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Papers in Innovation Studies no. 2024/01

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Submitted January 6, 2024

Forthcoming in Cantner, U. et al (2024) *The New Role of the State for Transformative Innovation*, Edward Elgar.

Abstract

In recent years, countries, regions, municipalities and the EU Commission have introduced a significant number of innovation policy initiatives under the banner of 'missions', 'societal challenges', sustainability and 'transformation', or systemic change. In parallel, there has been a rapidly growing body of literature seeking to analyze or assess these real-world manifestations of attempts to pivot innovation policy towards environmental and societal challenges. The aim of this chapter is to provide a reflexive overview of state of the art of the knowledge on transformative innovation policy design and implementation. To contribute real-world, real-time learning for planned or ongoing policymaking, we also synthesize lessons and insights from recent policy initiatives in Sweden, Finland and the Netherlands, with the purpose of distilling them into policy-relevant observations. Based on these, we draw conclusions on what recent experiences from trying to design and implement transformative innovation policies in the respective national and institutional contexts tell us about the role of innovation policy, and implicitly, the role of the state, in driving transformation.

JEL-codes: H11, I28, O33, O38

Keywords: innovation policy, transformation, societal challenges, public policy

1. Introduction

Climate change and pandemics but also disruptive technologies and the undermining of an open rules-based multilateral order are putting new demands on the state to govern, enable, and drive transformative change. Governments and public administrations are struggling with handling problems or issues that span several policy areas but also with the extent and sheer speed of change. This is perhaps particularly the case for mature democracies, which struggle to meet the need for increased agility and the ability to drive transformative change while maintaining accountability and transparency in their decision-making. The recent confluence of crises – the Covid 19 pandemic, the

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Russian war on Ukraine, growing geopolitical tensions between the US and China, the increasing occurrence and severity of extreme weather events, rising inflation caused by energy shortages and supply chain disruptions, and a looming recession – has further exacerbated the pressure on decision-making processes, governance and cohesion, not least in Europe and the US.

Innovation policy, particularly in the OECD countries, has long focused on promoting bottom-up, and often incremental, change, within clusters, firms or industries. Another focus has been on supporting commercialization of research, through attempts to strengthen opportunity-driven entrepreneurship and industry-academic cooperation. However, the changing context described above puts new demands on innovation policy to contribute to addressing urgent societal challenges and to fundamentally transforming production and consumption systems to combine economic, environmental and social sustainability. Furthermore, it challenges what has long been taken for granted to be an obvious positive relationship, namely the link between research and innovation policy on the one hand, and desirable development, on the other.

In this chapter, we present and compare some examples of innovation policies seeking or claiming to contribute to addressing societal challenges and to driving transformation. We synthesize existing research and analyses of these cases to identify some relevant features and lessons from these attempts to drive transformation through R&I policy. Finally, we point to a number of challenges and propose some ways forward when trying to align R&I policies with a transformation imperative.

1.1. The shift towards a more transformative innovation policy – from systems for innovation to innovation for changing systems

The context and objectives of innovation policy have changed considerably since the concept first appeared on the policy scene around 1980 (Fagerberg 2018). Schot and Steinmueller (2018) define three distinct 'frames' of innovation: (i) "innovation for growth", (ii) "national innovation systems for knowledge creation and commercialization" and (iii) "innovation to address societal and environmental challenges", or *innovation for transformative change*. The first two frames have dominated innovation policy for the past half century. The third frame has gained prominence in policymaking more recently. Its emergence is explained by firstly, an increasingly urgent, even existential, need for policymaking to respond to societal and environmental challenges, and secondly, a growing collective realization that the promotion of non-directional innovation capacities and processes on its own does not guarantee beneficial outcomes for society, the economy or the environment. Weber and Rohracher (2012) identify transformational system failures, for example directionality failure, as an important rationale for innovation policy that differs from the more widely recognized rationales of market failures and structural system failures. The notion of a 'transformative innovation policy' (TIP) can be described as more directional or 'aspirational' innovation policy, compared to the previous two frames (Dierks, Larsen and Steward 2019).

The conceptual link between research and innovation policy and transformative change – particularly in relation to environmental sustainability – is not new (see e.g. Lundvall 2022). Freeman (1992) identified a 'green techno-economic paradigm' as a "precondition for sustained economic growth in the twenty-first century" (ibid p.7). Rip and Kemp (1997) provide a thorough discussion of the relationship between technological development and social, economic and political context, making the convincing argument that the former, rather than being an exogenous factor, is strongly embedded in and shaped by the latter. In particular, they look at how "deliberate technological change" – which today might be called a directional innovation policy – could be "part of the solution to climate change problems" (p.328). Similarly, Freeman and Soete (1997) identified environmental sustainability as a long-term policy goal that is "urgently in need of being put much higher on the agenda of science and technology policy ministries, agencies and other policy-makers" (p.413). They also argued that it distinguished itself from other objectives pursued by STI policies in several ways that warrant

particular policy attention. This includes the long-term horizon of the required efforts to contribute to system change (which makes it significantly different from other policy goals, and arguably also the goals of private sector actors, that are most often short or medium-term), the complexity of the change process (requiring a wide range of policies, involvement of many different economic actors, and changes in existing economic, social, and cultural institutions) and the need for public-private interplay, engagement and alignment (recognizing that the public goal of environmental sustainability cannot be reached without ensuring that the private sector is both viable and capable of adjusting to change). Directionality in research and innovation policy practice is even older, as illustrated by the mission-oriented policies implemented in the US, France and the UK in the early post-war period (Ergas 1986), though these earlier mission-oriented policies tended to focus on technology or defense missions, rather than societal or environmental challenges.

The Lund Declaration from 2009, adopted by EU Member States during the Swedish Presidency, might be argued to be the first major policy document to explicitly link research and innovation policy and societal challenges. Beyond Europe, promoting innovation was also identified as an important instrument for reaching the goals for combating climate change agreed upon in the Paris Agreement in 2015 (Diercks et al 2019).

The pivot of innovation policy from a strong focus on technology and economic growth towards addressing societal challenges and driving system transformation is not a trivial or incremental change. It requires processes, instruments, governance, interactions and capacities that differ quite fundamentally from those that have characterized the hitherto dominant framings of innovation policy (Arnold et al 2023, Borras and Schwaag Serger 2022, Schwaag Serger et al 2023, Schot and Steinmueller 2018), a point reflected in a the title of a special issue in *Research Policy* in 2012: "The need for a new generation of policy instruments to respond to the Grand Challenges" (Foray et al 2012). Moreover, the aspirations and manifestations of a transformative innovation policy might actually conflict with the objectives and instruments of innovation policies whose primary goal is to strengthen economic growth and competitiveness (Schot and Steinmueller 2018).

In recent years, governments have launched a number of innovation programs and policies under the banner of transformation, particularly in Northern Europe and at EU level. Examples include:

- E-pilot (Norway), aiming to promote more rapid development and deployment of new, environment-friendly energy technology products and services to help to reduce emissions both in Norway and internationally (Polt et al 2020, Larrue 2021, Borras and Schwaag Serger 2022)
- Flagship programs (Finland), aiming to create future know-how and sustainable solutions to societal challenges and promote economic growth (Arnold et al 2022a, Borras and Schwaag Serger, 2022)
- Challenge-driven innovation program (Sweden), aiming to support collaborative initiatives which seek to provide solutions to societal challenges and thus contribute to the SDGs in Agenda 2030 (Schwaag Serger and Palmberg 2022)
- Strategic innovation program (Sweden), aiming to create conditions for strengthened international competitiveness and sustainable solutions to global societal challenges (Grillitsch et al 2019, Åström et al 2020)
- High-tech strategy missions (Germany), striving to direct the country's research and innovation policy towards addressing the most urgent societal challenges of our time, and pursuing twelve specific societal missions (Larrue 2021, OECD 2022, Wittmann et al 2020)
- Top-sector missions (Netherlands), aiming to tackle societal challenges in the areas of (1) energy transition and sustainability, (2) agriculture, water and food, (3) health and healthcare and (4) security, by pursuing 25 defined missions (Janssen 2020).

