessons in each of the dimensions, as well as from a systemic point of view. The findings show that phased efforts that start with a focus on building critical mass across the digital economy and that are based on existing capabilities are key to improving the effectiveness of public agencies supporting firms' digitization.

Methods: From the experience of assessing the policy mix and functionality of science, technology and innovation (STI) policies in developing and middle-income countries, it became clear that there was a need to develop a methodology focused specifically on the features of the agencies that played a key role in various phases of these policies, ranging from design through implementation and governance. Especially important was the need to gauge their effectiveness in fulfilling their mission and goals. With this a novel analytical framework was developed inspired in the organizational effectiveness approach from Quinn and Rohrbaugh (1981) adapted to the specifics of STI policy agencies. It takes into account recent reports on observed features of these agencies by NESTA (Glennie & Bound 2016) and the World Bank (Aridi and Kapil 2019). The analytical framework develops the framework of organizational effectiveness into a model with specific categories relevant to STI agencies that guide an empirical strategy for assessing their effectiveness.

Data and Results: The project gathered data from available agency reports and interviews with relevant agency personnel. Reports were used dating back to 2104 regarding budgets, mission transitions, project catalogs, statements of objectives and goals and evaluations of beneficiary satisfaction. Several rounds of interviews were conducted and followed up with written questions which received written responses and supplementary information on the available reports. Two sorts of results were of interest in this project: First, an empirically grounded assessment of the effectiveness of NIPA as a digitization innovation agency in Korea was sought. Second, the project aimed to establish whether the proposed analytical framework is useful for determining the profile and effectiveness of innovation agencies generally in other countries.

On the first result, the project found that NIPA has a very specific profile that is not found in other innovation agencies generally. It is an implementation and services organization that maintains close connection with the beneficiaries of the programs it implements and manages. It takes significant feedback directly from beneficiaries to adapt its approaches to better serve them and caters to their perception of what is most important and useful. Understanding the profile of the organization in this way, in its tightly constrained policy context, it can be said that it is very effective in its role. However, it is a limited role lacking many of the functions and capabilities that would be required for an organization that would be expected to have greater responsibility in broader technology policy strategies. The broader role of innovation policies is distributed across policy domains under the purview of several ministries giving implementation agencies a very narrowly focused role closely tied to their beneficiaries' satisfaction.

The second conclusion is that method is useful to determine the profile and effectiveness of innovation agencies generally. Even though there were some limitations in the availability of information, we were still able to determine the profile of the agency and get a sense of its effectiveness and how it may be considered as a model in other contexts. We were able to conduct interviews but were not able to run surveys or other more intrusive approaches to information gathering. Future use of the method would require fuller access to take advantage of its potential. Interestingly, the approach seems sufficiently general and, at the same time, detailed enough, that it did not require much ex-ante knowledge of the organization to arrive at the key findings. It seems the method is flexible enough for use in almost any government context if enough information is made available.

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[5944] *Measuring Ecosystems' Innovation Capabilities with The Innovation Potential of Individuals: A Systematic Review of Multidimensional Construct*

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Abstract

Purpose: Innovations are intrinsically driven by individuals. Collective innovation between individuals across various teams, organizations and innovation ecosystems convey additional uncertainty and complexity to measure innovation capabilities. How measuring the innovation capabilities of ecosystems with the Innovation Potential of Individuals (IPI)? As innovation capabilities transform the innovation potential of upstream resources into the result of downstream innovation potential, understanding the IPI construct supports the creation of new indicators to better adapting to collective innovation approaches. This systematic review identifies IPI construct's multidimensions and presents a research agenda to measure ecosystems' innovation capabilities.

Literature Review: An innovation ecosystem is defined as a collaborative network between firms and individuals who share resources and interact to mobilize and converge the group's innovation capabilities. The complexity of measuring innovation capabilities value generation is related to structural, human, social, and relational attributes. As an ecosystem is a set of collaborating actors and represents natural interactions between actors of a system and its environment its composition and social structure influence intensity of collaboration, connectivity, co-evolution complementarity or interdependence between individuals. The innovative potential of individuals is a relatively emerging concept; it has been studied more thoroughly in very recent literature, but its origins date back to the 1960s from underlying concepts: human capital, innovation capabilities, and innovative human capital. IPI represents the level of readiness for carrying out efficient tasks to achieve the targeted innovation objectives. According to existing definitions, the IPI is a set of characteristics that align with a firm's innovation strategy, an opportunity, a skill, a systematic use of resources and a capacity. These studies assess the innovative potential rather at the organizational and systemic level. None of the studies analyzed is specifically related to the individual level. The dimensions identified are thus more economic and strategic. Notwithstanding these contributions, we lack comprehensive understanding of IPI.

Methodological Procedures: Based on an inductive approach using grounded theory technique and a systematic review of 353 academic articles from Proquest databases, this study presents the development of the IPI construct. The natural language processing technique is used to analyze the corpus content with morphosyntactic analyses, multivariate analysis/vectorization, term frequencies, concordances, co-occurrences, clustering, and specificities.

Findings: An analysis of co-occurrences emphasizes the presence of combinations of terms: organization and change, market and study, relationship and supplier, technology, and research as well as development and activity. These term combinations seem less obvious in the corpus of 353 documents because the 13 terms with the most co-occurrences have equivalent relationships. Using information retrieval with a return to text and a Boolean matrix, we find that the term combinations are still present, except for relationship and supplier, which are both found in only 296 out of 353 documents.

When selecting a central terms – innovativeness and innovator – the co-occurrence network illustrates a strong relationship between 8 dimensions. The analysis indicates innovativeness as a central term but it rather indicates manager as a central term instead of innovator. The two networks demonstrate that team is the weakest dimension linked to the central term. Is the innovative potential therefore more linked to the individual, the organization and the ecosystem? The corpus has been segmented into 8 clusters which are segmented with a very unequal number of documents per cluster from 5 to 136. Cluster 4 attracts attention with 136 articles; the cloud of words most positively correlated to cluster 4 represents as example: network, ecosystem, team, and alliance. Additionally, as cluster 1 represents more meaning with the specificity of this cluster, we notice the most positively correlated terms to cluster 1: knowledge, capability, ambidexterity, absorptive, and dynamic. This reflects a strong link with the literature on dynamic capabilities and innovation ecosystems. These clusters demonstrate that the innovative potential at the individual level is weak in the literature. However, the articles in cluster 7 contain interesting keywords to understand the innovative potential specifically linked to human capital, such as skilled, workforce, human, and labor. The innovative potential as a construct is diluted in different fields of literature, such as dynamic capacities, innovativeness, collective innovation and innovation ecosystems. Each computer-assisted text analysis method yielded a set of keywords and each keyword was categorized. This categorization presents a pattern of 6 dimensions: process, innovator, approach, results, resources, condition/context.

Implications: It is recognized that the human factor is under-represented in innovation measurement indicators. In practice, many challenges arise in managing and measuring individual, collective, organizational or ecosystem innovation capabilities. New approaches must be used to identify, capture, mobilize, and enhance innovation capabilities. Measuring and managing the value of innovative human capital, in other words the IPI, remains a challenge. Despite all the importance given to innovation capabilities, the IPI is little explored in the literature (Patterson & Zibarras, 2017), more particularly dimensions and factors that influence the potential as well as the indicators for measuring these determinants. It's considered that the determinants are not fully explored and there is no consensus on the determinants (Mendoza-Silva, 2020). It's recommended to advance research on measuring innovation capabilities on ecosystem level to close the existing gap. Further research is needed to advance on measuring innovation capabilities on ecosystem level. By discussing dimensions of the IPI construct, this paper proposes a research agenda on IPI as key measurement for ecosystem's innovation capabilities.

