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Abstract

This paper examines the evolving role of universities in transferring and developing knowledge to foster transformative Science, Technology, and Innovation (STI) policy amid significant shifts in economic development landscapes. With a rising focus on geopolitics, defense, resilience, and disruptive technologies, universities are increasingly expected to engage and act as catalysts for sustainable development. The research explores how academic institutions interact with policymakers by analyzing "knowledge for policy" relationships, emphasising structural, operational, and practice-oriented factors. Building on a peer-learning exercise hosted by the Governing Resilience and Transformation (GReaTr) initiative in Sweden, the study draws insights from a comparative analysis of five cases of academic institutions, representing diverse contexts and experiences. Findings reveal the challenges universities face in aligning with transformative innovation policies, particularly given the multidisciplinary expertise and agile operational capacities required. Despite evolving practices such as action research and co-created knowledge products, the complexities of addressing urgent and multifaceted policy issues persist. The study concludes by calling for more dynamic and interactive approaches to knowledge creation, stressing the need for universities to adapt their strategies to better engage with policymakers' evolving contexts and demands.

Keywords

Transformative universities, transformative innovation policy, knowledge transfer for policy, science policy interfaces

Classification code

O33 (Technological Change: Choices and Consequences; Diffusion Processes), O38 (Government Policy), O48 (Institutions and Growth)

Declaration of interests

None declared.

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1. Introduction

Today's economic development policy landscape is shaped by a heady combination of new circumstances that cannot be addressed with existing approaches and toolboxes. This in turn requires significant policy experimentation and evolution. On the one hand, our societies are facing pressing ecological, demographic and social challenges that demand transformations of our economic and social systems. On the other hand, there is an increasingly volatile geopolitical environment that is pushing places towards adopting more inward-looking strategies focused on economic resilience, security and strategic autonomy. This rapidly evolving scenario casts a new light on the role of knowledge in economic development processes and asks different questions of how universities engage within innovation systems.

Recent academic contributions have traced the evolution of universities' roles from "entrepreneurial" and "engaged", to "sustainable entrepreneurial" and "transformative" (Cai & Ahmad, 2023; Trippl et al., 2023; Canto-Farachala et al., 2022, 2024). Indeed, universities are increasingly seen not only as producers and curators of learning, knowledge and thinking, but also as proactive catalysts and co-creators of sustainable development and transformation in their territories (Trencher et al., 2014; Aranguren et al., 2016, 2021; Benner & Schwaag Serger, 2017; Weber & Newby, 2018; Benneworth & Fitjar, 2019; Cuesta-Claros et al., 2021; Schwaag Serger et al., 2021; Pugh et al., 2022). They are expected to play a significant role in regional and/or national innovation systems, building productive multi-stakeholder partnerships and engaging with firms and other actors to drive sustainable transformation processes and/or boost strategic autonomy and resilience.

Yet while there is a strong trajectory of research that explores how universities and their academics engage with firms and/or as entrepreneurial agents (Bozeman, 2000; Davey et al., 2024; Guerrero et al., 2024; Meerman & Davey, 2025; Miller et al, 2018), there is less understanding of the key roles that academic knowledge can play in innovation systems through interactions with policymakers. This gap is highlighted in the context of the evolution of discourse around science, technology and innovation (STI) policy over the last decade towards transformative, third generation, or mission-oriented policies (Mazzucato, 2018; Schot & Steinmueller, 2018; Weber & Rohracher, 2012). While arguments for the need for more transformative STI policies are conceptually compelling, pivoting

policy in these directions in practice is challenging. Nevertheless, the strong inertia among existing STI organisations and instruments is gradually giving ground to new approaches that seek to co-design policy initiatives and that recognise the need for experimentation, organisational innovation and multi-actor governance (Uyarra et al., 2017). In this context the role of "knowledge for policy" has gained strategic importance within national and regional innovation systems, with important implications for how universities engage with the policy community.

While the ambition and "call to action" for universities to engage more interactively with policy practitioners exists, and is reflected in the adoption of more interactive research frames (action research, knowledge journeys, responsible research and innovation, citizen science, etc.), there are still many questions surrounding the factors that condition the knowledge for policy relationship and the options to strengthen it. This paper contributes to this gap by exploring how university research on STI policy (and related policy areas) interacts with policy practice in the context of more complex transformative challenges. We address two related research questions. Firstly, as policy becomes more transformative, how are the modes of operation changing in the relationship between knowledge and policy? Secondly, what implications do these changes have for university policies and strategies for knowledge transfer and engagement?

The paper is structured as follows. In the next section we build from theory ('left to right') by tracing the parallel evolution of STI policy, on the one hand, and universities' roles in innovation systems, on the other hand. We then set out our methodology, which is based on understanding emerging practice at the coalface of the knowledge for policy relationship ('right to left'). After analysing a set of five cases in a range of different institutional settings we discuss the key findings with respect to each of the research questions. The final section concludes with reflections on limitations, implications and ideas for further research.

2. The parallel evolutions of innovation policy and universities' role in innovation systems

The main contribution of this paper is to analyse the contemporary knowledge for policy relationship on the ground: moving from practice to theory, or from 'right to left'. Yet to contextualise what is happening on the ground we also need to move from 'left to right, building from an understanding of the existing context in two key domains: (i) science, technology and innovation (STI) policy; and (ii) the roles that universities play within innovation systems.

Evolution in STI policy

Starting around 2015, we can discern three significant shifts in science, technology and innovation policy. Firstly, in the wake of the adoption by the UN of Agenda 2030 and the Sustainable Development Goals in 2015, innovation policy pivoted from its traditional focus on the general promotion of commercialisation of research, economic competitiveness and growth to seeking to promote, and even drive, directional and normative transitions and development. Thus, innovation policy pivoted from a stance that 'all innovation is good for growth and competitiveness' to attempting to direct innovation efforts towards normative, and not purely economic, objectives. In particular, innovation policy

broadened its focus to include environmental and social sustainability priorities, in line with Agenda 2030. This shift could be discerned both in theory (see e.g., Schot & Steinmueller, 2018; Haddad et al., 2022) and in practice (Schwaag Serger & Palmberg, 2022; Avdeitchikova & Schwaag Serger, 2024). Mission-oriented innovation policy (MOIP) emerged as one manifestation of increasing attempts to target societal and environmental challenges through STI policy (see, e.g.: Mazzucato, 2017; European Commission, 2017; OECD, 2021; Larrue, 2022). The shift, firstly, from non-directional to directional innovation policy, and, secondly, from pursuing primarily economic objectives to targeting societal and environmental challenges has profound implications for the knowledge base for, and the design and the implementation of policymaking, which we return to below.

The second significant shift is that innovation policy went from working with complicated problems to struggling with complex problems. This shift is partially a consequence of the pivot towards more directional and normative policy described above. Complex problems (sometimes also called 'wicked problems') distinguish themselves by a number of features. They tend to be difficult to identify or pinpoint precisely, they are often contested, they generally require a systems approach, and they are rarely fully solved (Rittel & Webber, 1973). They also tend to be characterised by significant uncertainty and interconnectedness, and, furthermore, addressing them often requires stakeholder engagement (Head, 2022). To put this in the context of innovation policy, promoting innovation for growth can be characterised as a complicated problem in that it requires various instruments – e.g. funding, regulation, collaboration promotion – and targets several actors – e.g. universities, firms, intermediaries, customers, the state. Yet it has been rather uncontested. Trying to tackle challenges such as inclusion, cohesion, climate change and biodiversity are undoubtedly complex issues, according to the characteristics identified above. It is important to point out that increasing complexity is not limited to innovation policy. A report by the Group of Scientific Advisors to the European Commission published in 2019 addressed the growing complexity that governments and policymakers are confronted with (SAPEA 2019). In addition to the characteristics of complexity identified above, we would also add a further feature: urgency. The COVID pandemic illustrated both the complexity and the urgency that policymakers were confronted with (see also Sahlin & Schwaag Serger, 2022). As innovation policy seeks, or is expected to tackle societal challenges, the combination of complexity and urgency highlights the need for different instruments, modalities and approaches, many of which are outside the scope, reach, remit or toolbox of policymakers in the innovation policy domain.