- EU Missions on cancer, climate resilience, oceans and water, climate-neutral and smart cities, and healthy soils (European Commission, 2021).

Even more recently, there have been attempts to analyze or assess these real-world manifestations of attempts to pivot innovation policy towards environmental and societal challenges with an explicit ambition of contributing to or even driving transformation and systemic change (see, for example, Åström and Arnold 2020, Grillitsch et al 2019, Diercks et al 2019, Borras and Schwaag Serger 2022, Ramboll 2019 & 2020, Roth et al 2021 & 2022, Schwaag Serger and Palmberg 2022 and Wittmann et al 2022). These analyses contribute to the reflexivity, policy learning and 'tentative governance' which is important in designing effective innovation policies in general, and transformative innovation policies in particular (see for example Borras 2011, Lundvall 1982 & 2022, Kuhlmann et al 2018, Wanzenböck et al 2020, Weber and Rohracher 2012). In the wake of the increasing interest in innovation policy as an instrument or driver of transformation, a number of centers or institutes have sprung up that focus explicitly on understanding, evaluating and advising on transformative innovation policy and mission-oriented innovation policy. These include the Transformative Innovation Policy Consortium (TIPC), the Mission-Oriented Innovation Policy Observatory at Utrecht University, and the UCL Institute for Innovation and Public Purpose.

In sum, the literature now increasingly abounds with treatises, both academic and of a more policy-oriented nature (eg ESIR 2017, Mazzucato 2018) making a convincing case for why this pivot of innovation policy is necessary and desirable. There is also a growing body of literature which seeks to provide insights or guidance on how to achieve such a pivot, at national, regional and EU level (eg Flanagan et al 2022, Hill 2022, Larrue 2021, Mazzucato et al 2020, Polt et al 2021). This paper falls into the latter category. By placing and comparing relevant TIP initiatives in their respective national contexts we hope to contribute to advancing understanding of how the state can drive transformation through innovation policy and what might be important determinants of its ability to do so.

1.2. The aim and contribution of this chapter

Much of the debate and literature surrounding transformative innovation policy has hitherto been aspirational – arguing why such a policy is necessary – or conceptual, i.e., suggesting explanatory or descriptive frameworks (Janssen et al 2021). However, as Brown (2021) observes, "there has been little academic scrutiny of how mission-oriented policies … are implemented and operationally deployed by organizations" (p.739). He argues that the fact that "academics rarely confront the sometimes intractable difficulties of operationally implementing mission-based policies" (p.745) may partially contribute to policymakers underestimating the difficulty of shifting to a transformative innovation policy. On a similar note, in their review of the literature on TIP, Haddad et al (2022) conclude that "the approach still does not give us workable ideas on how to achieve 'broad stakeholder involvement', evaluate transformative outcomes, and build up dynamic policymaker capabilities".

The aim of this chapter is to provide a reflexive overview of state of the art of the knowledge on transformative innovation policy design and implementation, seeking to address some of these issues. To contribute real-world, real-time learning for planned or ongoing policymaking, we also synthesize lessons and insights from recent policy initiatives in Sweden, Finland and the Netherlands, several of which we have analyzed and followed closely in various contexts, with the purpose of distilling them into policy-relevant observations. Based on these, we draw conclusions on what recent experiences from trying to design and implement transformative innovation policies in the respective national and institutional contexts tell us about the role of innovation policy, and implicitly, the role of the state, in driving transformation.

Given the non-incremental nature of the shift towards a transformative innovation policy described above, combined with an increasing urgency, and the importance of policy learning and reflexivity, we

hope that our analysis can contribute to policymaking with a timely and relevant input and thereby to filling the gap identified by Brown (2021) and Haddad et al (2022).

This chapter is structured as follows:

In section 2, we summarize some of the key takeaways from earlier literature on the role of the state in enabling transformation, provide our reflection on the related terms of transformative innovation policy and mission-based innovation policy, and present what we know so far on the challenges in design and implementation of transformative innovation policies.

In section 3, we provide a brief overview of transformative innovation policy initiatives undertaken in OECD countries over the past decade, and discuss some of them in detail, addressing their design, implementation, and the findings of the evaluations of these that have been conducted in recent years. We discuss each case in the context of their national innovation policy setup, and present a comparative analysis, focusing on key themes, differences and similarities between the national experiences in implementing transformative innovation policies.

In section 4, we summarize our findings, synthesize key lessons learned, and suggest a number of recommendations with regards to design and governance of the transformative innovation policies going forward.

2. Literature review

2.1. The role of the state in enabling transformation

As we have explained above, innovation and innovation policy are increasingly expected to contribute to tackling societal challenges and to transformative change, in addition to promoting economic competitiveness and growth. The shift towards a transformative innovation policy has in many instances coincided with the acceptance of a more active role of the state, both in theory and in practice. The urgency of the envisioned change, the necessity of strong directionality of the efforts, the long-term nature of the change processes, the complexity of the endeavor in terms of thematic areas and actors involved, and the variety of instruments that the government can deploy, have all been used to argue that the role of the state in transformative innovation policy is even more important than in the earlier generations in R&I policy.

However, views diverge as to what exactly the role of the state should be. Borras and Edler study the "governance of change in socio-technical and innovation systems" (2014) and more specifically the role of the state in the systems transformation (2020). They identify a number of potential roles ranging from rather reactive or passive roles, such as 'observer' or 'warner', to more proactive or interventionist roles, such as 'promoter', 'initiator' or 'opportunist'. Schot and Steinmueller (2018) argue that the state should create spaces for experimentation and niche development while Mazzucato (2018) sees an important role for the state in defining or choosing missions, albeit in close interaction with stakeholders – or at least to initiate the process that can lead to the creation of missions. She also calls for the state to assume a greater role in and responsibility for creating or shaping markets and, more generally, driving innovation and transformation in various ways (Mazzucato 2013).

In a more recent paper, ESIR, an advisory group to the European Commission, pointed out that ensuring normative transformation – towards a more sustainable economy and society – requires a fundamental rethink and revision of how government behaves and acts (ESIR 2021), stating e.g., that "industry 5.0 requires government 5.0". Examples of such different behaviors include anticipatory regulation, risk taking, portfolio approaches in innovation project funding, horizontal and vertical policy coordination, agility etc.

2.2. Transformative and mission-oriented innovation policy – is there a difference?

Most of the literature on transformative innovation policy and mission-oriented innovation policy (MOIP) has been quite inexplicit as to whether these terms could, or indeed should, be distinguished from each other (see e.g., Wittmann 2021 and Janssen et al. 2023 for a more elaborate discussion on possible definitions). A reflection on definitions may therefore be in place here, as these concepts, we argue, have developed in parallel and stem from partially different streams of thought. While the concept of transformative innovation policy is deeply rooted in the literature on socio-technical transitions, often focusing on the environment, resource use and climate (where the research interest has increasingly been shifting from how transitions take place to how transitions can be induced and governed), the mission-oriented perspective comes from the idea of the role of the state and broad stakeholder mobilization in addressing societal challenges.

If we were to make a distinction, we would suggest doing it along two lines, namely that the pursuit of transformation does not necessarily require missions, and the pursuit of missions does not necessarily require transformation. We explain these two points below.

Firstly, while targeting R&I efforts towards societal challenges (directionality) is at the heart of both TIP and MOIP, the MOIP theory and practice puts by definition stronger emphasis on concrete, measurable and time-bound targets (missions). Transformative innovation policy on the other hand, tends to (also) address societal challenges in broader terms, be more open in terms of specific goals and desired outcomes, and in some cases, aims to promote 'transformativeness' more generally (or generically). The latter can refer to building actors' or systemic or generic capacity and approach to handle, enable and even drive structural change, rather than pursuing specific challenges. Examples include initiatives to strengthen innovation in the public sector (e.g. Vinnova), the so called 'policy labs' (e.g. Vinnova, RISE), and support to actor-driven challenge-based innovation with an open agenda (e.g. Vinnova). *Missions could therefore be argued to be the most tangible manifestation or embodiment of transformative innovation policy – but certainly not the only way to design TIP initiatives*.