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[4812] *Analyzing the Significance of Public Values in Artificial Intelligence Patent Documents*

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Abstract

Background and rationale

Determining patent eligibility for artificial intelligence (AI) inventions has become increasingly difficult to predict since the 2014 Alice Corporation v. CLS Bank International United States Supreme Court case. The case brought about concerns about abstract ideas being unacceptable for patent protection, yet foundational to computer software and technological inventions. At the same time, there has been both growing public debate and increased scholarship and policy dialogue on public and societal concerns associated with the rise of AI and its applications. This poster will present the results and insights gained from a systematic literature review on the societal dimensions of AI invention and innovation, focusing on the public values expressed in AI patent documents. We build on public value frameworks to conceptualize public values expressed in patents as statements regarding the potential social objectives and benefits of an invention, beyond the private value to patent holders. Although the United States Patent and Trademarking Office (USPTO) has no formal requirements for expressions of public values in patent documents, patent applications often describe the broader objectives or problems that the invention aims to address. Such public value statements inform the context for understanding the potential utility of a patent.

The United States and other countries spearheading technological innovation have begun widely developing AI, even promoting its proliferation. This is evidenced in the United States by growth of R&D investment in AI research and in the rapid expansion in recent years in AI patent applications and grants. Generally, in return for the private protection of intellectual property rights, patented inventions (and the innovations that flow from) are expected to contribute to R&D knowledge and, broadly, to the construction of social and public value. Yet, this is not straightforward, and there is much discussion about the heightened dilemmas that AI raises. For AI innovations, there have been concerns about the reliability of AI, the potential for bias across machine learning algorithms, and the loss of human agency and control. On the other hand, AI developers frequently promise that their AI inventions will address not only data security and bias concerns but also health, environmental, sustainability and other major societal challenges. In our literature review, we aim to analyze the emergence of literature that addresses the dilemmas presented by AI, considering how public value impacts associated with AI are framed and discussed, and how public values might be mapped in patent documents.

Methods

The methods used for the analysis that will be presented in the poster begin with formulating strategies for literature searches in the fields of public value theory, the public value of science, technology and innovation, the societal and public value implications of AI, and the societal and public value implications and assessment of patents. An iterative and structured search for relevant documents will be conducted in key scholarly databases (i.e., Scopus, Web of Knowledge). It is recognized that these topics represent potentially large swathes of literature. Bibliometric text mining tools (such as VantagePoint) will be used to organize, describe, and synthesize these literature landscapes. This approach will assist in identifying central and influential works and discerning diverse perspectives and schools of thought. Annotations will be developed from reading key works and the thematic literature review will highlight the recent developments in AI patent applications. A report will be produced that summarizes the findings of the literature review and contributes to the conversation about public value implications of AI and the associated concerns. From this, a visually communicative poster will be developed that details the method, the landscape of ideas, and the findings and implications. This research stands on it own as a deliverable poster but will also feed into an international project (undertaken by researchers from Georgia Tech, the University of Manchester, and the SKEMA Business School) to determine how text used in patent applications for AI technologies references public and private values. The broader project is using a machine learning method to text mine large volumes of AI patents. The project involves conceptualizing the public value frameworks that are used in patent applications and analyzing the anticipated uses, from a public values perspective, of AI inventions. The project will contribute to the existing literature surrounding AI and public values as described in the curated literature review portion of this research.

Anticipated results and significance

The research for this poster will identify, bring together, and evaluate aspects of the literature concerning patent protection, AI, and public values. After completing a thematic narrative literature review and considering how public value terminology is presented in the literature, the study will inform the algorithm training used for text mining expressions of public values in AI patent documents. This research will contribute to frameworks that evaluate ethical practices and morality for emerging technological innovations. This research will help to analyze and describe the textual evidence from patent applications and provide an opportunity to further explore anticipated societal implications for inventions and the effects of AI patents on human life. This presents an opportunity to explore positive and negative externalities associated with the increase of AI patents for healthcare use, digitalization, and other societal domains and

to develop new concepts and methods that can contribute to evaluating the harm reduction, equity, and transparency aspects associated with AI patenting.

[6474] *Evaluating Sectoral and Associative Policy: The Case of the FSAT Program in Argentina.*

Marcelo Fernando Molina (Universidad Nacional de General Sarmiento) and Mariano Alberto Pereira (Universidad Nacional de General Sarmiento / Centro Argentino de Información Científica y Tecnológica).

Abstract

The objective of this paper is to study the effects of the micro policy of sectoral funds on the innovative and economic performance of firms. For this purpose, we are going to study the High-Tech Sectoral Fund (FSAT), one of the instruments of the Argentine Sectoral Fund FONARSEC), implemented by the National Agency for the Promotion of Research, Technological Development and Innovation (I+D+i Agency) of the Ministry of Science and Technology of Argentina. The period of analysis is between the years 2010 - 2017. Evaluations of policy instruments in general focus on conducting impact analyses, either from a market failure or systemic problems perspective. In turn, these studies also mostly focus on studying horizontal programs that do not promote particular sectors. This research analyzes a sectoral fund whose goal is also to strengthen the link between the scientific and technological sector and the socio-productive sector in order to contribute to the solution of social and economic problems. In particular, we will take as a reference the policy of support to isolated innovation projects to evaluate whether the promotion of public-private partnerships generates a better innovative performance. This type of analysis becomes relevant due to the scarcity of studies that analyze the impact of vertical innovation policies. In particular, given the challenge that the covid-19 pandemic implied for policy in general, and science and technology policy in particular. Currently, the policy has shifted to a much more focused scheme, and this requires knowledge about the results of this type of policy. This paper thus contributes to policy by shedding light on the results of a vertical instrument. The policy of sectoral funds is a recent milestone in Argentine science, technology and innovation policy. In particular, in relation to the way in which technological innovation was supported in companies. Three elements make it possible to dimension this change. First, innovation policy shifted from horizontal instruments to vertical instruments that sought to provide support focused on sectors, regions of lesser relative development, or technological platforms. Secondly, there was a shift from isolated support for companies to innovate, to instruments focused on public-private partnerships. Finally, the size of the non-refundable contributions was substantially larger than that of the pre-existing horizontal instruments: the minimum non-refundable contribution was USD400,000 and could reach up to USD10,000,000. This policy was manifested in the Argentine Sectoral Fund (FONARSEC), composed of three instruments: Sectoral Technological Innovation Funds (FITS). Regional Technological Innovation Funds (FITR) Sectoral Funds for High Technology (FSAT). FITS was designed with a focus on sectoral development, while FITR has a regional focus. Finally, FSAT has a focus on intensive technology platforms, such as biotechnology, nanotechnology and ICTs. Within this framework, this paper aims to analyze the impact of FSAT. To this end, we will study the causal relationships between access to financing, the formation of a public-private partnership and the trajectories of the firms. We will analyze whether the trajectory of their innovative effort and/or market performance improved as a result of their participation in the program. Understanding the impacts of the instrument on the companies will make it possible to identify the public policy criteria that have worked and those that need to be focused on in order to improve. The methodological approach is based on an econometric study that will determine whether the trajectory of a firm that accessed the instrument was different from one that did not. For the evaluation, a panel of data will be constructed with a balanced structure and information for two moments in time, before and after the FSAT considering the average of three years. The identification strategy will combine two impact evaluation techniques. First, a Propensity Score Matching will be implemented to identify those firms in the control group that, due to their observable characteristics, are not similar and comparable to the beneficiary firms. Then, once the database has been cleaned, a Differences in Differences estimation will be implemented to estimate the trajectory that would have been observed in the absence of FSAT. By comparing the two trajectories, the observed and the counterfactual, we will be able to identify the Average Treatment Effect attributable to FSAT, controlling for unobserved and fixed factors over time. The results confirmed an impact of FSAT on the trajectory of the beneficiary companies. On the one hand, the evidence showed that the growth in spending per employee on innovation activities was higher thanks to FSAT. In addition, the growth in employment and total sales was more intense thanks to the program. No evidence was found on the trajectory of spending per employee on R&D activities and firm productivity. The first result could be reflecting the positive synergies of the public-private linkage promoted by FSAT. R&D activities were undertaken by academic research groups, which took advantage of the funding received to incorporate scholarship holders, train researchers, incorporate equipment and improve their infrastructure. This allowed companies to rely on the capabilities of these groups, and to undertake the rest of the innovation activities by increasing their investment effort. The second result may reflect the short time that has elapsed since the end of the FSAT. Previous evidence suggests that on average it takes 6 years to begin to observe impacts on the productive efficiency of companies participating in innovation support programs. Future research plans to conduct an evaluation that takes into account these possible dynamic effects.

