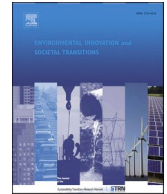




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## How does transformative innovation policy travel across physical and cognitive spaces? Exploring the role of mutable fluid space in experimental policy engagements

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### ABSTRACT

The growing call for public policy to begin addressing more robustly the challenges posed by sustainability transitions puts the onus on researchers to study how new meta-frameworks of transformative innovation policy and accompanying practices are implemented, applied, and received when they travel across different geographies. We discuss this question by tracing debates with reference to geography of sustainability transitions, policy mobility and actor network literatures. A methodological approach to analyse a cross-country policy initiative is developed and examined through three experiments of transformative innovation policy in diverse policy organisations with different missions and in contrasting geographical and professional spaces. The discussion highlights the relevance of building what we call mutable fluid spaces between academics and policy makers and its importance for transferring transformative innovation policy across geographical spaces.<sup>1</sup>

### 1. Introduction

The growing call for science, technology, and innovation (STI) policy to address more directly the challenges posed by social and environmental crises has focused attention on the policy processes to support sustainability transitions (e.g., see [Lundin and Schwaag, 2018](#); [Schot and Kanger, 2018](#); [Steward, 2012](#); [Weber and Rohrer, 2012](#)). This includes a call for the development of a new “meta-framework” for STI policy ([Schot and Steinmueller, 2018](#)) that is applicable across different geographies. A policy meta-framework for sustainability is a potent concept, implying the ability to articulate imaginaries, policies, public funding and private investment around common themes<sup>2</sup>. However, this also requires a careful re-visiting of how we understand policy transfer and

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<sup>1</sup> The concept of space in this paper is used in a flexible manner and refers to where different human practices take place ([Harvey, 2006](#)). See further discussion in [Section 4](#). The words place, physical space, geographical space or spatial(ity) are used interchangeably to refer to practices in three-dimensional coordinates or on a map or grid. Other meanings of space are also used, such as network space or fluid space that are defined in the text but have different scales and are governed by diverse processes of learning. By country we refer to a spatially defined policy jurisdiction.

<sup>2</sup> The rise of “missions-led innovation” similarly reinforces the popularity of meta-frameworks to guide policy frames.

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the policy processes that support sustainability practices across different physical spaces.

The sustainability transitions literature, or more specifically that part of it associated with the geography of sustainable transitions (Coenen et al., 2015; Hansen and Coenen, 2015), embraces the principle that it is necessary to understand and incorporate the complexities that specific places imply for sustainability transitions. Yet the questions of policy transfer, policy scaling and policy adaptation for transformative innovation policy (TIP) remain (Veldhuizen and Coenen, 2022). To address these questions from a sustainability transitions perspective, we suggest that incorporating recent insights from policy mobility and actor-network theory can help us to capture some of this complexity and treat transitions in a spatially sensitive way.

To understand the influence of spatial movement of policy, we focus on two features of the policy mobility and policy process debate. The first has to do with the question of policy governance: in particular, the tensions between conventional top-down versus participatory approaches (Estrella et al., 2000). A second important feature we wish to highlight concerns the cognitive process that takes place as policy frameworks, developed initially by experts such as academics (in reflective but at times closed networks), move into different geographical and cognitive/professional spaces. We work on the assumption that policies are socially constructed and translated within diverse cultural and political environments (Dolowitz, 2017; Kogut and Macpherson, 2011; McKenzie, 2017; Oikawa Cordeiro, 2020). However, as McCann & Ward (2012) comment, these environments can be conceptualised not only in terms of “places”, but also as “network spaces” (that may inhabit the same or different physical space): for example, an academic, policy or industry stakeholder space. This notion of network space derives from actor-network theory (see, e.g., Law and Mol, 2001), whereby the network is a stable configuration of actors, concepts, tools, specific administrative and occupational priorities arising from explicit or implicit rules where a particular configuration characterises a specific professional environment.

The broadening and incorporation of more than one scale of how we understand policy mobility (within the general agenda of sustainability transitions) is critical for understanding some of the complexity associated with the translations involved in replicability and scaling of policies. As the discussion unfolds, we will suggest that the policy processes involve negotiation between different forms of policy governance in different geographies. The dynamics and tensions these negotiations create can help to explain some of the complexities and inconsistencies in both the policy processes and outcomes we observe and help us to understand how new transformative innovation policies travel between different geographies and from academic to policy maker environments.

We explore these ideas through case studies of the experience of three policy experiments (defined in Section 2) under the auspices of the Transformative Innovation Policy Consortium (TIPC). The research and analysis are guided by the overarching question, “How does the TIPC meta-framework for transformative innovation policy evolve when applied across different and contrasting geographies?”. Furthermore, although a comprehensive evaluation of TIPC’s six-year programme is not the main objective of the paper, if we consider evaluation as a formative process built on the principles of learning, this paper may also contribute to understanding how initiatives such as TIPC can be more productive for advancing a policy agenda of sustainability transitions across different countries and geographies.

The paper unfolds in the following way. Section 2 discusses transformative innovation policy and provides an explanation of TIPC, on which the empirical case studies of the paper are based. Section 3 addresses the question of policy transfer through a discussion of policy translation and policy mobility. Two pathways for policy mobility are proposed: an “immutable pathway” in which technocratic approaches to policy are dominant and a “relational pathway” based on principles of policy assemblages. The latter opens-up spaces that are fluid (shared academic and policy maker) and plural (shared by academics, policy makers and industry/civil society stakeholders). As indicated above, we explore these propositions through a qualitative study of three experiments undertaken within TIPC’s six-year collaborative programme between 2016 and 2022. Section 4 describes the methods used for the case studies, and Section 5 details the cases themselves along with reflections on each case. Section 6 synthesises the findings from the cases. The results of the analysis are discussed in Section 7, which emphasizes the varied definitions of places and the hybridity of policy processes in each of these places. The discussion also engages with the complexity of applying common frameworks across different national geographies. Section 8 concludes the paper.