Missions have rapidly gained popularity among governments (the European Commission, Germany, Denmark, the Netherlands, Sweden, Austria and Norway, among others have launched missions as part of their research and innovation policy toolbox (see e.g. Larrue 2021). Their popularity is partially explained by the fact that they are easy to communicate and to rally support around – who could or would say no to a 'plastics free ocean' or a 'war on cancer', for example? When they are driven by clear political will combined with widespread support or buy-in from industry, civil society and academia, as well as a state capacity to coordinate and align policies, they can be very powerful at mobilizing and directing a multitude of forces and instruments towards a common goal and, ultimately, achieving desirable outcomes. At the same time, they cannot compensate for existing challenges regarding policy governance or fragmentation or unwillingness or inability to handle resistance to change. These challenges become particularly apparent, even insurmountable, when there is insufficient political will or determination to support a mission or when a mission has to compete with a sea of other initiatives and policies for funding and attention.

The second point of difference relates to the view of system transformation as such as a prerequisite for addressing societal challenges, and thereby, the need of understanding (and governing) the underlying processes. Being firmly grounded in the knowledge frameworks of socio-technical transitions, the TIP literature and practice puts greater emphasis on system dynamics, and the complex interplay between technology development and diffusion, demand creation, actor strategies, incentives and capacities, and other enabling or hindering factors. In this sense, transformative innovation policy implicitly rests on the assumption of the value of a 'theory of change' that underpins various efforts to drive transformation. This notion is much more weakly developed in the mission-based approach,

which we argue, tends to lack or neglect the idea of learning or systematizing transformation across policy problems or fields. We further argue that a *mission-based approach to societal challenges doesn't necessary imply a need for broad system transformation*. The pursuit of missions can fit within existing institutional structures, knowledge frameworks and actor behaviors, accelerating (rather than disrupting) existing development patterns (cf. Janssen et al. 2023).

In most of the academic and practitioner-oriented literature, however, the concepts of TIP and MOIP have often been used interchangeably, referring to programs or initiatives in the domain or realm of research and innovation policy which have an explicit ambition to promote or drive change towards socially desirable outcomes, "acknowledging the degree of wickedness of the underlying challenge, and the active role of policy in ensuring coordinated action and legitimacy of both problems and innovative solutions across multiple actors" (Wanzenböck et al (2020:476). While we stand by the TIP as a concept, and caution against equating transformative innovation with missions, we acknowledge that most of the MOIP literature remains relevant for understanding the nature and dynamics of transformation.

2.3. Transformative innovation policies – premises and challenges

Real-world experience practice shows that re-orienting R&I policies to address deeply rooted societal needs comes with its challenges. Below, we summarize a few key takeaways from earlier work in this area.

The need to translate the transformative ambitions into goal formulation and the challenges this entails. Based on a comprehensive overview of mission-oriented policy initiatives across the OECD countries, Larrue (2021:51) finds that "few of the MOIP initiatives have set objectives that have the expected mission characteristics: clear, bold and inspirational, with wide societal relevance, ambitious but realistic, targeted, measurable, time-bound and solution neutral… Many are qualitative statements turned into a mission format and are not very different from traditional thematic program objectives or even industry targeting policies." The lack of clarity in formulation of the goals of transformative innovation policies is however only partially due to the relative novelty of these practices and therefore, inexperience of the actors involved. Indeed, there is a great sensitivity in how policy goals are formulated, as it requires a broad stakeholder agreement on the nature of the envisioned transformation – that is not always in place. In addition, setting specific and measurable targets has proved particularly challenging in areas where there is high uncertainty, creating a need for more open-ended goal formulations (Janssen et al. 2023).

The need to understand and address the key actors, processes and bottlenecks that are at the heart of the transformation. When the focus of R&I policy moves towards achieving lasting impact in the society, it requires an in-depth understanding of what system needs to be transformed, what are the key components of the transformation, what are the barriers to transformation, as well as main mechanisms for promoting change. Also – what are the potential negative implications, and how can they be mitigated? This calls for a *theory of change* of the system transformation, as a basis for strategic decision-making, organization of efforts and action, which takes into account not only technological/scientific, but also infrastructural, behavioral and cultural aspects of change. This kind of analysis, however, rarely takes place in practice, as most of the R&I policy implementation happens at the ministry or agency level, that do not have capacity, and authority, to grasp the transformation process as a whole.

New demands on policy design, governance and coordination. Societal transformations span across different sectors of the economy and functions in the society, and thereby across mandates of multiple agencies and ministries. Transformative innovation policy requires broadening the policy mix toward policy instruments that lie far outside the mandate and reach of traditional R&I policy, including regulations, price mechanisms and public procurement (Larrue, 2021). Design and implementation of

transformative innovation policies therefore needs to be based on a "whole-of-government" approach - i.e., ensuring effective coordination in the design and implementation of policy between national and sub-national levels, between different line ministries, and between ministries and other publicly funded bodies (Arnold et al., 2022a). This requires not only the capacity and willingness to break through the policy silos, but also a long-term political commitment to driving transformation.

While policy coordination is critical for the success of transformative innovation policies (much more so than for traditional STI policies), it is also one of the key challenges. "Although these benefits are well documented in the literature, policy co-ordination is one of the oldest and most prevalent challenge for governments, as demonstrated in OECD Innovation Policy Reviews. This concern has become even more pressing since the 1980s with the diffusion of the New Public Management doctrine that promoted 'agencification' and the creation of individual programs. STI policies and instruments have become more differentiated, addressing specific failures from the support to basic 'free' research and social entrepreneurship, to the promotion of international collaborative research or the provision of problem-solving expertise to low tech SMEs, to name only a few. As these specific instruments interact, it is essential to ensure their consistency." (Larrue, 2021:52)

On a related note, most of mature economies struggle to balance and reconcile requirements on transparency and accountability of public policy on the one hand, and the need for agility in structures and decision-making on the other. While there is an increased awareness about the necessity of flexibility and creating room for experimentation in budgeting and planning, and the need for adapting decision-making processes to quick changes and emergent issues, it has so far had little influence on the actual practices of policymaking (e.g. Arnold et al. 2022b). *The need to critically assess policy instruments and implementation mechanisms*. According to Arnold et al (2022b), there is a strong tendency for challenge-oriented programs (such as Sweden's national research programs) to relapse into rather traditional patterns when it comes to instrument design and actor focus. Thus, program descriptions with rather high ambitions of addressing societal challenges and being transformative often end up being translated into rather traditional mechanisms for funding research. This is partially because the programs or initiatives are often designed and run by the same agencies that have been in charge of hitherto established instruments for promoting research and innovation. As a result, new initiatives with more transformative or challenge-oriented ambitions tend to be hamstrung by existing rules, competencies and practices which characterize the agencies that run them. This often means a strong focus on academic research and producing new knowledge but less understanding of societal needs and diffusion and application of new knowledge.

The need to mobilize broad societal involvement. One of the key pillars of transformative innovation policy is mobilizing broad engagement – competencies, resources, collaboration and the sense of ownership – from society as a whole. "Tackling societal challenges requires 'enlisting' and involving public and private actors well beyond the research and innovation arenas that are the traditional communities STI policy making bodies are in contact with." (Larrue, 2021:43). Engaging and mobilizing stakeholders for driving transformation proves however to be very challenging (e.g., Kuhlmann and Rip 2018), because transformative change is likely to be disruptive and threat current balance of power and resources, requires risk-taking, acceptance of new instruments and ways of operating, but also because public agencies that are in charge of implementing R&I policies struggle to find effective mechanisms for stakeholder involvement, beyond the more or less traditional public-private partnerships.