The two shifts in STI policy identified and described above lead inevitably to the third shift, namely the need for a different type of knowledge upon which to base policies that are more directional, normative and complex. We argue that this different need of knowledge for policy in turn requires different forms of knowledge generation, curation and knowledge-policy interaction.

The normative turn in research and innovation policy, manifested by embracing challenge-oriented societal goals and a holistic sustainability agenda as an overall direction, has important implications for the type of knowledge that can support policy design and implementation, including how it is created and used. More specifically, the complexity, urgency, uncertainty and also the contestation of challenges, call for opening policy processes up to new sources and types of evidence. This includes more reflexive approaches to policy learning that embrace a greater variety of perspectives on the challenges faced and on pathways to address them.

When promoting normative change (a ‘better society’, ‘just transition’, ‘people, planet and prosperity’), innovation policy becomes contested and politicised, the problems become wicked and there are conflicting goals – i.e. often it is difficult to even agree on what the problem is, let alone what the solutions might be. The difficulties for policymakers in tackling complex, wicked or intractable problems are not new. Several authors have discussed issues such as policy contestation, the need for multiple and different sources of knowledge, and for interactive policy processes (e.g. Nelson, 1974; Lindblom, 1959 and 1979; Wildavsky, 1973; Rittel & Webber, 1973; Head, 2022). As STI policy enters the realm of such problems, it becomes clear that the traditional STI policy toolbox is not equipped to address, not to mention drive, transformation, and nor does it have the reach (constituency), mandate or authority (governance) to do so. Different instruments, competencies and governance structures are needed. The question then becomes whether the current providers and sources of knowledge (universities, research institutes, think tanks) and the ways of accessing, disseminating and utilizing them (academic research and papers, publications, consultation, evaluation) are appropriate for a new, normative and transformative, innovation policy.

Evolution in universities’ role in innovation systems

The national and regional innovation system concepts emerged during the 1990s and have become an influential place-based frame for analysing innovation and innovation policy (Cooke et al., 1998; Lundvall, 1992; Freeman, 1995; Nelson, 1993). Nelson built his conception of a national innovation system from the evolutionary theory of technical change (Nelson and Winter, 1982), whereby diversity is introduced into organisations within a system by technical change and selection mechanisms support the emergence of new technologies and organisational forms. Lundvall, on the other hand, conceived innovation as a learning process and stressed the relevance of user–producer interactions and institutions, leading to a broader definition of a national innovation system that includes all the economic and institutional actors that affect learning within the production system (Mytelka & Smith, 2002). Cooke et al (1998) and others adapted the scale of analysis, conceiving the regional innovation system concept that has become a mainstay of regional innovation policy.

Universities are integral components of both national and regional innovation systems, but their role within these systems has evolved. The regional innovation system literature makes a distinction between “knowledge generation” and “exploitation” subsystems (Cooke, 2004, p. 3). Universities and other knowledge organisations are often seen as belonging primarily to the knowledge generation subsystem, from where they interact with the exploitation subsystem through technology transfer activities (for example, the establishment of technology transfer offices) (Bozeman, 2000; de Falani Bezerra and Torkomian, 2024). However, the emergence, consolidation and evolution of the concept of the entrepreneurial university blurs this distinction and offers a much richer vision of how universities engage within innovation systems (Bercovitz & Feldman, 2006; Cerver Romero et al., 2021; Clark, 1998; Guerrero & Urbano, 2012; Feldman, 2001).

The role of universities continues to evolve as innovation system thinking takes a more transformative direction, moving beyond a purely economic understanding of innovation in ways that respond to complex societal challenges (Schot & Steinmueller, 2018; Lundvall, 2024). In this context universities’ mission of external engagement and collaboration continues to expand and increase in complexity in ways that can be seen as a shift from purely entrepreneurial universities (collaboration and engagement

with industry to foster innovation, commercialisation and entrepreneurship that have economic impact) to "transformative universities" (collaboration and engagement with industry and a range of other actors to address societal challenges and contribute to a broader range of impacts). Cai & Ahmad (2023), for example, propose an evolution of the entrepreneurial university to a "sustainable entrepreneurial university", while others explore the changing roles of universities in place-based innovation systems in the context of sustainability transitions (Trippl et al., 2023) or smart specialisation strategies (Canto-Farachala et al., 2022).

This implies universities becoming engaged in sophisticated forms of multi-actor engagement conceived in terms of applied knowledge co-creation processes. New labels reflecting such an approach include "transformative academic institutions" (Canto-Farachala et al., 2024) and "fourth generation universities" (Lukovics and Zuti, 2017). The fourth-generation universities model, for example, champions an integrated approach to education, research and valorisation, with a strong focus on addressing societal challenges in the geographical context in which universities are situated (Lukovics and Zuti, 2017; Dumoulin and Malkov, 2024). It also has similarities with the civic university model (Goddard et al, 2016), which emphasises the place-based engagement of universities as key actors with responsibility for the development of their local and regional communities.

In such place-based and transformative paradigms, universities and their academics take on proactive roles of knowledge brokers (Bergenholtz, 2011; MacKillop et al., 2023) and boundary spanners (Williams, 2012) within their innovation systems. These roles extend beyond a concern with economic entrepreneurship, opening engagement with a wide range of regional stakeholders in an extended notion of "transformative innovation system". Within this there is a specific role for policy engagement, or for developing and applying "knowledge for policy".

With regards to business engagement, Miller et al. (2018) distinguish between "entrepreneurial academics" with a "softer, more informal, relational, partnering-style engagement" and "academic entrepreneurs" with a "harder, more formal, transactional, contracting-style engagement". Yet there is a gap in understanding around whether such typologies are relevant also with regards to the boundary spanning and knowledge brokering roles required for effective policy engagement.

In particular – and given the different nature of the relationship between universities and public administrations (as opposed to companies), or between academics and policymakers (as opposed to businesspeople), and the different disciplinary mixes required for policy engagement (primarily social sciences) – we need to understand more about the institutional settings that facilitate effective knowledge for policy relationships. Moreover, as highlighted in the previous subsection, these relationships must be forged in the context of an STI policy landscape that is itself rapidly changing in response to the demands of complex societal challenges such as ecological transition and demographic change. To foster the deep transformation required, these challenges require working across different policy domains, which in turn places new and constantly evolving demands on knowledge for policy.

3. Methodology

To better understand the evolving demands and the changing modes of operation in the knowledge for (transformative innovation) policy relationship, this research followed a qualitative approach based on

a comparative analysis of five case studies developed over the course of 2024. The research was conducted in three phases, described below.

Selection of cases and exploratory questions

The research was initiated as a peer learning exercise within the context of a two-year experimental initiative (GReaTr) in Sweden.[1] The organisations and initiatives that participated[2] were selected to represent a range of perspectives and experiences from regional, national and supra-national levels, as well as a range of institutional settings. The five exploratory cases included in this research were selected based on the following criteria:

- They self-identified as knowledge actors that were taking on the role of "transformative academic institutions" (Canto-Farachala et al., 2024) and that were active in the TIP (transformative innovation policy) knowledge-for-policy boundary spanning space.
- They were based in different geographies and policy contexts that were beginning to implement transformative innovation policies (Mazzucato, 2018; Schot & Steinmueller, 2018; Weber & Rohracher, 2012) directed at addressing complex societal challenges.

Initial data was presented from each academic institution, responding to five common questions:

1. What changes in the policy context have you observed in recent years? (new policy aims and/or programmes, governance/organisational structures, budget changes, etc.?)
2. How/how often do you/your research group interact with policy practitioners? (informal vs. formal, types of practices/processes)
3. What types of knowledge products result from the interaction?
4. (How) do you determine value/relevance/ impact?
5. What are the biggest challenges in your context with regard to work with/on knowledge-for-policy?

Initial identification of key similarities and differences were discussed at the workshop, and it was agreed to pursue a written cross-case analysis.