[1115] *An Analysis of Revealed Comparative Advantages in Scientific and Technological Disciplines in the Anglophone Caribbean Region, 1996-2020*

Marcos Segantini (Universidad ORT Uruguay), Natera José Miguel (Univesridad Autónoma Metrpolitana - Unidad Xochimilco) and Danilo Spinola (Birmingham City Bussines School).

Abstract

Background and rationale

This work aims to analyze the situation of the Anglophone Caribbean Region (ACR) scientific system. Despite being close to main research hubs such as the US and having cultural ties with others such as the UK, Netherlands, and other European countries, the ACR falls behind in research productivity compared to several regions of the world, which are closing the gap with the developed countries in specific research areas.

The ACR has specific barriers that make it a worth investigating region in terms of developing a well-suited scientific system for its development path. The ACR comprises CARICOM countries, which face similar obstacles. After the 2012 world economic recession, ACR experienced low economic growth rates. Also, an extraordinary economic downturn during the pandemic took effect, especially for those more tourism intense ACR economies. An increase in the frequency of natural disasters and historically high public debt rates are also causes of endemic fiscal issues in the region, which restrict countries' investment in areas such as science and technology. With a few exceptions in the ACR region, unemployment is pervasive throughout these countries, especially youth unemployment, which unfortunately ranks comparatively among the highest in the world.

However, the ACR region has similar advantages for developing a scientific system that fits its unique characteristics. Many initiatives were applied to foster research areas throughout several ACR countries, such as the green and blue economy, climate-resistant infrastructure, big data and digital development, geothermal energy, and several medical research investments focused on tropical viruses that can spread faster internationally. Also, despite the obvious negative consequences, the COVID-19 pandemic opened a window of opportunity for the region with the explosion of remote work. Some ACR countries (especially Barbados) took advantage of the last by attracting specialists in IT areas who work remotely for the US or Europe to their unique landscapes. While the consequences of the previous strategy are unknown for their STI system, other countries could have followed a similar approach.

These shared barriers and opportunities in the ACR open up the need to investigate which research disciplines will require more effort for capacity building and those in which the region excels. However, despite the similarities in the region, ACR countries and even specific islands within countries have their specificities. In this regard, it is essential to understand where the research capacities are located and where policy initiatives are needed for their development.

Descriptively, this research aims to answer in which research areas the ACR demonstrated an increase in its capacities during the last decades. Also, it turns necessary to understand in which countries this development occurred: this capacity building in specific research areas occurred homogeneously in ACR, or is the process concentrated in some countries? Also, it is intended to answer why capacities developed in specific research areas, and others do not.

The development of research capacities is an evolutionary process; thus, time is a key variable for this research. It would be a worthless effort to understand ACR research capacities nowadays without understanding how did evolve and interacted with the local ecosystem. For these reasons, our approach embraces quantitative and qualitative information analysis, explained in the next section.

Methods

This research describes and explains the evolution of the ACR's scientific output in the last 25 years. First, built on bibliometric information from the Scimago database for the 1996-2020 period, this study illustrates the ACR research output compared –in relative terms- to the world. For this goal, based on the well-known revealed competitive advantage approach, the inquiry establishes the research domains where a region or a country shows a revealed comparative advantage (RCA). Nevertheless, more importantly, it shows how the regional and country-specific RCA evolved during the last 25 years. The last exercise makes it possible to identify descriptively how the research capacities raised or declined during the period of interest.

The empirical tool helps identify an RCA in a research discipline if it has a greater participation in the national scientific production than the participation of that area in the world's scientific production. Published articles and citation measurements of the scientific output are presented for 27 research areas in this research. Specifically, the RCA is defined as the quotient between the discipline's participation in the scientific output of a country and the participation of this same discipline in world scientific production. Formally,

RCA = ((P_is/P_i)/(P_s/P))

Where P_is are publications in a research area s in country i, P_i is defined as the total publications in country i, P_s is the publications in subject area s worldwide, and P is defined as the publications worldwide. This indicator was also developed for citations, focusing on both cases comparing RCA for ACR and the specific countries of the region

throughout the entire 1996-2020 period. In terms of its interpretation, a revealed comparative advantage in a country's discipline is found if the RCA's value is greater than 1 in a given year. Otherwise, it does not show a competitive advantage for that specific year. Secondly, using the same database, we identify the specific research institutions that excel in research disciplines previously identified as the more productive in ACR. To go a step further in explaining the reasons for that success in such a deprived context for developing research capacities, the third goal of this research is interviewing leaders of the ACR's prominent research institutions and groups to understand their evolution. The last exercise aims to discern if the experience of prominent research institutions or groups is replicable in other ACR contexts.

Results and limitations

In our analysis, the ACR has revealed at least competitive advantages in six of 27 research areas for 1996-2020. These areas include agricultural and biological sciences, business, management, accounting, environmental science, medicine, nursing, and social sciences. However, enormous differences can be found in specific ACR countries. Heterogeneity in the ACR is the rule in terms of research capacities. Nevertheless, in some areas, it is possible to find no research capacities in the region and virtually in all ACR countries: Mathematics and Engineering and a few related disciplines.

These results raise questions for the debate regarding policy decision-making: Should the region enhance deprived research areas in all the countries? Or should they cooperate in interchanging the knowledge and professionals in the disciplines that each country revealed a competitive advantage? The experiences of successful research institutions and groups are replicable in other ACR countries? How could the ACR address its un-competitiveness in such important areas as mathematics and engineering?

The main goal of this research is to have the first long-term diagnosis of research capacities in the ACR. However, our analysis is not excent of limitations. First, the RCA as an analytical tool has its weaknesses mainly because our source of information comes from scimago database: meaning indexed databases, generating biases that minimize local non-indexed publications. Secondly, the interviews focus on successful research institutions or groups, which biases our results towards successful experiences. It is difficult or almost impossible to identify unsuccessful groups and the reasons for their decline since most of them are difficult to locate (few publications) or have already stopped operating.

[8753] *An Integrated Approach to Innovation Policy Analysis: The Case of Romania*

Marcio Cruz (World Bank), Natasha Kapil (World Bank), Christopher Haley (World Bank) and Juan D Rogers (Georgia Institute of Technology).

Abstract

Background and Rationale: The effects of policies to support innovation must be addressed in the context of the entire policy mix (Flanagan et al. 2011). Therefore, it is important to establish whether the collection of policies that may influence innovation activities do so in a coherent and constructive manner (Falk 2009). At the same time, the actual manner in which policies are designed, implemented and their governance context will also either facilitate or constrain the ability of such policies to deliver on expected goals. To address the needs of countries to improve their innovation policy approaches, World Bank has developed a public expenditure review framework (PER) for innovation policies (Correa 2014). This framework proposes and integrated approach to the science technology and innovation policy environment of a country. It consists of four stages, namely, policy mix analysis, functional analysis, efficiency analysis and effectiveness analysis. The first three stages have been fleshed out into detailed analytical methods and applied in several countries around the world providing useful insights for governments to improve their practices. This paper illustrates the application of the methodology with the specific case of Romania. Methods: In Romania, the policy mix analysis and functional analysis were conducted of the set of policies for supporting and enhancing innovation, especially in the context of its entrepreneurship ecosystem. Each one of these components of a PER have specific empirical strategies and instruments to carry out the analyses. The policy mix requires cataloguing all the policies and identifying a full range of features of each one. These include the institutional context of the policies, period the policies were active, their stated general and specific objectives, intervention mechanisms, intended beneficiaries, supported activities, budgets, including their origin, among others for a total of more than 100 possible items. The functional analysis uses a model of the policy intervention with 31 categories covering design, implementation and governance. For each category, an assessment of performance is coded on a Likert scale using criteria derived from a broad base of recommended practices found in scholarly journals, agency reports and consultations with experts. Data and Results: The data for the policy mix analysis is obtained from the government documents describing each policy instrument and government databases that contain budgets and other administrative information. Consultations with relevant ministries and agencies are often required to complete information needed for all the categories in the policy mix catalog. The functional analysis uses the results from the policy mix, documents obtained during the first phase and is complemented by in depth interviews with the relevant public officials who are responsible for managing the instruments in the analysis. The information on each policy instrument is used to address each of the categories in the model and assess on a likert scale the degree to which they reach best recommended practices in each area. In the case of Romania, the results of the