The need to manage costly trade-offs between short-term solutions and systemic transformation. E.g. data analyzed by the energy think-tank Ember Climate for the Financial Times suggest that European governments spent at least €50bn winter 2022/2023 on new and expanded fossil fuel infrastructure and supplies (as a consequence of energy crisis due to Russia's war in Ukraine, and rapid demand recovery after the dip during the Covid crisis). The prerequisite for transformative innovation policies to be effective are directly related to how much is simultaneously being invested in status quo technologies,

infrastructure and use, or how effectively the governments manage to divest, which goes back to the issue of broad and long-term political ownership and commitment.

3. Transformative innovation policy – selected cases

To our knowledge, the first program that might be classified as a transformative innovation policy at national level in the European context is the challenge-oriented innovation program that was launched in 2011 by the Swedish Government Agency for Innovation (see Borras and Schwaag Serger 2022 and Schwaag Serger and Palmberg 2022 for more in-depth analysis). Since then, countries, regions, municipalities and the EU Commission have introduced a number of innovation policy initiatives under the banner of 'missions', 'societal challenges', sustainability – either mainly environmental or more holistic sustainability (environmental, social and economic) in the spirit of Agenda 2030, and 'transformation' or systemic change.

There is a growing body of analyses and evaluations of transformative innovation policy initiatives. In this section, we synthesize analyses of a selection of these. We complement analyses of individual R&I programs with transformative ambitions with evaluations of actors running such programs, and the OECD Innovation Reviews that examine national conditions for tackling societal challenges or driving transformation through research and innovation policy. Combining instrument or program-specific analyses with evaluations of the hosting organizations and/or analyses of the respective national context in which they are designed and implemented allows us to gain a deeper understanding of how attempts at transformative innovation policy play out in practice.

The main purpose of the synthesis is to illustrate various designs and implementations of TIPs in their national contexts, and to derive policy lessons that may be common for the countries and initiatives analyzed, specific for certain types of policy set-ups, or specific to a country context. The cases selected originate from Sweden, Finland and Netherlands, based partially on prior experience of the authors, and partially on the richness of material available, in terms of availability of sufficiently ambitious/large scale R&I policy initiatives with a stated transformative ambition, and of recent evaluations of these initiatives. We believe that experiences from these countries may be particularly valuable to discuss and compare, as there are both strong similarities between the countries (size, high level of economic, industrial and technological development and mature R&I support systems), but also some notable differences, particularly in terms of the governance of the R&I support system, and to a certain extent, in terms of the transformative orientation of the innovation system.

It is however important to note that there are significant limitations to comparability between the policy initiatives (see Table 1 for an overview). Indeed, the initiatives were designed and implemented at different points in time, and have had different objectives, scope, governance and setup. Some have had transformative ambitions from the start, while others came to be deployed as TIP instruments during the course of their implementation. Also, the national economic and policy contexts within which these initiatives were implemented differ considerably. Some of the initiatives covered here have already been finetuned or reformed since the evaluations have taken place. Several new initiatives have been introduced in the countries, or are in the making, that have for obvious reasons not yet been evaluated. It is therefore with some caution that we embark on this comparative discussion.

Table 1 - An overview of country cases

Country	Program/initiative	Led by	Time period	Materials upon which our analysis is based
Sweden	Challenge-oriented innovation program	Vinnova	Since 2011 (planned to be discontinued soon)	Schwaag Serger and Palmberg 2022 OECD 2016
	Strategic Innovation Program	Vinnova, Energimyndigheten and Formas (Swedish Research Council for Sustainable Development)	Since 2012 (ongoing)	Grillitsch et al 2019 Åström et al 2020
	National Research programs	Formas; Forte (Swedish Research Council for Health, Working Life and Welfare); and Vetenskapsrådet (the Swedish Research Council)	Since 2017 (ongoing)	Arnold et al. 2022b
Finland	Flagship programs	The Academy Finland	Since 2018	Borras and Schwaag Serger 2022 Arnold et al 2022a
Netherlands	Mission-Driven Top Sectors and Innovation Policy (MTIP)	Ministry of Economic Affairs and Climate Policy (EZK), together with Ministry of Education, Culture and Science (OCW) and five line ministries.	Since 2018	Janssen (2020)

3.1. Sweden

National context for transformative innovation policy

Sweden can be considered to be one of the pioneers when it comes to identifying the need for a more transformative innovation policy. The 2009 Lund Declaration, adopted in the context of the Swedish EU Presidency, put a focus on addressing grand challenges through research and innovation policy instruments. Further, the first program that might be classified as a transformative innovation policy at national level in the European context was the challenge-oriented innovation program that was launched in 2011 by the Swedish Government Agency for Innovation. In 2016, however, the OECD provided a rather lukewarm assessment of Sweden's pivot to transformative innovation policy, stating that:

> "Sweden has yet to take up the opportunity offered by the Lund Declaration and to place efforts designed to tackle societal challenges at the heart of a distinctive national research and innovation strategy. Efforts so far have remained modest and piecemeal, and have not been sustained by an overall vision of how the system as a whole might develop, nor the direction it might take. In particular, there has been no indication of how a strong emphasis on societal challenges might fit into an overarching long-term strategy for support capable of satisfying the needs of all relevant stakeholders." (OECD 2016 p.17)

In recent years, government has placed an increasing emphasis on societal challenges as a point of departure in the formulation of research and innovation policies and programs. The 2016/2017 governmental Research Bill presented a ten-year research and innovation agenda to address a number of societal challenges that were prioritized by the central government: climate and environment, health, increased digitalization, sustainable society and improved quality of primary education. These challenges were to be translated into National Research Programs, to be implemented by three profile research councils, with an aim to strengthening research and innovation that meets societal challenges. While introducing a thematic orientation in the research agenda was an important departure from

previous R&I policy in Sweden, none of the areas in themselves were particularly novel in relation to how research funding has been prioritized in the past.

The design of innovation programs has also evolved to target new actors and processes, including efforts to promote innovation in the public sector, social innovation and innovation procurement (e.g., Engström 2019). Further, two of the largest governmental research and innovation funding agencies, the Swedish government agency for innovation (Vinnova) and the Swedish research council for sustainable development (Formas), have firmly embraced Agenda 2030 and the system transformation paradigm as guiding framework for their work. Also, efforts have been made to increase the cooperation and joint programming among several of the research and innovation funding agencies (particular in energy, environment and social policy), as well as with funding originating at the EU level, to enable organizations to address deeply rooted, complex and multidimensional societal challenges through a broader mandate, larger budgets and a larger toolbox of support instruments.

Sweden differentiates itself from many other countries in the fact that government agencies tend to be stronger and more independent from central government. This characteristic provides agencies, such as Vinnova, Formas and other R&I funding agencies, with relatively large freedom to act and take initiative, and to channel resources to strategic initiatives that are increasingly aligned with a transformative R&I approach. At the same time, it can pose challenges with regard to policy coordination at the national level, as well as risks associated with a lack of broad ownership within the national government.

Lessons from transformative innovation policy instruments in Sweden

Since 2011, Sweden has launched three national programs with an explicit ambition to address societal challenges through research, innovation and practical applications: 'Challenge-Driven Innovation-Societal Challenges as Opportunities for Growth' ('CDI') launched in 2011 (led by Vinnova), 'Strategic Innovation Area Program,' ('SIP'), launched in 2012 (led by Vinnova together with Energimyndigheten and Formas) and 'National Research Programs' ('NRP') launched in 2017 (led jointly by Formas, Forte and Vetenskapsrådet).

CDI supports collaborative initiatives which seek to provide solutions to societal challenges and thus contribute to the SDGs in Agenda 2030, and targets companies, institutes, universities and public sector actors. Initially, the program comprised four thematic areas: competitive industries, future healthcare, information society, and sustainable and attractive cities (Vinnova 2016). However, since 2018 these thematic areas have been replaced by a general orientation of the program towards Agenda 2030 and the SDGs (Ramboll 2019b). The program places a strong emphasis on multidisciplinarity, and there is a clear focus on 'boundary-transcending collaborations,' on achieving systemic change and on an international reach. As of January 2020, Vinnova had funded 731 projects with net funding close to 200 million Euros in total (Ramboll 2020), amounting to around 22 million Euros per year on average (Schwaag Serger and Palmberg 2022).