Elaboration of case studies

Initial case descriptions were elaborated over the course of three months. A common template and example case description was provided by researchers leading the GReaTr initiative. Then, each peer representative took responsibility for providing a written draft of their case study (covering background information on the institution as well as detailed elaboration to the five questions above). Case descriptions were based on a combination of primary (synthesis of interviews and experiences over

[1] GReaTr was a two-year experimental project (Oct '22 – May '24) that gathered policymakers, academics and policy experts from several countries, the EU Commission and the OECD to co-create and co-curate knowledge that could be of use and relevance in 'governing resilience and transformation (GReaTr)'. The initiative was funded by Vinnova, the Swedish Government Agency for Innovation with significant in-kind contributions from senior researchers and experienced practitioners (policymakers and other policy experts).

[2] Austrian Institute of Technology (AIT), Fraunhofer Institute for Innovation Systems Research (ISI), Governing Resilience and Transformation (GReaTr) initiative, Mission-Oriented Innovation Policy Observatory (MIPO) at Utrecht University and Orkestra – the Basque Institute of Competitiveness, as well as the Joint Research Center of the European Commission in Seville, and the OECD Directorate for Science, Technology and Innovation.

recent years provided by participating researchers) and secondary data (e.g. from institutions' websites and strategy documents).

Comparative analysis

Over the course of seven months, these initial case descriptions were further developed as written (5-6 page) briefs, from which a comparative analysis was conducted and refined. Building on the cases and previous work within the innovation policy practitioner and research communities (Eu-SPRI SAB, 2024), we used an interpretive and inductive approach (Alvesson & Sköldberg, 2000) to identify from the cases the core structural, operational and practice-oriented characteristics that underscore effective knowledge for policy processes and that could be applied in different settings:

- Structural characteristics include institutional setting, funding and mandate, territorial and cultural setting, types of policy stakeholders engaged with;
- Operational characteristics include staffing, skills and infrastructure;
- Practice-oriented characteristics include different modes of interaction and forms of knowledge creation with stakeholders.

These three characteristics were used as the framework for comparative analysis. Case descriptions were manually coded according to these characteristics and restructured to enable a more transparent comparative analysis of the five cases (shortened case summaries are included in Annex I.) An overview of highlights from the case descriptions and key findings from the comparative analysis are provided in the next sections.

4. Summary of cases

The five cases represent different sizes and types of transformative academic institutions, located within different regional and national innovation ecosystems and policy contexts in Austria, Germany, Sweden, Netherlands and Spain (see overview in Table 1). A short synopsis of key policy trends and relating structural, operational and practice-oriented characteristics is presented for each case below. An overview follows in Table 1. More detailed case descriptions can be found in Annex I.

Austrian Institute of Technology (AIT)

The Austrian Institute of Technology (AIT) is the country's largest research and technology organisation (RTO) with around 1500 employees working in seven research centers (six technology-centric centers[3] and the transdisciplinary Center for Innovation Systems and Policy) and various large research infrastructures and labs. AIT is co-owned by the government and industry, with the mission of enabling the realisation of innovative, infrastructure-related solutions by providing technologies, methods and tools (in Austria and elsewhere in Europe).

Since 2019 (and the formation of the Federal Ministry for Climate Action, Energy, Environment, Mobility, Innovation and Technology – BMK), the context for innovation policy has shifted from a focus on classical industrial and infrastructure technologies to mobilising the potential of emerging

[3] Energy, Low Emission Transport, Health & Bioresources, Digital Safety & Security, Vision, Automation & Control and Technology Experience

technologies (e.g. materials, digitalisation, AI) in conjunction with social and organisational innovations to address societal challenges such as decarbonisation or positive socio-economic development. Increased attention is also paid to matters of security, resilience and geopolitics. As a result, AIT owners are expecting different roles for their RTOs than in the past – providing more agile policy support and acting more like a change agent.

AIT is evolving into new roles as a systemic intermediary for digitalisation and decarbonisation of the economy and society (in line with the mandate of its governmental and private owners), while continuing to be an important source of technological knowledge and a gateway to European research to enhance the technological and economic competitiveness of Austrian industry. This involves new modes of interaction (including e.g. co-learning and co-development processes and formative monitoring and evaluation) and new types of knowledge products.

Fraunhofer Institute for Innovation System Research (ISI)

Since its inception in 1972, Fraunhofer ISI has been influential in shaping the German and international innovation landscape – providing research and strategic advice (to business, politics and societal stakeholders) regarding innovation and transformation toward a sustainable future. Part of the multi-institute Fraunhofer-Gesellschaft, Europe's largest applied research organisation, Fraunhofer ISI has more than 300 employees from 25 different countries and multiple disciplines, working within seven scientific competence centers[4]. Annual funding (36,9 MEUR in 2023) is mainly (80%) from competitive research calls and contract research (for national and international bodies, industry, and foundations), with the remainder provided by the federal and state governments.

In recent years, Germany (like many other countries) has seen an evolution in federal-level policymaking. Increasing global competition, societal shifts, and pressing challenges like climate change and digital transformation have led to a more dynamic and contentious policy landscape. The government's attempt (in 2019) to bring traditional industrial and competitiveness rationales together with a desire to address environmental challenges via the Climate Action Programme 2030 has been met with some skeptical views on the increased role of the state in (directing) R&I policies. Overall, R&I policies are becoming more politicised.

Fraunhofer ISI also experiences changing dynamics in practice, with more intense and interactive knowledge development processes – as studies often have to be positioned in complex political settings or in relation to specific discourse arenas, or in narrow windows of opportunity. Additionally, forms of interaction have gradually evolved in recent years to include action research, social innovation labs and co-design processes.

Governing Resilience and Transformation (GReaTr) initiative

GReaTr was formed as a temporary experimental project (a "pop up initiative") with the aim of serving as a forum for interactive knowledge generation and curation to inform and support policy development. The initiative (hosted at Lund University, Department of Economic History) mobilised resources in the form of time from senior researchers and experienced practitioners (consultants and policymakers), together with co-financing from Vinnova, the Swedish innovation agency, as a core

[4] Energy Policy & Energy Markets, Energy Technology & Energy Systems, Foresight, Innovation & Knowledge Economy, Sustainability & Infrastructure Systems, Emerging Technologies, and Policy & Society

base. The small (3-person) core engaged other researchers, experts and policymakers from Austria, Finland, the UK and elsewhere in Sweden (in total 30) in agile "learning spaces" on two thematics: the medium-term effects of recovery and stimulus measures on innovation, transformation and resilience; and the evaluation and design of transformative innovation policy.

In Sweden, the rise of TIP is apparent with the launching of several new innovation programmes (including Impact Innovation and other mission-oriented innovation programmes e.g. Food system, Viable Cities, etc.) or instruments for system transition (like system demonstrators for climate neutral cities). These new policy instruments give rise to new knowledge and capacity demands. In parallel, the changing geopolitical context (including Sweden's membership in NATO) and focus on green "new industrialisation" has led to relatively greater focus on other policy objectives (e.g. security, defense, tech/AI, energy, resilience) and how innovation policy can contribute to achieving these.

GReaTr attempted to address policymakers' changing demands for knowledge and capacity by testing new, more agile, forms of interaction with policymakers and expert practitioners (including facilitated learning processes and co-production of various knowledge products). The experimental initiative contributed to initiating a new (transdisciplinary and cross-sectoral) platform for system innovation research in interaction (SIRI).

Mission-Oriented Innovation Policy Observatory (MIPO)

MIPO was established in early 2020 at Utrecht University (UU), the Netherlands, by scholars from the Innovation Studies and Environmental Governance groups as a reaction to the rise of new challenge-led innovation policies (and renewed interest for societal missions). The core of the team is formed by 4 UU assistant professors, with 8 associated researchers and PhD students (as well as a broader informal network of affiliates) – all focused on the topic of mission-oriented innovation policy, using real-time empirics. MIPO does not have institutional funding. Rather, funding comes from commissioned research and a pre-seed research fund, as well as traditional research projects.

The Netherlands belongs to the selected group of countries pioneering the MOIP approach in an experimental way and at a large scale. The Dutch began working with MOIP in 2018 when the Ministry of Economic Affairs and Climate Policy (EZK) attempted to turn its industry policy into challenge-led innovation policy (Mission-oriented Topsector and Innovation Policy – MTIP). The EZK is currently debating the question of future directions for MOIP. In parallel, security issues feature more prominently in national policy strategies (highlighting the possibility that this may overshadow the debate on how to gear innovation policies towards (other) societal challenges), while regional authorities display a growing interest in MOIP applied in local settings.