policy mix analysis show that, first, the current portfolio of policies is highly concentrated, with significant resources devoted to a few instruments and a 'long tail' of much smaller instruments which are likely to be sub-scale. Second, most instruments have multiple top-level objectives, such as productivity improvement combined with job creation. This may suggest a lack of clarity in the design of instruments. Third, there are gaps in intermediate-level objectives, especially regarding improvement of management practices and linkages with foreign firms and market access. Fourth, there are gaps in support for entrepreneurs, especially regarding early-stage, pre-profit, startups and individual entrepreneurs - as well as the intermediary organizations which support such startups, such as incubators and accelerators. Some 'entrepreneurship' instruments may potentially reinforce the role of incumbents rather than encouraging the growth of innovative startups. Fifth, grants are the dominant intervention mechanism, which may be appropriate in a relatively under-developed innovation and entrepreneurship ecosystem, notwithstanding their potentially distortionary effect. However, it is important to remember that not every element of the ecosystem can necessarily be resolved through the addition of public money: regulatory reform is also needed and factors such as cultural perceptions of innovation and entrepreneurship are also important. In the case of the functional analysis, the results of the analysis show, first, that Instrument-level evaluation could be improved. This is currently stronger at the Priority Axis level of EU supported instruments. Improved evaluation at the instrument level would also support rationalization of the portfolio, by providing information about which instruments should be scaled-up. Second, instrument design is consistently weak in the articulation of a theory of change. Developing and articulating these models should enable better accounting of inputs and activities by managing authorities, as well as improved targeting of the instrument. It should also prompt ideas for alternative instruments and mechanisms, which would assist with rationalization of the portfolio and the development of a wider range of mechanisms. Third, administrative burdens for many beneficiaries are still high. There has been a significant effort by managing bodies to simplify the application processes for support scheme and reduce the bureaucracy for applicants. However, there are still indications that these processes remain overly complex for applicants and could be further simplified. Fifth, bureaucratic burdens for administrators are also significant. In particular, multiple auditing of instruments appears to impose a significant burden on administrative teams. Bureaucratic friction is likely to be increased by the structure of many instruments which have both a Managing Authority and a separate Intermediate Body; this may be a necessary condition of some European funding but is unlikely to be optimal.

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[6551] *Navigating the tightrope: Understanding Shenzhen, its contemporary contexts, and its future as a center for Chinese technology and innovation*

Anthony Xu (Georgia Institute of Technology), Miji Xu (Georgia Tech Shenzhen Institute) and Michael Best (Georgia Institute of Technology).

Abstract

Background & rationale

Over the last four decades, the city of Shenzhen in southeastern China has enjoyed exceptional success as the country's first special economic zone (SEZ). Despite humble beginnings, Shenzhen has emerged as the locus of China's technological revolution, evolving a dense and idiosyncratic innovation ecosystem founded upon export-led manufacturing, labor and capital flows, industrial policy, and a distinct entrepreneurial spirit. However, while more recent literature has remained largely positive on Shenzhen's prospects in the near term, the last several years have seen sweeping socioeconomic, political, and cultural change threaten ambitions for the city's innovation-centered development. Within these new contemporary contexts, Shenzhen's historical model of growth has become increasingly unsustainable. As such, on March 11th, 2021, China's National People's Congress endorsed the 14th Five-Year Plan of the Chinese Communist Party (CCP). The plan, which is to guide development policy for the period spanning 2021 to 2025, represents an important economic transition and a remarkable departure from the traditional instruments of Chinese development since the country first began its economic reforms. Rather than the investment-led, hyper-globalized model of growth upon which Shenzhen has relied and the country itself has staked its developmental legitimacy, the 14th Five-Year Plan paints a new vision of China's near future: one of self-sufficient supply chains, consumption-led growth, and (perhaps most sweepingly) technological and innovative preeminence.

Therefore, by virtue of its central place with regard to China's technology and innovation, Shenzhen will be embroiled necessarily in the sweep of this most recent Five-Year Plan. In the forty odd years since paramount leader Deng Xiaoping designated the small urban center the site of one of China's most consequential market-oriented reforms, Shenzhen has grown beyond all imagination—indeed, in the decades after the SEZ's establishment, even the CCP's wildest conjectures failed to estimate the city's meteoric ascent. Today Shenzhen is the third-largest city in China, home to some 17 million

residents and counting, and is the professed nucleus of the country's domestically cultivated technology sector. Global heavyweights such as Huawei, Tencent, and DJI headquarter there, to say nothing of other major conglomerates like Ping An Insurance and SF Express (both of which, incidentally, are looking to rebrand as technology companies). The streets bustle with entrepreneurial life, and scores of ambitious professionals flock from across the country and the wider world to make their fortune. Since its nascent days, Shenzhen has doggedly stood at the forefront of China's reform and opening-up, and its urban character has been shaped by decades of immigration, Party taglines, and a pervasive sense of economic opportunity. Key to understanding China's technological, innovation-driven ambition on the world stage, then, is understanding the city of Shenzhen: its history, its economy, and how the city's contemporary contexts and the variegated trends that inform them lay the groundwork for the next stage in Shenzhen's ongoing evolution.

Methodologies

The two primary methodologies utilized for this research were literature review and qualitative, semi-structured interviews. The first stage of the study consisted of a detailed assessment of existing published work, noting broader trends in the archival research, and developing a conceptual framework with which to analyze Shenzhen's innovation ecosystem. This assessment was done to provide a holistic understanding of the city's history and political economy, and helped ascertain Shenzhen's position within the wider Chinese and international technology industries. However, to obtain a more granular view of Shenzhen and its people, and, moreover, to identify the cultural and societal factors behind the city's success, the second stage of the study included semi-structured, 60- to 90-minute-long interviews with academics, experts, and industry professionals. These interviews furnished the contextual background upon which we interpreted recent events in Shenzhen, and were instrumental in characterizing the sociocultural conditions of city life. Both methodologies helped mitigate the lack of available or trustworthy data over this most recent period of Shenzhen's development, and are commonly utilized for research of this nature.

Results

Our findings indicate that—contrary to assumptions of smooth, steady development over the next several years—innovation in Shenzhen will enter a "tightrope era" of pronounced uncertainty as the city seeks to transition from one model of growth to another. Virtually every factor of innovation that we identified as crucial to Shenzhen's success will stall or has already begun to stall over the next several years. Shenzhen's previously exceptional demographics will be haunted by low birth rates, flagging migration, and soaring housing prices and cost of living. Rising costs in its manufacturing sector have made Shenzhen less cost-competitive for firms who increasingly look outside Shenzhen or even China for their manufacturing needs. The city's proximity to Hong Kong has become a liability as a harsh government response to protests there roiled investor confidence in what was once a sure thing, and even the distinctive shanzhai networks which built Shenzhen's early technology industry have become less relevant as large corporations and reduced market competition become the norm in the city today.

The political and cultural indicators have fared no better. The progressive policies which had historically fueled the city's entrepreneurial culture are no more as the government under Xi Jinping has demonstrated a willingness to crack down upon the technology sector, empowering regulatory authorities and intertwining CCP cadres ever closer with designated private enterprises. The cultural backlash is apparent as well, as public dissatisfaction with lifestyles like the 996 working hour system prevalent throughout Shenzhen bubbles to the surface: in the last two years, both the tang ping and bai lan movements have proliferated online, spurred on by poor labor conditions, long hours, and the significant societal pressure to overwork in China.

Even the international business environment has become far more hostile. The European Union labeled China a "systemic rival" and froze an investment deal in 2021. India has banned hundreds of Chinese apps from the country's digital infrastructure. In 2018, the United States ignited a trade war with China during which several of Shenzhen's major corporations were caught squarely in the crossfire, and the Biden administration's 2022 ban on semiconductor exports has signaled no end to the conflict in sight. All of this is occurring as the government implements draconian "zero-COVID" measures to address the ongoing pandemic, and as the country faces a sharp downturn in its property sector (triggered by the default of the China Evergrande Group, a company that is headquartered—coincidentally—in Shenzhen).