The purpose of the *SIP program* is 'to create conditions for strengthened international competitiveness and sustainable solutions to global societal challenges' (Vinnova 2013, p. 3). Specific goals are to renew Sweden's innovative strength in a number of strategic areas, to develop new value chains and to strengthen cross-sectoral competence, knowledge, technology and service development (Vinnova 2013). An important feature of the SIP program was that the selection of the strategic areas was based on a bottom-up process, where innovation actors were invited to work together to define common visions, objectives and strategies. As of December 2020, there were a total of 17 SIP programs including lightweight materials; metallic materials; mining and metal extraction; production 2030; process industrial information technology and automation; aeronautics; graphene; ICT electronic components and systems; Internet of Things; bio-innovation, among others. Between 2013 and 2029, when the program is expected to come to an end, the total government funding allocated to the

partnerships is projected to amount to around 800 million Euros (Schwaag Serger and Palmberg 2022). Thus, an average SIP program is significantly larger, and longer, than the average CDI project.

The purpose of the *NRP* was to strengthen research and innovation that meets societal challenges that the Swedish government has identified in the Research Bill 2016/2017. In order to succeed in this, the programs also have the objective to strengthen cooperation between researchers, research funders and other actors in society. Seven research programs were funded between 2017 and 2021, with total allocated funding of approximately 350 million Euros to the areas of climate, sustainable spatial planning, health, welfare, working life research, food and migration. Each program had a committee of 'problem-owners' that was responsible for setting the research agenda based on the societal needs that the programs aimed to target (Arnold et al. 2022b).

Both CDI and SIP have been subject to evaluations commissioned by Vinnova (Ramboll 2019b, 2020; Åström and Arnold 2020, Åström et al 2020) and academic study (Palmberg and Schwaag Serger 2017; Grillitsch et al. 2019; Borras and Schwaag Serger 2022). Below are some key takeaways from these evaluations/analyses, as they are presented in a recent overview by Schwaag Serger and Palmberg (2022).

Both UDI and SIP programs were found to have clear *transformative ambitions*, as they seek to tackle societal challenges and to promote transformative change and involve and engage a larger group of stakeholders than traditional innovation promotion programs in the past. The evaluations conducted to this date (e.g. Grillitsch et al. 2019, Ramboll 2020) find however that these transformative ambitions have only partially been integrated in the design and implementation of the programs. One observation is that the transformative long-term goals of the programs are not sufficiently well-translated to the specific objectives of the underlying projects/partnerships that receive funding, that have predominantly been formulated on the actor and network or consortium level, rather than on the institutional level. Also, both programs are national by design – a limitation that is inherent in national innovation policy, but that becomes very significant when it comes to programs that envision to contribute to transformation would go well beyond the national borders.

The programs were assessed to have *limited directionality*, both at program and project level. Both programs are found to be rather non-prescriptive in their orientation, limiting themselves to pointing broadly to Agenda 2030 or societal challenges as guiding frameworks. The emphasis of both programs is clearly on actor-identified and -driven areas and initiatives as opposed to top-down steering and priority-setting.

Although involving 'problem owners' and other users or relevant stakeholders is a part of design of both CDI and SIP programs, in practice both *demand-articulation and orientation* have been assessed as rather underdeveloped. The evaluation of six of the 17 SIP programs concluded that the user- or needs-driven perspective was rather neglected (Åström and Arnold 2020). Similarly, the evaluation of CDI (Ramboll 2020) finds that the projects were characterized by a strong focus on technology and technological development, and not sufficiently addressing the importance of regulatory issues, developing viable business models, and overcoming barriers to market entry. Here it is important to note that market-creating instruments, such as innovative public procurement, are largely beyond the remit of the agencies running the programs, which means that appropriately integrating these perspectives would require engaging other parts of the government.

Policy coordination has been a challenge for the CDI and SIP programs, both at the project and program levels. The evaluations and analyses identify a number of key components of addressing system and especially transformational failures that these programs do not seem to address in their current form or implementation, and which have bearing on, or are explained by lack of policy coordination. These relate to the institutional environment (including regulatory conditions) and other framework conditions, and change and conflict management (e.g., how to deal with 'incumbents' and

the ‘losers’ of socio-economic transitions), but also policy mixes and governance (see, e.g., Grillitsch et al. 2019; Ramboll 2019a, 2020; Borras and Schwaag Serger 2022). In many cases, the absence of elements to address these types of failures can be explained by the fact that the agencies responsible for these programs do not have the tools nor the mandate to address these issues.

Further, in CDI and SIP programs there has been a clear ambition to promote *new interactions and partnerships* across sectors, disciplines and actors. The CDI program involves a broad range of stakeholders in a structured process to formulate priority areas while the SIP programs encourage actors from different industries, disciplines and sectors to work together in formulating strategic visions, agendas and roadmaps. Several examples illustrate that the programs indeed have been able to activate new types of interactions and partnerships, even in areas that are relatively established. Nonetheless, the programs are so far less explicit in their efforts and approaches to overcome path dependencies and lock-ins, which often connects to the pronounced role of incumbents in the implementation of the programs.

In the recent evaluation of NRP, Arnold et al. (2022b) point to a number of quite similar challenges that have limited the potential impact of the research programs, including following:

- The societal challenges that were at the heart of the programs were generally too broadly formulated to be guiding in terms of what change the programs were aiming to achieve. The design therefore was reliant on broad and systematic stakeholder dialogue to feed the content of the programs with specific societal needs.
- While the design of the programs put a lot of emphasis on the user perspective, which was also integrated in the governance of the programs through including the ‘problem-owners’ in the program committees, the implementation did not live up to this ambition. Specifically, the mandate of the committees was often unclear, the legitimacy of including other actors than research funders as members of the program committees was questioned, and the influence of the committees appeared to decline once the first agenda was written. In addition, some of the programs went ahead with the first calls before the program agenda was in place.
- The research agendas that were developed together with the stakeholders were not utilized to drive the contents of the calls to the level that would be expected given the explicit challenge-oriented ambition of the programs. Specifically, the content of the calls only partially mirrored the knowledge gaps that were specified in the research agendas.
- The NRPs have been “prisoners of the funders’ usual rules, instruments, and practices” (p. 4) and were strongly influenced by the strategic, management, and funding rules and traditions of the lead agencies. This has effectively led the challenge-based research programs to transition to rather traditional (thematic) research programs, with a strong focus on traditional funding instruments for university research and generating new knowledge, and less on understanding societal needs, experimentation, mutual learning, utilizing and disseminating new knowledge.

One of the important values of the NRP so far has been the creation of the platform for collaboration between research councils, thematic agencies, universities and, to a certain degree – a broader group of societal stakeholders, which creates a stronger basis for multi-agency and multi-actor initiatives going forward.

3.2. Finland

National context for transformative innovation policy

Finland made substantial investments in development of its system for research innovation from early 1990s to most of the 2000s, including strengthening its R&I funding institutions like TEKES (the funding agency for innovation), SITRA (the Finnish innovation fund), VTT (a state-owned Finnish technical research institution), and the Academy of Finland. The Research and Innovation Council

played a key role in providing strategic leadership and governance. This period also saw a significant development of applied industrial research. The trajectory changed however in early 2010s, as a result of the economic crisis and political decisions, followed by refocusing of the R&I system towards basic research on the one hand and support to high-potential entrepreneurship on the other, which resulted in a significantly reduced capacity for innovation and collaborative industry-led research (Fagerberg and Hutschenreiter 2020; for an overview of the changes in Finland's R&I funding environment see also Deschryvere, Husso and Suominen 2021; OECD 2017 and Schwaag Serger et al. 2023).