MIPO researchers have maintained close relationships with policy makers since the beginning – having frequent (ad-hoc) exchanges that support policy design, implementation and evaluation strategies. Much of the knowledge co-creation takes place via direct forms of interaction with policymakers (in advisory committees, commissioned or action-based research projects). This is complemented by "innovation and transition policy" courses for policymakers and external PhDs (affiliated to policy organisations). In addition to traditional written (articles, policy briefs) and practice-oriented products, MIPO serves as a platform for ongoing interaction and sensemaking/co-creation of knowledge.

Orkestra – Basque Institute of Competitiveness

Orkestra was established in 2006 within Deusto Foundation (the foundation for knowledge transfer of the University of Deusto) with an explicit mission to foster the competitiveness of the Basque Country through action-oriented research that improves the well-being of its citizens. Orkestra's funding is independent of the university, coming from a mix of direct funding from regional stakeholders and competitive research funding. Orkestra has around 40 full-time researchers and research-related staff working within four transformative research labs.[5] Each lab acts as a fluid space for the co-creation of knowledge and action among researchers and the regional stakeholders with whom they work.

The Basque innovation policy context has experienced a sharpening of the environmental sustainability agenda in all areas of policy, with clear implications for the economic and social dimensions of regional development. In addition, there has been a sharp increase in concern with attracting and rooting talented people within the region and addressing skills gaps – an issue that has implications for policies in multiple areas. A consequence of these shifts has been important changes in how policy is designed, implemented and evaluated. There is increased interaction between policy domains, greater recognition of the need for multi-level policy coordination, and a widening of the realm of 'policymakers' to extend across the quadruple helix.

Orkestra actively develops its research agenda focused on the methods of action research alongside the thematic agendas within the four labs. Across its labs, action-oriented research projects are developed and implemented in collaboration with one or more regional stakeholders. Knowledge products include frameworks, observatories or platforms, practitioner-oriented reports, action research processes and events, in addition to traditional academic publications.

[5] in the areas of (i) public policy; (ii) smart business; (iii) wellbeing; and (iv) energy and environment

Table 1: Overview of peer institutions

	Policy context (trends in economic development and innovation policy)	**Structural characteristics** (mandate/institutional setting, funding, types of policy stakeholders with whom engage)	**Operational characteristics** (staffing, research focus areas/skills, infrastructure)	**Practice-oriented characteristics** (modes of interaction, forms of knowledge creation)
Austrian Institute of Technology (AIT)	Shift toward potential of emerging technologies together with social/organisational innovations to address societal challenges Increasing attention to security, resilience and geopolitics Demand for more agile support and different (systemic intermediary) roles	Largest RTO/Institute for research and technological development, est. 2007 Mandate of providing technologies, methods and tools Co-owned by the government (Fedl Min for Climate Protection, Environment, Energy, Mobility, Innovation and Technology) and industry (Federation of Austrian Industries)	About 1500 employees 6 technology-centric research centers, and overall competence (transdisciplinary center) in the area of innovation systems and policy Various labs and large research infrastructure for applied R&D	Evolution from traditional interaction (providing scientific evidence/data and advice) to new modes (supporting transformative governance and mutual learning processes with transdisciplinary research, co-development of knowledge, and formative monitoring and evaluation) Scientific articles, etc. as well as new products/formats (e.g. learning materials, frameworks/guides, networks and co-creation processes)
Fraunhofer Institute for Innovation System Research (ISI)	Government attempts to combine traditional focus on industrial competitiveness with addressing societal challenges (e.g. Green Agenda) Increased role of the state in directing R&I policies met with skepticism…becoming more politicized	Institute for innovation research, est. 1972, within the framework of the Fraunhofer Gesellschaft Research institute with important advisory function in the German STI landscape on research and e.g. innovation policy, sustainability, internationalisation Annual budget of 36,9 MEUR (2023) of which 80% contracted research	More than 300 employees from 25 different countries 7 scientific competence centers and multiple cross-cutting research topics Around 400 research projects annually	Main interaction mode via contract research and advisory support (usually uni-directional forms), yet increasingly bi-directional forms of interaction within complex political settings, etc. (leveraging action research, social innovation labs and co-design processes) Knowledge products include traditional articles/reports/policy briefs as well as toolboxes, co-design processes for organisational innovation and demonstrators of (new) science-policy interaction formats

Governing Resilience and Transformation (GReaTr) initiative	The Swedish innovation agency's launch of mission-oriented policy initiatives (addressing societal challenges); created a demand for new knowledge and capacity (e.g. system mapping and analysis, new approaches to monitoring, evaluation and learning, etc.); Greater focus on aligning R&I investments across levels of governance Increasing focus on security, defense, tech/AI, energy, resilience	Experimental initiative (10/21-3/24); organised within dept. of Economic History, LU Aim of providing more agile and timely knowledge inputs to inform policy developments Co-financed from Vinnova (national innovation agency) and in-kind financing from LU senior researchers and external policy practitioners and experts	Core team of 3 researchers; mobilised engagement of other researchers, students and practitioners in Sweden and internationally (total 30 engaged researchers and policymakers) Focused on two thematics (Transformative impact of EU recovery and resilience packages, TIP evaluation)	Tested new, more agile, forms of interaction (facilitated learning processes, short-term affiliations to a theme, co-production of knowledge) between researchers, policymakers and practitioners Knowledge products included written briefs and articles, but also syntheses/overviews from learning processes and international benchmarking exercises Key outcome was initiation of a cross-disciplinary and cross-sectoral platform for interactive knowledge exchange and co-development spaces (evolved into SIRI)
Mission-Oriented Innovation Policy Observatory (MIPO) at Utrecht University	Transformation of traditional "Top Sector" policy (for economic growth) to mission-oriented top sector and innovation policy (in 2018); accompanying collaboration across ministries (whole of government approach) and govt involvement in development of knowledge and innovation agendas Growing focus on national security (and risk of overshadowing other societal challenges) Rising interest for regional missions (and application of MOIP in local settings)	Interdisciplinary platform initiated by the Copernicus Institute of Sustainable Development, Utrecht University (est. 2020) Main collaboration with Ministry of Economic Affairs and Climate Policy (EZK) with aim of collaboratively exploring challenge-led innovation policies Funding from commissioned research and a pre-seed research fund, as well as traditional research projects; no institutional funding	Core team of 4 with 8 associated researchers and PhD students; broader informal network Focus on mission-oriented innovation policy – in particular the circumstances driving the transformative nature of societal missions, using real-time empirics (including other countries' experimentation with MOIP)	Frequent (informal) interactions – providing ad hoc expert advisory support to program development, implementation, and monitoring, learning and evaluating In addition, design of courses for policymakers, external PhDs and action-based research Traditional written products, as well as handbooks, training materials and practice-oriented knowledge products (co-developed with other universities and consultancy) Main knowledge product in the form of platform for ongoing

				interaction and sensemaking/co-creation of knowledge
Orkestra – the Basque Institute of Competitiveness	Growing emphasis on environmental sustainability (with implications for economic and social dimensions of regional development) Focus on attracting and retaining talent and tackling skills shortages (to maintain competitiveness) Greater interaction/convergence between policy domains and multi-level coordination in policy design and implementation, as well as a widening realm of 'policymakers' (all sectors of the quadruple helix) New demands for/research emphasis on governance analysis and new governance mechanisms	An independent institute (est. 2006) as an initiative of the University of Deusto, through the Deusto Foundation Explicit mission to foster the competitiveness of the Basque Country through action-oriented research that improves the well-being of its citizens Funding independent of the university, coming from a mix of direct funding from regional stakeholders (government institutions at different levels and firms) and competitive research funding Annual budget around 3 MEUR	43 people (of which 60% PhDs and PhD students) Transformative research focused on competitiveness and regional development, with regularly updated research agendas driven by changes in (and interactions with) the Basque (and international) policy context Research organised in four transformative research labs, acting as fluid spaces for co-creation of knowledge and action	Response to (policy) challenges addressed by action-oriented research projects with different levels and types of engagement with regional actors (leveraging own "action research for territorial development – ARTD" framework) 30-40 projects/year across the four research labs (each project associated with one or more regional or other external actors) Knowledge products include frameworks, observatories or platforms, reports, action research processes, events and academic publications

5. Key Findings

The five cases presented above highlight a variety of insights and opportunities, as well as tensions and challenges in the relationship between knowledge and policy in a significantly changed economic development and innovation policy context. The five cases reflect similar policy trends in each territorial setting, including an increasing focus on security, resilience and strategic autonomy while also attempting to advance efforts to address environmental and social agendas – all under tightening budgets and rising political scrutiny on government's role in directing research and innovation investments. Nevertheless, the need to undertake ambitious changes in a variety of policy domains is undisputed. And interest is gathering among local ecosystems (in cities and regions) to formulate and mobilise action on place-based transformative agendas. The increasingly complex set of challenges that policymakers are facing have led to new demands on knowledge – both the types of knowledge sought (spanning a broad range of disciplines and application settings) and the dynamic modes in which it is developed and put into practice (leveraging new sources of knowledge, real-time empirics and agile/reflexive approaches to policy learning).