Significance

Shenzhen's symbolic, entrepreneurial, and innovative importance to China is difficult to estimate. It stands as a testament to the country's enormous progress and its towering ambition, and the city's macroeconomic trajectory serves as a guidepost toward understanding trends prevalent throughout all of China. As one of the most prominent engines of Chinese technology and innovation, how it weathers what we have coined "the tightrope era" will be indicative of how the entire country fares in the near future, and informs others countries that have since adopted China's SEZ model of development of how they should or should not implement policy. It remains to be seen whether Shenzhen can navigate the myriad of challenges it faces, or if it is destined to fail, but the city's future will have widespread implications for innovation, technology, and urban development, regardless of result.

[3019] *An Analysis of Autonomous Vehicle Deployment Forecasts: Understanding a Technology Hype Cycle*

Naseeb Souweidane (Georgia Institute of Technology), Diana Hicks (Georgia Institute of Technology), Gordon Kingsley (Georgia Institute of Technology) and Min Cha (Georgia Institute of Technology).

Abstract

Background and Rationale In the mid-2010s, companies producing autonomous vehicles (AVs) were projecting the widespread deployment of this technology to happen very soon, which did not occur. Current company projections focus on narrow AV deployments in limited areas and circumstances. As companies have missed their deployment goals and commercialization becomes more distant, enthusiasm for AVs has waned. Some companies are narrowing their focus to lower levels of automation, and none have commercialized high automation at a large scale. Investor enthusiasm has cooled, and several companies have gone out of business. The industry recently realized that this deployment would not happen as fast as projected.

The public, and in some cases, policymakers, have yet to recognize the lack of progress in AV development after such widely reported, bullish projections last decade. The lack of technological advancement can help clarify the federal, state, and local policymaking process. While many companies have identified the lack of policy progress as a barrier to development, the policymakers at NHTSA have argued that policy will not make sense until development reaches a practical level. Georgia Tech currently has a concurrent research project assessing state policies and reports. That research can help bridge the gap on how policy has responded to the stagnation witnessed in these projections. The research indicates that states produced legislation and reports with the early AV technology hype cycle. An analysis of industry projections and their evolution can give insight into the AV technology hype cycle and guide policymakers faced with a similar hype cycle in the future.

Methods While company projections are narrow today, Georgia Tech and the Center for Automotive Research collected all initial forecasts, including projected timelines and their fulfillment. The data consists of estimates from auto manufacturers, tech companies, parts suppliers, and startups. These projections can be aggregated and cleaned to illustrate the technology and innovation hype cycle. Additionally, the underlying data can provide a deeper understanding of trends throughout the industry to which governments seek to respond. The research team at Georgia Tech will utilize the data on these early projections for quantitative analysis of how projections have scaled back and which sectors missed their forecasts. The data will likely be split into two parts: the initial stage of the AV hype cycle (2014-2019) and the most recent stage of development (2020-2022). The comparative data analysis of the two phases will also enhance the understanding of how AV deployment has changed and the proper expectations for the future. Lastly, the data can be utilized to understand which sectors have given up on the deployment of automation.

Anticipated Results The current data shows that all sectors missed most of the projections early in the hype cycle. However, it is expected that auto manufacturers, startups, and tech companies missed their forecasts more than parts suppliers. There is also an assumption that results will show projections have begun to decrease in time and milestones. It is unclear which sector has the lowest success rate in its commercial viability. Still, it is likely that the companies like Waymo and Zoox, funded by big tech companies like Google and Amazon, have the most robust success rate. The results can help inform policymakers on the imminence of AVs and how to adjust expectations to industry projections properly. A more practical understanding of AV development will allow policies to occur at a rate more in line with their development.

[1566] *The Quest for Strategies of Social Control: from State Policy Documents for Autonomous Vehicles*

Min-kyeong Cha (Georgia Institute of Technology), Gordon Kingsley (Georgia Institute of Technology), Diana Hicks (Georgia Institute of Technology) and Naseeb Souweidane (Georgia Institute of Technology).

Abstract

Background How will state-level administrators respond to the arrival of emerging technologies, such as autonomous vehicles (AV)? With the expectancy of new technology, state actors are likely to face Collingridge's dilemma (Collingdridge, D. 1980): at the early stage of technological development, it is difficult to forecast the social impacts of the technology, while at the later stage after the technology matured, social control is costly. In other words, state actors, who are responsible for public roads, must learn and react in a situation of great uncertainty about how the emerging AV technology will be developed and how it will affect society. In the study, we explore strategies in which state actors respond to uncertainty, learn the technology and its social possible impacts, and adapt to innovation.

Method & Data In this study, we collect two classes of policy documents 1) state laws and executive orders and 2) the reports about technical and socioeconomic aspects of autonomous vehicle technology, which are commissioned by

states, both from 2012 to 2021. We use content analysis and topic modeling to analyze the contents of these policy documents. The core text of each document was extracted for modeling, and the text was preprocessed using snowball stemming. We found a peak at about 30-35 topics; 35 topics were specified in the final model.

Anticipated Results In our analysis, we take two approaches: first, we examine how states legislate for the arrival of autonomous vehicles, and second, in state reports, we explore topics states share and specific patterns in the content. We find a remarkable similarity of texts, especially in laws across states, suggesting common sources outside the states and/or institutional isomorphism. Also, we find the extent to which states track actions in other states in the reports, which might be a process leading to isomorphism. By combining two approaches, this study will provide an overview of strategies that various states are taking in anticipation of autonomous vehicles on the road.

Reference Collingridge, D. (1980). The social control of technology. St. Martin's Press

[8116] *Knowledge Intermediaries and Evidence Use in State Policymaking: Topic Modeling and Analysis of Two Consequential Policy Areas*

Gordon Kingsley (Georgia Institute of Technology), Kim Isett (University of Delaware), Diana Hicks (Georgia Institute of Technology), Megan Haegley (University of Delaware) and Min-kyeong Cha (Georgia Institute of Technology).

Abstract

Evidence-based or evidence-informed decision-making is the paradigm by which public decision-makers leverage knowledge from various sources to craft policies and programs that are fair, efficient, and effective. Evidence can come in a multitude of packages and be leveraged with different calculuses about what matters most. In this work, we build on Head's three lenses of evidence-based policy where he articulates that evidence can come from science (what we traditionally think of as "evidence"), from practice (the tacit and earned knowledge of front-line public servants), and from the political sphere (knowledge about political dynamics, authority, and feasibility) by examining policy documents from two consequential public policy domains in the United States: autonomous vehicles and state-level opioid strategic plans.

The focus is on how state governments, often in conjunction with knowledge intermediaries attempt to monitor and understand innovation trends and develop strategies to adapt to changes in science and technology. Policymakers and public administrators frequently draw from research in science and technology to address problems confronting society. Relatively little is known regarding how state public managers scan for, access, and employ consensus science. This panel explores the variety of sources of information that can be accessed, the development of intermediary organizations to help structure and access information at the state and local levels, and the methods local governments use to communicate that information to their constituencies.

Policy reports and plans can be used as artifacts of policy processes that capture the decisions and dynamics of complex policy activities, rather than as an end of the policy process (Freeman and Maybin 2011). As such, detailing the people and sources used to create the policy document can reveal important aspects of how the policy evolves in a location. We use policy documents from the two domains mentioned above to identify important aspects of how the policy deliberations occurred and the impact they had on the outcome (report construction). We created unique datasets for this investigation.

Data and methods. All reports from the 50 states and Washington DC relative to the two substantive areas were scraped from publicly available sources on the internet. All reports from 2013 until 2020, when the COVID-19 pandemic started) were considered for this investigation. Reports were then reviewed for their focus on program implementation and governance, rather than a technical focus. There were 68 reports on the AV side and 72 in the opioid case.

Reports were then analyzed on a number of dimensions to understand how they used evidence in their work. Our methods were centered on bibliometric techniques which catalog and enumerate the contents of scientific documents. We assessed images and figures, references, word/page count, topics covered using NLP, authors, and committee/task force membership. We also ran clustering models to find distinct patterns of reports.