In mid-2010s, the Government of Finland sought to strengthen the contribution of the research and innovation funding in Finland to tackle major societal challenges. The SRC (Strategic Research Council), created in 2914 and chaired by the Prime Minister, focused on strategic, problem-oriented research, addressing government-determined societal challenges, with an explicit emphasis on supporting and strengthening policymaking. Between 2015 and 2018, the key priorities of the SRC funding included: a climate-neutral and resource-scarce society; equality and its promotion, health and the changing of lifestyle, overall security in a global environment, dynamics of urbanization, and migration. Approximately 55 million Euros have been distributed annually through this mechanism (OECD 2017).

Focus on societal challenges, and transition to sustainable society in a broad sense, as stipulated in Agenda 2030, has also been integrated in instruments supporting scaleup and internationalization of innovative products/solutions. Business Finland and VTT Technical Research Centre of Finland, have over the past years reframed their innovation support through a lens of SDGs, providing funding in areas that include clean energy, renewable raw materials, the circular economy, and health (PMO 2020).

The Government of Finland introduced in 2014 multi-year national innovation strategies within the areas of health, bioeconomy and sustainable urban development, that were implemented with involvement of multiple line ministries, research funders, innovation support agencies, cities and private and public organizations. The sustainable urban development strategy also mobilized co-funding through the European Regional Development Fund.

Further, the Ministry for Economic Affairs and Employment of Finland (MEAE) has in 2020 launched the National Roadmap for research, development and innovation (RDI). This roadmap emphasizes the importance of continued RDI investments to maintain a strong competence base, a new partnership model to strengthen university and industry collaboration, innovation ecosystems facilitation, and the importance of an innovative public sector. The MEAE has also launched a national study to create an SDG Finance roadmap to strengthen synergies between Agenda 2030 and innovation policies (Schwaag Serger and Palmberg 2022).

In 2021, the Finnish government commissioned an evaluation of the Academy of Finland, with the objective of providing "a comprehensive view of the activities of the Academy of Finland based on international and national expertise and to find means for improving the Academy's impact, operation and structures". One of the key conclusions of the evaluation was that "Finland has not evidently reprogramed significant amounts of R&I effort towards the societal challenges or made organizational responses to these challenges" (Arnold et al. 2022a p.127). More generally, the evaluation pointed to the lack of a holistic approach to research and innovation policy at national level. One consequence of this lack was "an inability for the Finnish policy system to make a structural response to the societal challenges" (p.140). The evaluation argued that this was particularly problematic since, "[i]f the 'innovation systems' paradigm under which the RIC succeeded required holistic policy, tackling the societal challenges or 'third generation' R&I governance does so even more" (p.140).

With the Flagship program and the SRC, the Academy has implemented new instruments in response (at least partly) to the need to tackle societal challenges. However, the lack of a portfolio perspective at

the Academy combined with the absence of a holistic approach to R&I policy at the national level undermine the ability of these initiatives to contribute to the transitions required to tackle such challenges. The evaluation pointed to insufficient funds for management and administration as an important factor preventing the Academy from advising and supporting the Finnish R&I policy and system in tackling societal challenges (Arnold et al. 2022a).

Lessons from transformative innovation policy instruments in Finland

The Academy Finland launched its Flagship Program in 2018, as part of government initiatives toward 'economic and societal renewal', to promote strategic research and the commercialization of research, and to strengthen ecosystems (European Commission 2018). The program seeks to address concerns about the fragmentation of Finnish research (OECD 2017), and requires that flagships target 'sustainable solutions to societal challenges and advancing economic growth' (Borras and Schwaag Serger 2022).

According to the Flagship program call text (2018), "a flagship is an effective mix of cutting-edge research, impact in support of economic growth and/or society, close connections to the business sector and society at large, adaptability, and a strong commitment from host organizations to meeting the set targets. Flagships are high-quality, high-impact competence clusters that work in flexible ways, simultaneously running several research projects and other activities" During the first three years of the program, ten Flagships had received funding. Six of these programs had during their first two years of operations secured approximately €530 million in funding, most of which came from sources other than the Academy of Finland, including the host organizations, Business Sweden, EU structural funds, companies and other domestic public funding.

Below are some key takeaways from these evaluations/analyses, as they are presented in a recent analysis by Borras and Schwaag Serger (2022).

The Flagship Program has been assessed to have limited *directionality*. The ten flagships funded between 2018 and 2020 were selected covering very diverse areas, and only the last four of them have shown an increasing orientation toward addressing grand challenges: on atmosphere and climate; chronic disease treatment through gene, cell and nano therapy; the immune system; and forest-human-machine interplay. The program has at least initially focused strongly on scientific excellence, while being less oriented toward creating spaces for experimentation and risk-taking in a transformative manner. However, there has been a gradual shift towards addressing grand challenges in later stages.

The *policy coordination* is overall assessed as rather weak. Borras and Schwaag Serger (2022) point out that there is no apparent integration with, or linkages to, sectoral policies or agencies, and no indication of conscious efforts to view or describe the Flagship Program as part of a policy-mix. Yet, some indirect policy-mix discussions are taking place at the flagships, e.g. the collaboration of the welfare state flagship with regulators on new developments and combinations of welfare interventions and regulations. Also the cross-agency collaboration is overall assessed as limited, to a few interactions per year with Business Finland. This points to a more general problem of a growing divide or even disconnect between highly commercially oriented R&D and innovation support programs (currently run by Business Finland), and programs for funding excellent academic research. Yet, it is important to note that the program also has been one of the most successful in Finland this far in terms of mobilizing a variety of financial sources, including EU structural funds and domestic (national and regional) funding, which indicates that there indeed is a certain alignment of goals and priorities, even if it is not made explicit.

Demand articulation and *stakeholder involvement* can be argued to be limited in the way the program is designed since, at least initially, only universities and public research organizations could be funded by the program. This is a significant limitation in terms of the transformational potential of the program, as the mechanisms for transformation, specifically in terms of promoting practical

applications and dissemination are not clear. Some of the flagships have been exploring alternative ways to engage with stakeholders outside the consortia, for example by attracting funding from Horizon 2020.

Overall, the focus of the flagships has not been on *transformative dynamics*, but rather on excellence of scientific research. While there is an implicit assumption that scientific breakthroughs from the individual flagships will bring transformative effects, the program was not designed to enable or facilitate that to any significant degree, nor to promote synergies between projects in view of enhancing their potential transformative effect.

3.3. Netherlands

National context for transformative innovation policy

The OECD innovation review from 2014 described the Dutch innovation system as advanced, relying on a strong technological and knowledge base, and underpinned by several strong institutions on the national level, including TNO (the Netherlands Organization for Applied Scientific Research, founded in 1932), the Royal Netherlands Academy of Arts and Sciences (KNAW) and the Netherlands Organization for Scientific Research (NWO). The Netherlands started to systematically promote cooperation between industry and knowledge institutions in the mid-1990s. This national policy led to the creation of innovation contracts, which provided a framework for collaboration between the government, industry, and knowledge institutions on research and development projects. Following that, in the early 2000s, the Dutch government introduced the "Pieken in de Delta" (Peaks in the Delta) program, led by the Ministry of Economic Affairs, which focused on strengthening the innovation capacity in selected sectors. The program identified nine key sectors, including water, agri-food, high-tech systems and materials, energy, chemicals, life sciences and health, horticulture, creative industries, and logistics. The program was reframed as Top Sectors in 2011 and aimed to promote innovation in the selected sectors by providing funding and support to companies, research institutes, and universities. It also aimed to encourage collaboration between the government, industry, and knowledge institutions to promote innovation (Janssen 2020).