Knowledge institutions have reacted in different ways to these demands. Comparative analysis of the five cases provides insights on the changing modes of operation and raises a variety of implications for policymakers, researchers and university strategies for knowledge transfer and engagement.

Changing roles and modes of operation

The diversity of contexts, institutional settings and experiences included in this research provide an opportunity to examine the practical pursuit of working with knowledge for policy in these transformative times. The cases were categorised and compared with respect to their structural characteristics, operational characteristics and practice-oriented characteristics. Findings and insights from the comparative review are presented for each set of characteristics below.

Structural characteristics

'Structural characteristics' are not easy to change, and they condition academic institutions' possibilities for doing 'knowledge for policy'. They include: (i) the institutional setting/mandate and funding, (ii) the territorial and cultural setting, and (iii) the types of policy stakeholders engaged with (policy levels and domains).

Among the cases, two were large, long-standing national institutions, one was an independent regional institute, and two were more informally organised networks of researchers (from multiple academic institutions). The different institutional contexts were reflected in different approaches to funding and governing. For example, independent institutes define their research agendas to align with the needs of their key stakeholders, are more actively engaged in expert advisory functions, and share the challenge of continually adapting to changes in national/regional stakeholders (and their needs). University-based groups, on the other hand, have a more stable organisational framework but tend to be more distanced from the dynamics and practical questions of policymaking. In all cases, the engagement with policy stakeholders was conditioned by history and the trust relationships (between individuals and institutions) that were built over time.

The comparative analysis highlighted the benefit of stable funding for: sustained efforts to build trust and understanding of the context and its particular challenges; engagement on an ongoing/continuous basis (and the ability to more easily be part of real time empirics); and the possibility to take on new roles as e.g. systemic intermediaries, process conveners/facilitators, and action-oriented researchers. Whereas independent research institutions' organisational and financial structures are based on more active engagement with stakeholders and alignment with their needs, university-based institutions may experience challenges with their "organisational distance". This can be alleviated with alternative operational practices (see next characteristic).

Operational characteristics

Innovation and economic development research are a social science. Thus 'operational characteristics' refer primarily to the staff and range of skills that organisations have to engage in knowledge for policy. This also encompasses enabling infrastructure (e.g. databases and advanced data analysis tools) and operational practices (e.g. mobility programmes, research affiliations, etc.) that enable engagement of practitioners and other experts in knowledge creation.

All cases have core expertise in innovation research (spanning technical, economic, social, policy, historical and geographic perspectives), yet noted an increasing need for literacy in a mix and broader range of knowledge fields (now spanning e.g. systems design, behavioural sciences and big data analysis). The five institutions also highlighted an increasing demand for translational and action-oriented research and process leadership capacities to enable (and actively facilitate) the co-development of knowledge.

The case examples highlighted several emerging instruments and changing modes of operation including hiring (or training) individuals with new skill sets and methodologies (including action research and foresight methods, big data analysis and visualisation/communication of data). Another changing mode is the adoption of new, more agile, operational practices to enable interaction, such as formation of "transformation labs" or similar and dynamic affiliation (of researchers and others) to "thematic spaces" or processes for co-design, exploration and co-development of knowledge.

Practice-oriented characteristics

'Practice-oriented characteristics' are the day-to-day practices and mechanisms that characterise how academic institutions do knowledge for policy, including different modes of interaction with stakeholders, as well as different types of knowledge products and methods of communication.

Despite the significant differences in institutional contexts and capacities, all cases highlighted an evolution of practice. In addition to more traditional forms of engagement, newer modalities of interaction that leverage real-life empirics, such as action/accompanying research and co-designed/co-created research, are becoming more prevalent. In a similar way, we see an evolution in the types of knowledge products that are being generated. While organisations continue to produce academic articles and analytical reports, there is increasing demand for more accessible and practice-oriented written products, as well as frameworks, observatories and data-driven platforms that enable benchmarking, analysis and trend tracking over time. There is also a rising demand for other types of knowledge products that foster a common doing (e.g. guides and training material), with a more hands-on approach to implementation.

Accompanying this (shared) evolution in practice, the comparative analysis highlighted a shared perception of related challenges including sharing responsibility for (actions based on) co-developed results and successfully managing the combination of leading interaction processes and producing (a wider range of) written products.

Implications for university strategies for knowledge transfer and engagement

As (transformative) academic institutions undertake changes to their structures, roles and modes of operation to meet the evolving demands of (transformative innovation) policy, there are implications not only for the 'interacting' policymakers and researchers, but also for university strategies for knowledge transfer and engagement.

For **policymakers**, the changing modes of operation desired from academic institutions necessitate changes in their operations as well. Two primary changes are engaging at different levels (i.e. not just reactively receiving knowledge but also being a participant in knowledge co-creation) and enabling "agile/dynamic knowledge spaces" through e.g. institutional support and adjusted aims and criteria in research funding calls.[6]

For **researchers**/research groups in transformative academic institutions (TAIs), there is a need for working continuously to deepen and broaden interactions with policymakers and build stronger awareness and understanding of their knowledge needs (working more "right to left" vs. "left to right"), as well as developing capacity and applying more action-oriented approaches to research.

Whereas independent research groups have a more natural 'route' to aligning their practices to the needs of policymakers, university-based TAIs are reliant on strategic backing from **university leadership** and legitimacy (through codified **policies and strategies**) to undertake new roles and long-lasting changes to their modes of operation. Traditional modes of knowledge transfer have focused on a one-way flow of information from knowledge actors to recipients and a passive (assumed) assimilation of that knowledge (often codified in articles or technical reports). Many existing university-based technology transfer and innovation offices are based on "standard support structures" to students and researchers to achieve "standard targets" in terms of publications, patents, innovation, start-ups and investments.

In current "transformative times" and complex situations, knowledge transfer is a much more dynamic, multi-directional process enabled by regular interactions, active learning and collaboration that leads to deeper understanding, critical thinking and the (co-)creation of new knowledge and action that is tailored to the challenges of the particular context. This requires new enabling structures (such as neutral spaces for exploration and experimentation and working with people who are not in the academic promotion systems), new policies (such as adapted merit structures – recognising different types of knowledge products and impact), and new strategic aims for universities' engagement with policymakers and other actors in their surrounding ecosystems.

[6] A recent example of such a change is Vinnova's 2024 call for Research in interaction for transition to sustainable societies and institutional support to SIRI (Swedish platform for System Innovation Research in Interaction).

6. Conclusion

The roles universities are expected to play in innovation systems are changing significantly and rapidly in an era of transformative STI policy. This paper explores the important, but little analysed, contribution of social science research to policymaking in this context, where differences in structural, operational and practice-oriented characteristics of research institutions influence how they respond to the changing demands of policymakers.

In general, the nature of transformative innovation policy (TIP) – aimed at addressing urgent and complex problems spanning multiple, interacting and contested policy areas that are evolving quickly over time – changes the content and modalities of knowledge for policy. Knowledge actors are expected to: have a broad overview and expertise in multiple fields; the legitimacy, mandate and capacity to provide real-time evidence and expert inputs (related to ongoing empirics) quickly and sustained over time; and the agility to both understand, translate/communicate and facilitate interactive processes of policy design, implementation or evaluation. Moreover, these new expectations are "added on" to existing expectations to teach, supervise, write and publish.