We used topic modeling to characterize the contents of the state reports, state laws, and executive orders. The core text of each document was extracted for modeling. Wordstat 9.0.8 was used for text processing and topic modeling using the nonnegative matrix factorization (NMF or NNMF) method. The text was preprocessed using snowball stemming. Words that occurred at least 30 times in the corpus were retained, or about 2,000 words in total. Other settings remained Wordstat defaults. Examining coherence statistics showed a peak at about 30-35 topics; 35 topics were specified in the final model.

Findings. We found three distinct clusters of reports within each of the two substantive areas. While the specifics of the clusters across the two areas are slightly different, they are remarkable in that they have the hallmarks of Head's three lenses of evidence for policymaking. On the AV side, we see three clusters that are expert-engineering (practice evidence), expert-academic (scientific evidence), and convening, legislative focus (political evidence). For the opioid

reports, we see that reports that have a lot of private organizations (rather than state agencies) emphasize practice-based knowledge, while those reports that are oriented by task forces emphasize political knowledge, and finally, those reports authored by groups with heavy representation from public health departments emphasize scientific knowledge.

[3245] *Policy innovations spawned by the advance of rooftop solar systems*

Alyson Laura (South Face), Min-Kyeong Cha (Georgia Tech) and Mailyn Brown (Georgia Tech).

Abstract

The emergence of affordable smart meters, solar panels, electric vehicle charging, and stationary storage systems, has spawned a new generation of policy innovations. These breakthrough technologies have motivated the creation of new policies, such as electricity tariffs that blend energy, demand and capacity in novel ways; new rules and regulations about who can sell electricity to retail customers; buy-back rates for excess solar generation; and minimum bills and interconnection fees to help ensure coverage of fixed costs.

The challenge now is to design retail electricity rates that reflect "cost causation" and prevent inequitable cost shifts—two Bonbright principles of utility ratemaking. As solar penetration advances, for instance, there may be a shift of costs from technology participants to nonparticipants, which has raised concerns about the equity principle.

The "classic" net energy metering tariff (where excess solar generation is bought back at a retail rate) has spawned an array of alternative tariff configurations. There are now buy-all, sell-all rates, value of solar tariffs, and net billing, as well as instantaneous versus monthly netting. Each of these options reflects stakeholder aspirations for these evolving technologies and markets.

In this study, we explore the reciprocal relationship between technological advances and policy innovation using a combination of qualitative and quantitative analysis.

First, we review the new wave of state net energy metering (NEM) policies and identify the extent that retail tariffs are evolving in response to technological advances and the market penetration of rooftop solar systems. The case studies show that policy innovations have been spawned by technological advances, but that their design is also a reflection of the structure of regional electricity markets.

Second, we conduct a statistical analysis of the continental U.S. states and the District of Columbia to explore how policies with various configurations correlate with technological adoption. A review of the new wave of state net energy metering (NEM) policies and a statistical analysis of correlates of their adoption are conducted. These allow us to identify the extent that retail tariffs are evolving in response to technology advances and the market penetration of rooftop solar systems.

Our research finds that net energy metering policy encourages the adoption of residential solar photovoltaics, with varying effects depending on the policy design. Further, we document the impact of increasing levels of adoption of distributed solar on the design of a new wave of variants to the design of net energy metering policy.

[4665] *The Division of Scientific Labour: An empirical view on contributions to global science from the periphery*

Francois Van Schalkwyk (Stellenbosch University).

Abstract

Acknowledged in the contribution dynamics of authorship is an asymmetry between the Global North and the Global South (also referred to as the 'scientific periphery') in the production of new knowledge. Marginson (2022) points to a dominant global discourse that frames science as a centre-periphery hierarchy. Baber (2003: 621) refers to a perpetuation of 'an unstated but real global division of intellectual labour'. Others argue that theoretical and methodological innovations are considered legitimate tasks for Global North scholars while data collection is the designated role for those from the Global South. This paper examines the contribution of scientists from the Global South by relying on multi-authored scholarly publications to assess their changing contributions to global science over time. The focus on the contributions of scholars in the Global South in an asymmetrical global science system provides a unique and empirical perspective. It is a perspective that accounts for the networked nature of science that shapes the relative contributions to the global scientific network and provides important insights for funders and policy-makers seeking to establish equitable partnerships between the Global North and the Global South in global science.

[4515] *Policy considerations for AI and genome editing shaping humanity*

Sana Zakaria (RAND Europe).

Abstract

Introduction

Science policies (or lack of) have the potential to maximise opportunities as well as expose society to risks presented by emerging technologies. The integration of artificial intelligence (AI) and biotechnology, whilst in its infancy, presents significant opportunities and risks, and proactive policy is needed to manage these emerging technologies. While AI continues to have significant and broad impact, its relevance and complexity magnify when integrated with genetic editing in particular; applying AI elements such as machine learning and deep learning can foster substantial benefits as well as daunting risks that range from ethics to national security. Yet, this combined field has not been adequately studied from a policy perspective. The components need clear definitions and analyses with respect to their practical combined implications for society. The study of genome editing, and its technological advances have been facilitated to a large degree by their underpinning bioinformatics platforms, which has allowed screening and detection and gene manipulation to become common practice. Application of AI to this technology will catapult the revolutionary potential of genome editing from 'hypothetical' to imminent. However, application of AI to this rapidly advancing field poses severe risks from potential weaponization and bioterrorism as well as opportunities to improve health and wellbeing. Both genome editing and AI technologies are being pursued at scale in various global markets and the genome and AI research agenda is moving towards a progressively permissive landscape, with AI and genome editing technologies being brought together to cut costs and time. For instance, DNAnexus, a cloud based commercial platform, offers products utilizing machine learning techniques for mutation predictions, diagnostics, and gene target optimisation. Verge Genomics, an AI driven therapeutics company, is bringing together human genome and machine learning to create predictive models for drug development with its first ALS drug just entering the clinical market. It is just a matter of time before these developments are further exploited with AI tools, not just to modify the human genome to cure disease but to develop resistance to diseases, enhance vision, create superhuman strength, and pave the way for a species evolution. There clearly is an urgency to addressing policy issues surrounding these emerging technologies. Given this gap, we are investigating the policy implications of the application of AI to genome editing in humans, in particular technology governance as a cross-cutting theme. This analysis will help regulators take stock of advances with AI-facilitated genome editing and develop a future scenario-focussed framework to protect human interest by considering the implications of these technologies being pursued at scale and globally. Our methods outlined below will ensure that this is not just an academic exercise, by engaging relevant sector and policy experts and ensuring that the outputs reach a variety of audiences.

Methods

Landscape assessment: We will use software-assisted horizon scanning for assessing the state-of-the-art of AI and genomic tools, creating a typology for their use, and assessing where they have been or integrated. We will complement this approach with interviews with up to 10 subject-matter experts. We will conduct a desk-based review of the current regulations surrounding genome editing and AI applications in the life sciences as a frame of reference for understanding the areas in policies that are unclear or uncertain. Landscape assessment will enable us to identify the most important factors that affect the trajectory of AI and genomic tools. Futures framework: Landscape assessment will form the basis for how the relationship between AI and genomic editing is currently configured, and a futures framework will then be used to explore how this relationship might change over time. We will use a scenarios-based futures exercise, where the landscape assessment will facilitate crafting of illustrative stories that outline how AI and genomic tools might remain the same, improve, or change in some other way based on the effects of the factors identified in the landscape assessment. A basic scenarios-based table-top exercise (TTX) will be conducted based on the trajectory of the landscape over the next 25 years, bringing together key stakeholders in genomics, AI, and regulatory sectors, to contemplate the various policy dimensions of these technologies. The TTX will identify opportunities, risks, and policy issues, with special consideration of technology governance challenges as a cross-cutting issue. The proposed approach will serve as a blueprint for future areas of research in multiple sectors where various policy lenses could be applied (e.g. impact on agriculture and food security). Going through such scenarios with stakeholders will enable us to characterise how well current policy addresses these scenarios and what changes may be needed taking this further than just an academic exercise. The project team will use MURAL software for scoring the scenarios, to enable the prioritisation of the most important policy responses or changes required. Key risks, opportunities, policy implications, and actions will be identified as outputs of the exercise.