Parallel to that, the Dutch government has attempted to integrate transformative objectives into the design of its R&I policy. In 2002, Dutch policymakers adopted the transition management approach (Rotmans et al. 2001, Kemp et al. 2007, Loorbach 2010), which was also led by the Ministry for Economic Affairs. They established a number of transition platforms composed of individuals from the private and public sectors, academia, and civil society to focus on issues relevant to the transition to sustainability. The outcome was a "transition action plan" that set ambitious goals for reducing greenhouse-gas emissions, enhancing energy efficiency, and proposing concrete initiatives to support the transition in various ways, including through the use of demand-side instruments. While the program was officially discontinued in 2011, following a general election and a subsequent change of government (Fagerberg and Hutschenreiter 2020), the focus on societal challenges in the innovation policy has reemerged through the Top Sector program, that in 2018 was reframed as the Mission-Driven Top Sectors and Innovation Policy (MTIP). The decision to shift the overall ambition of the Top Sector program from economic growth and competitiveness to producing concrete solutions for societal challenges was subsequently endorsed by the whole cabinet of ministers of Netherlands, which “effectively makes it a truly national policy, rather than just a departmental one” (Janssen 2020: 14).

Lessons from transformative innovation policy instruments

The MTIP is currently one of the most comprehensive mission-oriented strategic frameworks in OECD countries, that aims to systematically organize the interactions between economic sectors and societal missions, targeting 25 missions in four overarching areas: (1) energy transition and

sustainability, (2) agriculture, water, food, (3) health and healthcare and (4) security. MTIP is governed by a high-level committee on the overall strategic level, consisting of representatives of key ministries, industry, research councils, regions and stakeholders (Larrue 2021). The mission themes were formulated with involvement of line ministries carrying responsibility for the societal domain in which one can find the problems addressed by the missions, aiming to contribute to a broad anchoring of the policy setup across the government. Further, each Topsector consists of a Topteam of high-level representatives from science, industry and policy, and one or more 'Topconsortia for Knowledge and Innovation', that together are responsible for creating and implementing the Knowledge and Innovation Agendas (KIAs) for the missions. Implementation of each mission is coordinated by a mission team, with representatives from science, industry, policy and other stakeholders. Most of the missions are "owned" by two ministries, reflecting the cross-cutting nature of the envisioned transformations.

Despite its scope and ambitions, MTIP involves relatively little new funding, and operates mostly by influencing the use of current policy instruments controlled by the involved ministries and R&I funding institutions (Janssen 2020).

While no formal evaluation of the MTIP has yet been conducted, Janssen (2020) has undertaken an initial analysis of the setup shortly after its launch, where he articulates some potential challenges with the setup, based on the early experiences:

- The program has clear *transformative ambitions*, manifested in several ways: the overall policy intention to leverage the Top Sector structure to address societal challenges, the governance mechanism that is intended to identify and prioritize real-world problems and address them with innovation-based solutions, and the formulation of quantified and time-bound missions. Some concerns have however been raised at the early stage in terms of how flexible the existing structures around the Top Sectors will be to adopt a new set of goals; whether they will be able to break out of the silos and to "spur cross-sectoral, multidisciplinary and integrated solutions".

- While concrete, quantified and timebound targets would imply a high level of *directionality*, in practice, this comes with significant challenges. First, a large number of missions that are inherently related (e.g. circular economy, sustainable agriculture and energy reduction) with a lack of explicit alignment of targets, creates confusion about how these interrelate, and what it means for the implementation. Second, as the setup of the program is solution neutral, the formulation of missions in itself does not provide guidance as to how these should be approached, which instead relies on the ability of the governance structure to provide guidance and priorities. This in turn has been difficult, at least during the initiation phase of the program, due to complex governance structure, large number of stakeholders involved and unclear mandates of different levels of program governance. In practice this implies a risk that "(too) many solution directions are being pursued simultaneously, while actually there might already be signals regarding which directions are more promising than others", and that "as long as there is no consensus which solution directions and applications to focus on, many investments and synergies might remain out of reach" (Janssen, 2020: 37).

- The *policy coordination* is overall assessed to be high due to several factors related to the program design. In particular, through the embeddedness of the MTIP in the existing Top Sector program, extensive engagement of the innovation system actors, including major R&I funding institutions, broad ownership from the side of line ministries (and alignment with the policy development goals in respective areas), and the setup that implies that the program should primarily be realized through the use of existing instruments, which effectively makes it a coordination platform around the specific missions. In addition, formulation of some of the missions is closely aligned with the national Climate Agreement, and indirectly, to the Paris

Agreement. Still, challenges to policy coordination exist, particularly due to involvement of various ministries and regional authorities, which may crease an "illusion of a common goal, while each individual government then sticks close to its own objectives" (Janssen 2020:34).

- Broad *stakeholder involvement* in the setup and governance of the missions is overall considered a key strength of the program, as well as embeddedness in existing structures and networks, that allows for effectively setting up consortia for design and implementation of projects fitting the missions. Yet, there are concerns that agencies providing funding will exercise more power over the agendas of the missions. Janssen (2020) points further to a need to strengthen the user perspective, by closer linking up with parties who are involved in adopting the solutions, and more focus on addressing adoption challenges in the implementation of the program.

3.4. Summary and reflection

The key observations from the selected cases are summarized in Table 2 below.

Table 2 Summary of the cases

	Transformative ambitions and directionality	**Policy coordination**	**Stakeholder engagement and demand articulation**	**Program resources**	**Learning and renewal mechanisms (reflexivity)**
Sweden					
CDI	Well-specified on project level, not for the program as a whole	No clear policy-mix complementarity.	Overall, wide stakeholder involvement, but lacks regulatory and market creation tools.	The instrument funds small projects and is thus only appropriate for initiation/ experimentation	The program was evaluated and further developed at several stages
SIP	Formulated in broad terms on program level, not specified for the specific partnerships	Limited with regards to e.g., regulatory and other framework conditions, change and conflict management (incumbents, "losers")	The partnerships engage actors from different industries, disciplines and sectors, but largely lack market creating tools.	The partnerships are well-funded and can run up to 12 years.	The program was evaluated and further developed at several stages, including broadening the agenda and strengthening stakeholder involvement.
NRP	Societal challenges generally too broadly formulated to be guiding in terms of what change the programs were aiming to achieve		Clear user perspective in the design, however not fully integrated in the implementation (legitimacy issues, unclear mandates of the program committees)	Significant funding, however likely too thinly distributed over many areas.	n/a
Finland					
Flagships	The goals for transformative change were not formulated	Limited cross-agency collaboration. No clear policy-mix complementarity.	Knowledge creation is the main instrument used. Some of the flagships engage stakeholders (mostly businesses), but it is not integrated in the design and not funded by the program.	The flagships are well-funded and attract significant amounts of co-funding. The funding period is 4+4 years.	Some learning with regards to formulation of call themes has been integrated in the design.
Netherlands					
MTIP	Formulated in broad terms on the program level, well-specified on the mission level.	High, due to embeddedness of the MTIP in the existing Top Sector structure, goal and policy mix alignment through line ministry engagement, and extensive use of existing instruments.	Broad stakeholder involvement in the setup and governance of the missions, and related governance challenges. Concerns about power imbalances on funding decisions, need to strengthen the user perspective and address adoption challenges.	Little new funding. Operates mostly by influencing the use of current policy instruments controlled by the involved ministries and R&I funding institutions. Some targeted complementary funding for increased adoption/diffusion.	Concerns about lack of strong leadership/mandate to translate gained experiences to program priorities. Risk of conservation of current structures through inert actor constellations.

Below are some reflections based on the results of the case analysis.

Path dependencies create barriers to re-orienting the R&I support system towards transformative goals. Overall, all of the countries that we have looked at seem to be experiencing significant path

dependencies with regards to the structure and operation of the R&I support system. This creates barriers to re-orienting the R&I support system towards transformative goals, due to the dominant role of existing actors, structures, governance frameworks, funding mechanisms, evaluation practices, and resistance from the scientific community to perceived changes in the power balance between 'society' and 'research'. While the academic literature on TIP has produced a substantial repository of knowledge on instruments and approaches for design and implementation of TIP, the practice systematically lacks behind, which illustrates the inherent difficulties in aligning governance with the transformation imperative.