Given the above challenges to university-based efforts in providing knowledge for (TIP) policy, universities may want to re-consider existing strategies for engagement and knowledge creation. Specifically, there is a need to develop more demand-awareness within academic institutions that seek to work with policymakers, requiring a deeper and more intimate understanding of policymakers' context and needs as and when they evolve. This requires structures, skills and practices that are more interactive and action-oriented and which place greater emphasis on the process of research, alongside existing focus on the results of research. Moreover, there is also a need to broaden understanding and acceptance of the results of research themselves, to include different types of knowledge products that extend beyond (and are complementary to) scientific articles.

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Annex 1: Knowledge for Policy – cases of evolving practice

In January 2024, a peer learning workshop on the theme "Knowledge for policy in a transformative age – initiatives, insights and ideas for the future" gathered experts working with transformation-oriented policy analysis and advice (i.e. working to deliver more agile and timely knowledge inputs to support policy development) to compare and share experiences and insights with this more interactive and demand-driven approach to knowledge and policy development. The organisations and initiatives that participated in the peer learning workshop were selected to represent a range of perspectives and experiences from regional, national and supra-national levels, as well as a range of institutional settings.

Peers from independent research institutions (larger and smaller) and groups based at universities (Austrian Institute of Technology (AIT), the Fraunhofer Institute for Innovation System Research (ISI), the Governing Resilience and Transformation (GReaTr) initiative at Lund University, the Mission-Oriented Innovation Policy Observatory (MIPO) at Utrecht University, and the Orkestra Basque Institute of Competitiveness) served as cases to advance our thinking about the conditions and practical pursuit of working with knowledge for policy in these transformative times. Short versions of the five cases are presented below – highlighting the changing policy context, as well as structural characteristics (including institutional and territorial setting), instrumental characteristics (including skills and infrastructure/tools), and characteristics of practice (including different modes of interaction and knowledge products) for each.

Austrian Institute of Technology (AIT)

Recent changes in the Austrian policy context

Related to an evolution in the industrial and innovation policy context, in particular since the elections in 2019, which led to the formation of the Federal Ministry for Climate Action, Energy, Environment, Mobility, Innovation and Technology (BMK), the focus shifted from classical industrial and infrastructure technologies to mobilizing the potential of emerging technologies – e.g. materials, digitalisation, AI – in conjunction with social and organisational innovations to address societal challenges such as decarbonisation or positive socio-economic development. More recently increased attention is paid to matters of security, resilience and geopolitics. As a result, owners are expecting different roles for their RTOs than in the past – providing more agile policy support and acting more like a change agent. AIT is evolving into new roles as a systemic intermediary for digitalisation and decarbonisation of the economy and society (in line with the mandate of its governmental and private owners), while continuing to be an important source of technological knowledge and a gateway to European research to enhance the technological and economic competitiveness of Austrian industry.

Structural characteristics

Growing out of its predecessor organisation Austrian Research Centers, the origins of which can be traced back to the year 1958 when Seibersdorf Laboratories was founded as Austria's main nuclear research site for civilian purposes, Austrian Institute of Technology (AIT) was founded in 2007 as a technology and knowledge provider to industry and government. Today, AIT is the country's largest research and technology organisation (RTO) with the mission of taking a leading position in the Austrian innovation system and a key role in Europe as the RTO that enables the realisation of

innovative, infrastructure-related solutions by providing technologies, methods and tools. AIT is co-owned by the government (Federal Ministry for Climate Action/Protection, Environment, Energy, Mobility, Innovation and Technology) and industry (Federation of Austrian Industries).

Instrumental characteristics

Today, AIT has about 1500 employees, working in seven research centers. The six technology-centric research centers[7] are complemented by the competencies of the Center for Innovation Systems & Policy which conducts inter- and transdisciplinary research and gives strategic advice on public, private and third sector organisations on matters of research, technology development and innovation and related policy strategies (including TIP) (see Box 1). In addition to its research capacity, AIT runs various labs and large research infrastructures to enable applied research and development (including digital urban planning, new energy for manufacturing industry, and road maintenance driving labs) and large-scale system pilots.

Box 1: About AIT Center for Innovation Systems and Policy

Since the early 1990s, then Austrian Research Center Seibersdorf was home to a research group, which – throughout the 1990s – was the leading domestic think tank inspiring the modernisation of Austria's technology policy, and later on through its Diploma/Master and PhD training in collaboration with Austrian universities a source of trained experts in matters of technology and innovation policy. In close collaboration with the Ministry for Science and Transport, the first strategic thematic and structural funding programmes were designed and implemented, giving rise to the first Competence Center Programme (which over the years evolved into the current COMET Programme) and range of thematic funding programmes in areas like energy, transport, housing, environmental or information and communication technologies. Over the years these programmes have became more 'systemic' and, more recently, more mission-oriented in approach.

Today, the Center is active at European level, in Austria and in selected other countries in strategic research topics of relevance to regional, national and European R&I policy and – to a lesser extent – industry, mostly in relation to major societal and systemic challenges that call for transformative and transdisciplinary strategies and policies. With its research and policy supporting activities, the center covers the entire policy cycle from system and policy analysis, to foresight, policy rationales, policy design, impact assessement, monitoring and formative learning, as well as ex post evaluation of policies, programmes and institutions.

Evolving characteristics of practice

While AIT's key mission has not fundamentally changed since the departure from the civilian use of nuclear power in 1978,[8] the modalities for research and policy support through its Center for

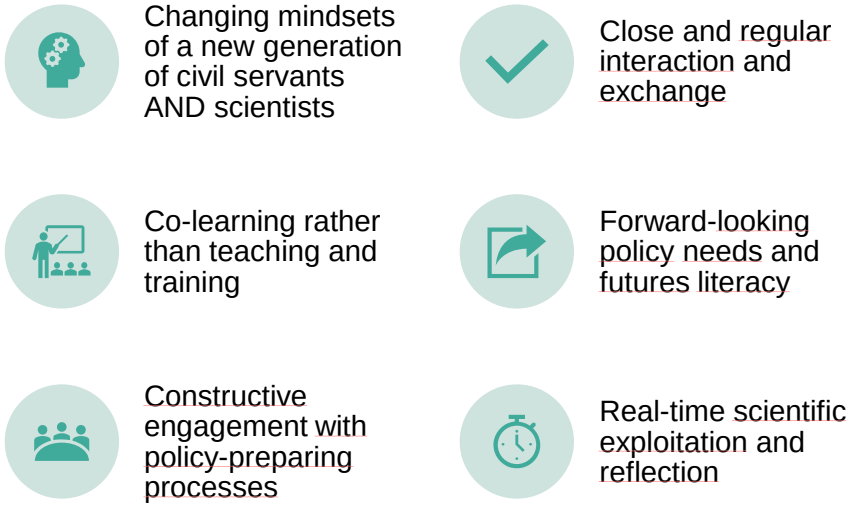
[7] Energy, Low Emission Transport, Health & Bioresources, Digital Safety & Security, Vision, Automation & Control and Technology Experience

[8] On 5 November 1978, a referendum took place in Austria on the peaceful use of nuclear power, and specifically on the putting into service of the almost finished Zwentendorf nuclear power plant near Vienna. With a narrow margin, voters rejected the law that would have allowed the peaceful use of nuclear power

Innovation Systems and Policy have evolved significantly over the past three decades. Four main phases of evolution can be distinguished: (1) From a starting point in technology policy and corporate research and technology planning, with modes of interaction focused on providing scientific evidence and data (in through the European Research Infrastructure for Science and Innovation Policy Studies RISIS) and early-stage concepts and feasibility studies (for Austrian governmental bodies and infrastructure providers at regional and national level), the center moved to (2) support innovation system policies (with modes of interaction including expert advice, involvement in foresight and strategy processes and other forms of strategic intelligence).