Anticipated results

The current regulations and discourse are not appropriate to respond to the melding of AI and genome editing technologies and to regulate them at scale. Using a combination of landscape review and futures methodology, we will create a novel frame of reference for policymakers and the public. This work approaches the understudied sector of the confluence of AI and genome editing, and it explores technology governance as a broader policy challenge that could be applied to other sectors and technologies. The outputs of this work will be consolidated into a short report, summarizing opportunities, risks, and policy considerations for countries investing in R&D, thus supporting responsible innovation. The evidence will provide a steppingstone for a roadmap for policymakers and will serve as a mechanism for engagement

with potential clients in Europe and the US such as DARPA, NATO, DoD, and more. We will pursue further dissemination via development of a podcast with sector experts delving into the output produced and assessing their views. This will further our research and help reach policy makers and the wider public to generate interest and a public discourse as well as policy considerations. We will actively engage our networks and potential clients to discuss our findings and create bespoke policy briefs and concept notes as a follow up activity.

[5954] *Net Zero? An assessment of the technological innovation research funding towards low-carbon transitions*

Abdulrafiu Abbas (University of Sussex) and Abdul Abbas (University of Sussex).

Abstract

Confronting climate change implies substantial and rapid acceleration into new innovative technologies that would promotes clean energy systems, zero-emission in energy systems, transport and mobility and industrial emission reduction that can reduce global emissions. This paper asked which countries have funded the most energy, transport, climate change, and industrial decarbonisation research? And why (i.e., what could have influenced the high/lower funding rate)? What are the disciplinary politics of funding? Which disciplines have received the most funding, and which countries have funded the most social science research? To what extent are funded projects interdisciplinary or trans-disciplinary? To answer these questions, this study catalogue and examines comprehensive global public research programs across some of the world's largest funders (and countries), including the most substantial funders of public research or countries responsible for the highest carbon emissions. It synthesizes data from 1990-2021 for 69 countries involving 163 research councils to examine and understand the global funding patterns on energy, transport, climate change, and industrial decarbonisation research. The study reveals the mean external cost for R&D funding is $2.3 billion, and the cumulative total amount of research funding from 16 countries that are the largest funders in the data was $2.268 billion from 97 research councils. Using percentile estimations of the cost of funded projects, the data reveals 69.4% from the United Kingdom, 8.11% European Union Commission, and 4.16% United States and others 18.9%. When we put the global context into the funding patterns, the data provides that the United Kingdom contributed about 40%, European Union Commission 27%, the United States 21%, and others 5% of the cost of the funded project. The analysis of global research funding across general areas reveals that Engineering and technology attract significant funds, with 28%, followed by social sciences and economics 27%, the Arts and humanities receive 18%, 16% was for Natural and physical sciences, and the least as shown in the data was 11% which is for Life sciences and medicine. The study discusses the results of the review, which are based on R&D funding as a game changer of deep transitions, before discussing how countries, research councils and academic institutions are being funded and how research results are creating a socio-technical change.

[4076] *Open Access policies, their effectiveness and unexpected consequences*

Thed van Leeuwen (Leiden University).

Abstract

Introduction: in the last part of the previous century, the world witnessed tre upraise of a movement aiming at organizing the access towards scientific knowledge in a more egalitarian manner. In particular the university librarians in the US plead for a more evenly distributed access to global scientific literature for scholars in the Global South, and hence declared war on the power of the scientific publishing industry. So, the initial aims of the Open Science movement, as it was coined, focused on equal access to scholarly literature, as subscription rates were sky-high, which meant that reading of the most important scholarly journals was impossible for many in low- and middle-income countries. Only when three major statements were made, in gatherings in Budapest, Bethesda, and Berlin, with increasing attention, and known as the B-B-B declarations on open science, science policy and research funding got involved, leading to the development of national open science mandates, institutional open science policies, and open science requirements for research grants. Note that in these initial initiatives, it centered mostly around measures on open access to scholarly publishing. In this study we will aim at a few of these policies, and the way these have worked out. In doing that, we will analyze the full broadness of results, including any un-wished for outcomes, in line with Stone's book "The Policy paradox", in which she claims that undertaken policies often have paradoxal consequences, for which one did not aim at the time the policies were developed and undertaken.

Policies: As stated above, many countries issued national policies and mandates on open science, in particular on open access for scholarly publishing. Policies focused on various types of open access publishing, like a preference for Gold Open Access in the UK and the Netherlands, and a focus on Green Open Access in for example Denmark. This national perspective often resulted in likewise policies on the institutional level, although these often also covered other aspects of open science, such as open data, open source code, open logbooks, etc. In 2018, a consortium of international funders,

under the name of cOAlition S, launched Plan S, an outline on how to publish in open access format. Plan S prioritized Gold open Access over other types of open access, in particular over Hybrid Open Access. The difference between Gold and Hybrid Open Access is in the fact that Hybrid still relates to the subscription journal, so publishers still cash in on both subscription incomes, as well as the individual payments for individual single papers submitted to their journals, while the Gold Open Access type means that the whole journal is open access, and accessible for everybody who is interested, without any restrictions whatsoever. A crucial role is played in the debate around Plan S by these payments for open access publishing, the so-called Article Processing Charges (APCs). Plan S proposed to use a cap, a maximum of money one single open access publication might cost. In the hybrid situation, it is still up to the publisher, often owners of highly prolific internationally oriented journals, to determine the value of the APCs.

Studies: In this section we will discuss the outcomes of two studies, both related to open science policies and both evolving around the phenomenon of APCs. In the first study we will show that the national open science policy of the Netherlands, started in 2013/2014, and aiming at Gold Open Access as the standard format for open access publishing, is clashing with the development initiated by the Dutch universities. Ibn the Netherlands, universities do have a high degree of autonomy, and are well organized in contexts such as university library settings, evaluation cycles, and overall governance of the institutions. After the national government issued a national open access policy, prioritizing Gold as the default open access format, the universities, organized together with the royal library in the so-called UKB, negotiated with the publishing industry specific deals that allowed Dutch scholars to publish in journals within the subscriptions with these publishers, so in Hybrid open access format. This development started in 2016/2017, and we will show the effects of these two contradictory initiatives and the way scholars from various scholarly domains have reacted to this. The second study focuses on the Gold Open Access publishing on a global scale. While the original motivation for the open science movement was a better access for the scholars of low- and middle-income countries to reading scholarly literature form the Northern hemisphere, this analysis shows that the current development of Gold Open Access publishing is driving into the direct opposite direction. The study will show that scholarly publishing in Gold Open Access journals via the payments of APCs is becoming more and more expensive. A direct translation of numbers of publications times APC-rates is showing that publishing becomes more costly, but when normalization for national welfare situation is conducted, by applying the OECD based PPP-rates (Purchasing Power Parity), the situation even worsens. So while initially, scholars form the low- and middle-income countries could publish, but had a hard time reading scholarly literature, we are now moving into a situation in which these scholars can read the global literature, but do have little to no access to the publishing dimension anymore.

Conclusions: What we witnessed in the two studies we conducted is a complex power structure, with a variety of actors, both supra-nationally and nationally, conflicting interests within the national context, funding agencies, and a variety of motivations (academic, commercial, individual). A clear issue in the debate around Plan S was the relationship of the consequences of Plan S with the existing reward & recognition systems, as well as career perspectives of early career researchers in an international context. This is also reflected in the study on the Dutch system, whereby academic freedom to choose the journals that suit you best is conflicting with prescribed ways of publishing in both the national mandate as well as in Plan S. Finally, the study on global Gold Open Access publishing reflects a development towards a more unequal access to scholarly publishing, along the line of available financial resources. All these outcomes clearly show unexpected consequences of the policies undertaken.