Notable differences in transformative orientation of the innovation systems in Sweden, Finland and Netherlands. In the case of Sweden, we assess the transformative orientation of the innovation system as moderate. Some of the factors contributing to the transformative orientation are industry leadership, public support for sustainability, large degree of independence of agencies that pursue TIP initiatives, and the emergent meso-level governance of TIP initiatives. The limiting factors include lack of clear ownership of a transformative R&I agenda at the national policy level, which makes the transformative agenda vulnerable to changes in policy priorities with regards to both political rhetoric and budget allocations, especially in the face of recent macroeconomic and political turbulence, and results in significant shortcomings regarding policy coordination (horizontal and vertical).

In the case of Finland, we assess the transformative orientation of the innovation system as rather low. The limiting factors include the overall weakening of the innovation part of its eco-system over the past decade, the less pronounced central government ambition to prioritize transformative change in the economy (that may be perceived as competing with the perhaps more acutely felt need to promote growth and competitiveness), and single agency-led implementation of TIP initiatives, also resulting in vulnerability of a transformative agenda and a lack of horizontal and vertical policy coordination (partially explained and illustrated by the erosion of the strength and purpose of the R&I Council).

In the Netherlands, we assess the transformative orientation of the innovation system as rather high. Some of the contributing factors are the broad government ownership through cross-ministerial cooperation on MTIP, and the history of applying a system transformation perspective to innovation policy, and thereby substantial actor knowledge about how system transformation can be induced. The high level of embeddedness of the MTIP in the existing Top Sector structure may however also be a limitation to transformativeness, reinforcing rather than reforming existing structures.

Directionality remains a common challenge despite different approaches to goal setting. The initiatives implemented in both Sweden and Finland exhibit limited directionality largely due to the lack of concrete goals in terms of what change the programs are aiming to achieve, but also how this change is to come about (transformation pathways), although in Sweden this is partially compensated by more concrete partner-driven agenda on the project level. MTIP in the Netherlands is an example of a different approach goal setting, where the goals are well-specified and quantified on the mission level. Challenges to directionality remain however, as a result of lack of explicit alignment of targets in related areas, and significant openness in terms of transformation pathways, where the current governance structure in providing only limited guidance and leadership in terms of direction and change mechanisms.

Various levels of stakeholder engagement between the analyzed policy initiatives, where high levels of engagement create a new set of challenges. In the example of Flagships in Finland, stakeholder engagement is least pronounced in the design and implementation of the program, contributing to low level uptake and practical application of the results of the research programs. While the Swedish NRP program attempts to widen stakeholder engagement, the effectiveness of this is in practice limited, due to legitimacy issues and unclear mandates of actors other than the research funders in setting the agenda. Experiences gained from the MTIP in the Netherlands illustrate a different dynamic, where broad stakeholder engagement contributes to a complex governance structure, that in turn may

constrain decision-making, agility, and opportunities for upscaling of promising solutions and realizing synergies between different areas. High stakeholder engagement may therefore come at a price of a weaker leadership.

4. Findings and policy lessons

In this chapter, we have reviewed and synthesized research and evaluation findings from five R&I programs implemented in Sweden, Finland and the Netherlands over the past decade, that all have an explicit ambition to contribute to transformative change by addressing societal challenges. The programs were designed and implemented in their specific national contexts, that we have addressed in the respective country section, and vary significantly in terms of objectives, scope, governance and setup. In most of the cases, it is too early to assess fairly the impact or outcome of these policies, but there are valuable lessons to be learned from the design and implementation of these.

Below, we summarize our findings, and suggest a number of policy lessons that may be valuable for future work on design and implementation of TIP initiatives.

- Overall, we see *rapidly increasing efforts* to design and implement innovation policies that tackle societal challenges and drive transformation and systemic change. While in mid-2010s, only a small fraction of R&I policies had explicit ambitions to address societal challenges, today this is underway to becoming a common practice in R&I policies in OECD countries. Increased learning on the design and implementation of TIP, including real-time observation, reflection and structured cross-country analyses, is therefore key to leverage this momentum.

- In many cases, the implementation *falls short of transformative ambitions*, due to a combination of several factors. The *under-conceptualization of the transformation* itself is an important factor, which includes a lack of clarity on the system definition and boundaries, transformation goals, actors and theory of change, which goes hand in hand with *too narrow framing of initiatives*, under-involvement and under-utilization of key stakeholders. Another important factor is *lack of policy coordination*, that relates both to the, to this day rather pronounced, need to strengthen coordination and joint action between innovation agencies and line ministries and their implementing bodies on the national level, and the coordination within the innovation system itself, including the EU, national and regional level. Other factors include *path dependencies in the R&I support system* and overreliance on existing instruments, logics and governance structures.

- Transformative R&I policies are introduced *in a context of more traditional first- and second-generation R&I policies* (see also Smink et al. 2015, Diercks 2019, Janssen et al 2021). This creates *frictions and tradeoffs*, e.g., with regards to perceived conflict with the growth and competitiveness imperative, incumbent interests, and the problem of 'losers', that need to be acknowledged and addressed, to provide better strategic and practical guidance on the 'how' of transformative R&I policy.

- '*Missions*' have rapidly become the most popular approach to design (and particularly goal setting) in transformative innovation policies. While they may be impactful as a tool, it is important to understand that 'missions' is not the only way to design TIP, and may not be the best way. In particular, formulation of quantified and time-bound goals does not necessarily solve the issue of *directionality*, as illustrated in the case of MTIP in this chapter. The usefulness and limitations of mission approach needs to be scrutinized much more than it has.

- It is important to acknowledge that both *top-down and bottom-up approaches to defining the direction* for transformative change have their limitations, and we need to further discuss what are the possible applications and combinations of these, that will bring the necessary change. While the top-down approaches require wide mobilization of stakeholder support, political leadership, and long-term commitment, they may still fall short, in the face of fast-changing environment and the emergent grand challenges that are hard to foresee (e.g., the Covid pandemic, Russia's war on Ukraine, and overall deteriorating global security). The bottom-up approach, while being superior in ensuring ownership and support among the innovation actors, often falls short when it comes to directionality and coordination, which risks resulting in smaller-scale initiatives with a lack of focus and unclear theory of change, in terms of how the efforts are to contribute to the system-level transition at the scale that is needed. The approaches must also be sensitive to whether the challenge at hand implies a low or high degree of disagreement on intended outcomes and envisioned change (e.g., Stacey and Griffin 2007, Janssen et al. 2021).
- There is a need to move beyond initiation and experimentation, towards *taking solutions to scale*. This requires more focus, both in research and in policy practice, on system destabilization and phasing out current solutions and alignment of laws and regulations. This also requires strong leadership and mandate to set priorities, (re)allocate resources and if needed discontinue ongoing initiatives. The latter has so far proved very challenging, especially in cases with broad stakeholder involvement and complex governance structures with unclear mandates. Another potential way of taking solutions to scale is through better *utilization and leverage of partnerships that are already in place* and have experience in implementing joint agendas to address societal challenges. These may include existing intergovernmental partnership that are well rooted at the national level (i.e. have built-in mechanisms for coordination), e.g. Nordic Council of Ministers and EU macroregional cooperations.

A final, key conclusion from our analysis, is that policies are not designed or implemented in a vacuum. National contexts, path dependencies, institutional and framework conditions all play significant roles in shaping policy design, practice and effects. At the same time, comparing appropriate policies in different national contexts, as we have attempted to do here, reveals interesting similarities and differences that can serve to inform future policymaking. Finally, one might question whether we have selected and compared the appropriate policies or whether our analysis suffers from a selection bias. Cross-country comparisons of policies are never perfect for the reasons we have listed above. Nonetheless, we think that juxtaposing policies with comparable purposes or ambitions, as we have done, is a valuable tool for uncovering both peculiarities and common features in governments' attempts to drive transformation through research and innovation policy.

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