More recently, the focus has been on (3) supporting transformative governance and addressing societal challenges with further evolved modes of interaction including transdisciplinary research, co-learning and co-development processes, and formative monitoring and evaluation processes (for Austrian cities and for national funding programmes in Austria and Germany, for the European Commission). Current modes of interaction take on (4) an intermediary function – enabling and guiding mutual learning processes and co-production of knowledge (e.g. through leading the 'Foresight on Demand' programme for the European Commission or coordinating the Austrian Mission Facility in close interaction with the Austrian Ministry for Education, Science and Research (BMBWF) and the Austrian Research Promotion Agency FFG).

Figure 1: Guiding principles of interaction between science and policy



Aligned with this evolution, the knowledge products have also evolved. In addition to **scientific articles and other written reports** (with increased attention to accessible – brief, visual, digital – formats), AIT delivers: **learning materials** (workbooks, playbooks, games) for education and capacity development; **new processes and associated frameworks/tools** for e.g. monitoring and evaluation, policy labs and regulatory sandboxes; **dialogue and co-creation proceses**; and **networks and (online) communities of practice** to accelerate knowledge exchange and mutual learning.

Fraunhofer Institute for Innovation System Research (ISI)

Recent changes in the German policy context

In recent years, the context for federal-level policymaking in Germany has evolved significantly, like in many other countries, particularly in traditionally uncontested areas such as science, technology,

and innovation policies. Increasing global competition, societal shifts, and pressing challenges like climate change and digital transformation have led to a more dynamic and contentious policy landscape. In a highly industrialised and export-dependent country like Germany, maintaining the strength of the industrial base and competitiveness never ceased to be a key political concern. The attempt by the current German coalition government to bring together these rationales with the Green Agenda, is increasingly contested as the polycrisis unfolds, and in particular there are rather skeptical views on an increased role of the state, in R&I policies (and other so far seemingly 'undirected' policy areas). So the notion of mission-oriented innovation policies or sustainability transitions and related policies is contested among political parties. This underlines that R&I policies are not any more a predominantly technocratic policy area, but are becoming more politicised, as value-based decisions about major policy objectives have to be taken.

Structural characteristics

Since its inception in 1972, Fraunhofer ISI has been influential in shaping the German and international innovation landscape. Its research mission is aimed at tackling challenges facing present and future generations – providing strategic advice (to business, politics and societal stakeholders) regarding innovation and transformation toward a sustainable future. The aim is to contribute to Germany's international competitiveness and the integration of the content and structure of the German science system. The annual budget, 36,9 million euro (2023), is mainly (80%) earned from contracts performed for national and international public bodies, for industry and for foundations and scientific organisations. Of contracted research, 47% is for national public bodies, 22% is for the EU, and 20% is for industry. Approximately 20% of operating budget is basic funding provided by the federal government and state governments – allocated to individual Fraunhofer institutes on the basis of a distribution key that is fed by performance-related indicators. This funding model ensures a "market orientation" of Fraunhofer institutes' research and development work. At Fraunhofer ISI, this fosters a close integration in the ecosystem of innovation actors in Germany – in particular with its home region around Karlsruhe and in the federal state of Baden-Wuerttemberg.

Instrumental characteristics

Fraunhofer ISI has more than 300 employees from 25 different countries, among them scientists from the fields of natural sciences, engineering, economics and social sciences who each year work on about 400 research projects. The organisation is structured in seven scientific competences centers (Energy Policy & Energy Markets, Energy Technology & Energy Systems, Foresight, Innovation & Knowledge Economy, Sustainability & Infrastructure Systems, Emerging Technologies, and Policy & Society) and multiple cros-cutting research topics.

Evolving characteristics of practice

The main mode of interaction with policy actors is through contract research and expert advisory support. Sometimes, these interactions take rather uni-directional forms, in the way that studies and reports are simply being handed over to policy. However, increasingly those interactions are more intense and bi-directional, as the studies often have to be positioned in complex political settings or in relation to specific discourse arenas, or in narrow windows of opportunity. Additionally, forms of interaction have gradually evolved in recent years to include action research, social innovation labs

and co-design processes. Likewise, knowledge products have also begun to evolve. In addition to the core **written products** (studies, reports, policy briefs) and **toolboxes**, Fraunhofer ISI, and more particularly its Competence Center Policy and Society increasingly works with **co-design processes** for organisational innovation and **demonstrators of science-policy interaction formats** (leading the recently launched science policy dialogue training for early career researchers and the newly launched European network of 'pairs' of knowledge institutions and policy-making bodies TRIP-EU-Hub as part of the Policy Dialogues Demonstrator (P2D) launched within Eu-SPRI Forum).

Fraunhofer ISI takes a neutral stance and develops policy options and recommendations based on empirical evidence, so as to underline its independence from Fraunhofer society's organisational interests and policy.

Governing Resilience and Transformation (GReaTr) initiative

Recent changes in the Swedish policy context

The rise of the TIP is apparent with several new programmes including a new generation of strategic innovation programmes (Impact Innovation) launched by Vinnova, Formas and the Energy Agency and other newer mission-oriented innovation programmes (e.g. Food system, Viable Cities, etc.) or instruments for system transition (like system demonstrators for climate neutral cities). These new instruments are associated with new knowledge/capacity demands including: system mapping and analysis; approaches to monitoring, evaluation and learning; international benchmarking, etc.

Parallel to these new policy developments, a recent governmental inquiry (SOU 2023:59[9]) has resulted in a proposed re-organisation of the research and innovation funding landscape in Sweden. In addition, public agencies (including universities), regions and municipalities have all been undergoing budget cuts. This has led to a greater need to prioritise and align research investments across agencies and levels of governance.

The changing geopolitical context (including Sweden's membership in NATO) and focus on green "new industrialisation" has led to a pushback against innovation policy and relatively higher attention being placed on other policy areas (e.g. security, defense, tech/AI, energy, resilience).

Structural characteristics

Driven by an acknowledged need for more agile and timely knowledge inputs to inform and support reflection for policy development, GReaTr (Governing Resilience and Transformation) was formed as an experimental project initiative with the aim of serving as a forum for interactive knowledge generation and curation in Sweden. The initiative (hosted at Lund University, Department of Economic History) has mobilised resources in the form of time from senior researchers and experienced practitioners (consultants and policymakers), together with co-financing from Vinnova, as a core base.

Instrumental characteristics

GReaTr was led by two researchers, with involvement of other researchers and students at Lund University and engagement of other researchers, experts and policymakers from Austria, Finland, UK and elsewhere in Sweden (in total 30 other researchers and policymakers). The experiment was focused

[9] Ny myndighetsstruktur för finansiering av forskning och innovation - Regeringen.se

on two thematics: the medium-term effects of recovery and stimulus measures on innovation, transformation and resilience; and the evaluation and design of transformative innovation policy. Each topic mobilised smaller groups of researchers, policy practitioners and experts who were interested in "affiliating" to the thematic and committed to spending time on a concrete analysis or a broader knowledge exploration process.

Evolving characteristics of practice

During the short-term experiment, different forms of interaction with policy practitioners were explore (ranging from jointly conducted comparative analyses to facilitated workshop series with smaller groups, as well as presentations and organisation of interactive workshops with broader policy audiences and presentations at academic conferences). Each topic's interactive knowledge development process was developed through ongoing dialogue and flexible decisions on appropriate next steps or questions to explore. Common to both themes was the blend of perspectives from theory and practice, the agile approach to interactive learning processes, and the active work to **compare (or co-learn) with similar cases internationally** and plug into relevant international and supra-national networks.

The main product that GReaTr generated was the cross-disciplinary and **cross-sectoral platform** that mobilised researchers and policy experts in interactive knowledge exchanges and co-development spaces (structured around the two thematics mentioned above, but also explored the topic of interactive knowledge development itself). For each topic, the **interactive learning processes** produced various iterations of **written knowledge products** – from informal insights and reflections from the workshops to more structured syntheses or knowledge overviews, comparative case analyses, policy briefs, conference and working papers and academic articles.