Stone, D., “The policy paradox”, New York: W.W. Norton & Company, 2002

[4013] *Governing Transformative Innovation Policy: a policy regime approach*

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Abstract

Background

Policy makers and scholars are increasingly embracing the idea of using science, technology, and innovation (STI) policy to tackle grand challenges (Castellacci, 2022; Diercks, Larsen, & Steward, 2019; Edler & Fagerberg, 2017; Fagerberg, 2018; Hicks, 2016; Kuhlmann & Rip, 2018; Mazzucato, 2018; Schot & Steinmueller, 2018). Such ambitious initiatives often come under the label transformative innovation policy (Diercks et al., 2019). Design, implementation, and evaluation of transformative innovation policies are more challenging than traditional innovation policies because they span across multiple policy subsystems, levels of government, and industrial sectors (Flanagan, Uyarra, & Laranja, 2011; Haddad, Nakic, Bergek, & Hellsmark, 2022; Howlett & Del Rio, 2015). The literature has largely taken a rationalistic approach (Geels & Schot, 2007; Mazzucato, 2018; Nunez-Jimenez, Knoeri, Hoppmann, & Hoffmann, 2022) to studying transformative innovation policies, and political failure has been suggested to be a ‘missing piece’ in the innovation policy analysis scholarship (Bonvillian, 2011; Karna, Karlsson, Engberg, & Svensson, 2022; Marburger III, 2011).

Aim

The purpose of this study is to introduce the policy regime approach to analyzing governance challenges in transformative innovation policies and demonstrate its utility to shed light on political dynamics of transformative innovation policies. It operationalizes the original policy regime approach proposed by Jochim and May (2010) into a two-by-two policy regime matrix with policy legitimacy and policy durability axes so that it can be used as a heuristic to assess how favorable the political environment is for a transformative innovation policy.

Method

This is a conceptual study based on a literature review of studies related to transformative innovation policies. It primarily focuses on the mission-oriented innovation policy (MOIP) framework (Mazzucato, 2018), the multi-level perspective (MLP) framework (Geels & Schot, 2007; Kanger, Sovacool, & Noorkoiv, 2020), and the policy mix scholarship (Flanagan et al., 2011). Then it attempts to apply the concept of a policy regime (Jochim & May, 2010) in the context of transformative innovation policy.

Results

Innovation scholars have attempted to understand transformative innovation policies from largely two directions: a Mission-Oriented Innovation Policy (MOIP) framework and a Multi-Level Perspective (MLP) framework (Haddad et al., 2022). The MOIP framework suggests a list of prescriptive advice on desirable features of a transformative innovation policy (Mazzucato, 2018); the MLP framework contributes to a holistic description of the process of socio-technical change (Geels & Schot, 2007) and identification of potential intervention points (Borras & Edler, 2020; Edmondson, Kern, & Rogge, 2019; Kanger et al., 2020).

However, both frameworks remain short to explaining how the state can be successful in mobilizing relevant actors and their resources to transform the socio-technical system in the intended direction. While the MLP framework provides a comprehensive lens to understand interactions across multiple levels, it does not well explain when meaningful interactions are likely to occur. The prescriptive advice provided by the MOIP framework insists a normative role for the state that could potentially be used to explain implementation failure; however, the framework does not directly address how to respond to challenges that arise from boundary spanning activities.

In response, it has been argued that STI policy in general has not given enough attention to political design (Bonvillian, 2011; Marburger III, 2011). The policy mix scholarship has responded to this challenge by taking into account interactions across levels of government (Borras & Serger, 2022; Magro, Navarro, & Zabala-Iturriagagoitia, 2014; Magro & Wilson, 2019; Uyarra, Shapira, & Harding, 2016), documenting all available policy instruments and how they interact with each other (Borras & Edquist, 2013; Edmondson et al., 2019; Kern, Rogge, & Howlett, 2019; Magro & Wilson, 2019; Meissner & Kergroach, 2021; Nunez-Jimenez et al., 2022; Rogge & Reichardt, 2016; Scordato, Klitkou, Tartiu, & Coenen, 2018), investigating the politics of tool choice (Acciai, 2021; Capano & Lippi, 2017), and proposing various strategies and roles for the state to accelerate socio-technical transitions (Borras & Edler, 2020; Hayter & Link, 2020; Kanger et al., 2020; Mowery, 2012; Nunez-Jimenez et al., 2022; Parks, 2022).

A policy regime approach sheds light to whether the current environment is supportive of a policy of interest and can potentially inform what strategies or alternatives are feasible. A policy regime is defined as “a governing arrangement that spans multiple subsystems and fosters integrative policies” (Jochim & May, 2010, p. 307). A policy regime differs from a socio-technical regime in the MLP in that it is much more expansive to the extent that it could be viewed as network of socio-technical regimes. The motivation behind a policy regime is to go beyond policy subsystems as the unit of analysis to make sense of comprehensive governmental efforts that are implemented through boundary-spanning governance arrangements (Carter & May, 2020; Jochim & May, 2010). Due to this, the locus of a policy regime is a wicked problem, whereas the locus of a policy subsystem is a public policy (May & Jochim, 2013). This makes a policy regime a good fit to analyze the governance of transformative innovation policies.

A policy regime consists of ideas, institutional arrangements, and interests. Ideas are shared commitments around a policy goal. Institutional arrangements refer to the structures of authority, attention, information, and organizational relationships. Interests are the actors that provide support or opposition. The outcome resulting from the dynamics among ideas, institutions, and interests is described across three dimensions: policy legitimacy, policy coherence, and policy durability (Jochim & May, 2010).

A shortcoming to this approach is that the relationship between components and outcomes in a policy regime is not clear. In response, this study operationalizes the concept into a policy regime matrix. The three components of a policy regime are reduced into ideas and institutions. There is high level of policy legitimacy when ideas are shared as opposed to being disjointed, and there is high level of policy durability when institutions are aligned versus fragmented. Policy coherence is considered to be high at the intersection of high policy legitimacy and high policy durability.

Among the three outcome dimensions, policy coherence and policy durability have been identified to be critical for success in the transformative innovation policy literature. Incoherence of policy mixes within government has been cited as a cause of policy failure that aim for sustainability transitions (Magro & Wilson, 2019; Uyarra et al., 2016). Also, strong commitment from the government (i.e., a high level of policy durability) that provides a clear direction and strong signal to the private sector is thought to be critical for MOIPs to succeed (Mazzucato, 2018).

[8194] *Governing the Platform Economy: Accommodating, Defensive, and Generative Strategies*

Angela Garcia Calvo (Berkeley Roundtable on the International Economy), Martin Kenney (University of California, Davis) and John Zysman (University of California, Berkeley).

Abstract

Online platforms have become essential infrastructure for social, economic, and political activities. In doing so, gatekeeper (dominant) platforms started fulfilling functions that used to be the sole purview of the state, such as solving disputes and regulating content, "taxing" transactions, and regulating ever greater parts of the economy. Various states are responding according to their own sensibilities and internal pressures resulting in divergent national internet governance systems. We explore these evolving systems by introducing a framework that identifies three strategies through which governments respond to the infrastructural power of platforms: accommodative, defensive, and generative. We use our framework to make sense of the evolving nature of governance models in four key jurisdictions: the US, the EU, China and India, and to explore the general direction of change and its implications for the global digital economy and international trade. Ultimately, our goal is to use our analysis to raise intriguing new questions: Moving forward, will the previously largely open global market for platforms continue, or is a fracturing of the global market emerging? And what will be the major fault lines?

[4093] *Diversity and STEM: Women, Minorities, and Persons with Disabilities*

Amy Burke (National Science Foundation), Steven Deitz (National Science Foundation) and Christina Freyman (National Science Foundation).

Abstract

Lunch Breakout Session A diverse workforce provides the potential for innovation by leveraging different backgrounds, experiences, and points of view. Innovation and creativity, along with technical skills relying on expertise in science, technology, engineering, and mathematics (STEM), contribute to a robust STEM enterprise. Furthermore, in the United States, STEM workers have higher median earnings and lower rates of unemployment, compared with non-STEM workers. This session will provide high-level insights from Diversity and STEM: Women, Minorities and Persons with Disabilities, a biennial report produced by the National Center for Science and Engineering Statistics (NCSES) within the National Science Foundation. This congressionally mandated report represents the U.S. government's most comprehensive collection of data on diversity trends in the U.S. STEM enterprise. This session will offer a unique perspective on long-term changes in the demographic composition of the STEM workforce and educational populations in the United States.