Mission-Oriented Innovation Policy Observatory (MIPO)

Recent changes in the Dutch policy context

Since 2018, the Dutch Ministry of Economic Affairs and Climate Policy (EZK) has been transforming its traditional Top Sector policy into a mission-oriented top sector and innovation policy (MTIP). This shift involves collaboration with other ministries around 25 mission goals grouped into four themes. A key feature of this approach is the development of Knowledge and Innovation Agendas (KIAs), where government, business, research, and (increasingly) civil society articulate shared ambitions. While these agendas are still largely shaped by the core (research interests) of the Dutch innovation system, ministries now play a more active role in steering research and enabling the development and diffusion of solutions. This reflects a broader move toward a 'whole-of-government' approach to innovation policy. There is ongoing debate about the future direction of MTIP—whether to maintain its holistic nature or or decouple mission-oriented innovation policy from the R&D- and competitiveness-oriented business and research organisations that dominate the Topsectors

In parallel with the EU's emphasis on open strategic autonomy, EZK has highlighted the importance of securing vital societal functions as a key rationale for innovation and industrial policy. [10] However,

[10] EZK (November 2022). Action plan Innovation and Valorisation.

the growing focus on national security may risk overshadowing other societal challenges such as sustainability, circularity, biodiversity, and health.

Meanwhile, regional authorities are showing increasing interest in these broader challenges. The rising attention for 'regional missions' fits MIPO research stressing that the concept of MIP is particularly promising in local settings.[11]

Structural characteristics

MIPO was established early 2020 at Utrecht University, the Netherlands. Recognizing the rise of new challenge-led innovation policies, and in particular the renewed interest for societal missions, scholars from the Innovation Studies and Environmental Governance groups joined forces in establishing an inter- and transdisciplinary platform for examining the question: "Can missions be transformative, and under which circumstances?". MIPO has been established and managed much like a lean initiative. It started out as a small working group in which all involved parties collaborated voluntarily, in their own time or via projects that were already funded. Currently, funding comes from commissioned research and a pre-seed research fund, as well as traditional research projects. The MIPO is not dependent on any sort of institutional funding.

Instrumental characteristics

The core of the team is formed by 4 UU assistant professors, with 8 associated researchers and PhD students (as well as a broader informal network of affiliates). Neither member nor associate is a formal status; the MIPO, just like the MOIP concept itself, has relatively fuzzy boundaries. All the engaging researchers bring slightly different perspectives, and none of them work on missions or MOIP exclusively. The 'Observatory' status refers to the objective of answering questions by closely following a select set of key examples, regardless the societal domain/problem, policy level (supra-national, national, regional) they are concerned with – or even whether they explicitly carry the 'mission' label. This scope is complementary to efforts to collect, synthesise and disclose more descriptive information on how countries are experimenting with MoIP (as the OECD started doing around the time MIPO was established).

Evolving characteristics of practice

Since the beginning, researchers engaging with the MIPO maintained close relationships with policy makers sharing an interest in MOIPs. The frequent interactions between MIPO researchers and policy practitioners typically occur on an ad-hoc basis, and services provided are usually limited to expert advisory support (helping policymakers apply concepts in program development, implementation or monitoring, learning and evaluating). MIPO researchers have been involved in 'innovation and transition policy' courses for policymakers. Additionally, there are several MIPO PhD students who are doing an external PhDs (affiliated to a policy organisation). A recently granted research project and membership of several expert / advisory / scientific committees allows MIPO researchers to also start

[11] For instance: at the regional level there is typically more clarity on what the cause of a prioritized societal problem is, and there are fewer actors that propose competing solutions. For both proximity and capacity reasons, regional policy makers might be in a better position to engage heterogenous stakeholders in contesting and negotiation views on how to tackle the problem.

engaging in action-based research, in addition to the more conceptual, observative and reflexive research that was conducted so far.

Much of the knowledge transfer, and in fact knowledge co-creation, takes place via **direct forms of interaction with policy makers**. In the life-long-learning activities to which MIPO contributes, this involves the use of new **training materials** like presentation slides and workshop exercises. Additionally, the MIPO has been publishing various kinds of **written products** (including scientific articles, (hand)books, several policy briefs, a couple of op-ed articles for professional audiences, and reports following from commissioned research projects). Together with consultancy NewForesight and Nyenrode University, both from the Netherlands, MIPO has also been developing **practice-oriented knowledge products** under the label of the 'TransMission Institute'.

Orkestra – Basque Institute of Competitiveness

Recent changes in the Basque policy context

A key shift in the policy context is the growing emphasis on environmental sustainability, with clear implications for economic and social dimensions of regional development. This is driven by global frameworks like the UN's Agenda 2030 and by local concerns that Basque firms must adopt greener production methods to remain competitive.

Equally important is the rising focus on attracting and retaining talent and addressing skills gaps. While this issue has gained traction over the past decade, it now dominates policy discussions across departments. Tackling skills shortages is also part of the broader effort to ensure Basque firms remain rooted in the region, influencing policies related to finance, investment, innovation, and overall business competitiveness.

Alongside the changing policy context stimulated by the need to address such environmental, skills and business competitiveness challenges, there have been important changes in how policy is designed, implemented and evaluated. There is increased interaction – even convergence – between policy domains, greater recognition of the need for multi-level policy coordination, and a widening of the realm of 'policymakers' to extend across the quadruple helix (government, business, research and civil society). In terms of Orkestra's research, this changing context has placed special emphasis on analysis of governance, and new governance mechanisms (within, between and beyond government), and has also changed how (and with who) action-research projects are configured and carried out.

Structural characteristics

Orkestra was established in 2006 within Deusto Foundation, the foundation for knowledge transfer of the University of Deusto, a Jesuit university founded in 1886 in the Basque Country region of Spain. Orkestra was created with an explicit mission to foster the competitiveness of the Basque Country through action-oriented research that improves the well-being of its citizens. While it maintains a strong relationship with Deusto University and is physically located on its campuses in San Sebastian and Bilbao, Orkestra's funding is independent of the university, coming from a mix of direct funding from a relatively stable set of regional stakeholders (primarily government institutions at different levels and firms) and the pursuit of competitive research funding (regional, national, EU, international funding calls). Given the rooting of its research agendas in the problems and challenges being faced

by regional stakeholders in the pursuit of sustainable regional competitiveness and wellbeing outcomes, Orkestra's work is very sensitive to changes in the Basque (and international) policy context – which impact both 'what' Orkestra researches and 'how' it researches.

Instrumental characteristics

To fulfil Orkestra's mission, its team of around 40 full-time researchers and research-related staff are expected to be at the frontiers of international academic knowledge in their areas of expertise and to leverage that knowledge to respond to practical challenges related to the Basque Country's competitiveness and wellbeing. Being at the frontier of international knowledge is achieved through engagement with academic literature, debates, and networks, while responding to practical challenges is achieved by developing action-oriented research projects that involve a spectrum of different levels and types of engagement with regional stakeholders. In addition, Orkestra has undergone a change in recent years – explicitly seeking to hire and/or train people to evolve capacities to engage in certain types of research processes.

Research at Orkestra is organised in 4 transformative research labs in the areas of (i) public policy; (ii) smart business; (iii) wellbeing; and (iv) energy and environment. Rather than formal structures, these are conceived as fluid spaces for the co-creation of knowledge and action among Orkestra researchers and the regional stakeholders with which they are working. Indeed, they are dynamic spaces that change continually, in terms of the challenges being worked on, the researchers and stakeholders involved, the methodologies being employed, and the specific projects in which concrete research questions are grounded.

Evolving characteristics of practice

Across the four research labs, Orkestra typically develops 30-40 projects a year, each of which is associated with one or more regional stakeholders (different departments of the regional government, provincial councils, city councils, development agencies, firms, etc.) or external stakeholders (European Commission, policy agencies from other regions or countries, etc.). A significant proportion of Orkestra's projects pursue action research approaches that are based on continuous interaction with policy practitioners. Indeed, Orkestra actively develops a research agenda focused on the methods of action research alongside the thematic research agendas within the four research labs, a key result of which is the action research for territorial development (ARTD) framework (Karlsen & Larrea, 2014; Larea, 2019; Larrea, 2020).

The knowledge products generated by the research labs and projects can be grouped into six main categories: **frameworks** (conceptualizing different dimensions of regional competitiveness), **observatories or platforms** (enabling access and visualisation of latest indicators of competitiveness), **reports** (internal or external publication series, and an annual flagship *Basque Country Competitiveness Report*), **action research processes** (making use and/or resulting in other knowledge products), **events** and **academic publications**.