## 2. Advances in transformative innovation policy

We begin the discussion with a brief overview of transformative innovation policy (TIP) which, although still contested (Diercks et al., 2019), appears to be finding some conceptual convergence and broad themes of agreement (Haddad et al., 2022). Fundamental to the development of TIP is the argument that contemporary innovation policy must be focused on overcoming grand societal challenges – such as avoiding climate breakdown, halting biodiversity loss, and eradicating poverty and inequality – rather than just maximising economic growth (Schot and Steinmueller, 2018). The specific characteristics of TIP, as summarised by Haddad et al. (2022), p. 18, are (1) prioritising grand challenges and inclusive growth, (2) setting the directionality of innovation policy, (3) implementing multi-faceted policy interventions, (4) working with multiple actors and global networks, and (5) engaging in multi-level governance.

Different TIP approaches are used in different places but in this paper we analyse in detail experiments conducted through the TIPC programme. A core element of this is to conduct experimental policy engagements – often referred to as policy experiments or, simply, experiments – with policy-relevant actors who are attempting, through various interventions, to address societal challenges (such as those codified in the Sustainable Development Goals, SDGs). In outline, the target of an experiment is decided in collaborative

deliberations between the policy-relevant actors and the TIPC team, primarily academics. This involves all actors in the experiment working to develop a theory of change (TOC) that the experiment undertakes (see the Methods section below for more detail<sup>3</sup>).

The TOC is, in essence, a policy meta-framework, although its application is intended to be place-sensitive and so is intended to “travel” across geographies that are significantly different from each other. The objective of this paper is therefore to understand how the TIPC meta-framework evolves as it travels across different geographies. In the following subsection we engage the relevant literature to develop the framework.

### 3. Framing policy translation in sustainability transitions

Early work in sustainability transitions conceptualised spatial extensions of transitions as an aggregation of practices based on common search heuristics and the establishment of dominant cognitive rules within new stabilised global socio-technical regimes (see for example discussion on aggregation in [Geels and Deuten \(2006\)](#)). However, very few studies have specifically taken up the question of how sustainability transitions policy “travels” between places ([Heyen et al., 2021](#); [Köhler et al., 2019](#)): i.e., policy translation across both time and space. The work that does exist on translation, for example by [Ulmanen et al. \(2022\)](#), focuses on translating policy theory to practice rather than the specific issue of translation of a policy method across physical spaces. Where this is addressed empirically, for example in [Bhamidipati et al. \(2019\)](#) and [Pitt & Jones \(2016\)](#), the focus is on the motivations of specific actors, such as transnationals, in scaling practices “up and out”. But the question of how policy moves, its adaptability (or immutability) to specific places, and the process by which this happens, needs also to be considered through a lens that incorporates policy studies.

We therefore propose an analysis that considers two types of mobilities. These are the mobility and subsequent policy translation dynamics across “physical” spaces, and the mobility across “network” spaces, and the interaction between them. This is consistent with our relational approach that considers how knowledge is constructed in specific places. We discuss these two questions in turn in the following sections.

#### 3.1. Policy mobility for sustainability transitions across countries

The literature on policy translations and TIP – for example, [Ulmanen et al. \(2022\)](#) on within-country translation and [Haddad et al. \(2022\)](#) on creating legitimacy for TIP – has been useful for understanding how policy adapts, but less so for understanding adaptations across countries where the composition of institutions and the make-up of policy organisations can vary considerably. We therefore draw on recent contributions from the area of policy mobility that, as will be argued, can point to some of the dynamics inherent in translation processes across countries and from which some contrasting pathways for policy adoption can be developed. This discussion draws attention to tensions in the implementation process of grounding TIP.

The literature on policy mobility has shifted considerably from the narrower view of policy transfer, in which the knowledge in policy is codified in methods and instruments that are largely immutable as they travel between places, to a greater emphasis on the policy mutations that take place during “transfer” ([Dolowitz, 2017](#); [McCann and Ward, 2012](#); [Savage, 2019](#)). It is relevant to discuss both approaches because, although the academic literature may have changed focus, policy practice still reflects both ways of thinking about policy mobility.

The first of these approaches we will describe as a “technocratic” notion of policy construction that is typically associated with ante development of instruments and indicators that can be established a long way upstream from their intended destination. Such approaches are especially dominant where assumptions of policy processes are based on reductionist discourses that privilege one-way linear flows of information from “technical experts” to individuals ([Rogers, 2010](#)). Within the science and technology field, they are also based on assumptions of “sound science” ([Essex, 2008](#)) that somehow place them beyond public debate. Technocratically dominated approaches to policy construction are also in evidence where evaluation is primarily an auditing and control exercise. In this view, geographical scaling of policy processes is considered largely unproblematic since geographical differences are not considered as an added complexity. Policy transfer, in this line of thought, reproduces the assumptions of linearity of policy.

A contrasting approach is proposed that recognizes the continuous evolution of policy and the impossibility of transferring a policy package intact across spatial scales ([Peck and Theodore, 2010b](#)). Therefore, if we conceive a region as a relational space, where social interaction and connectivity drive and define the nature of change, policy transfer can be profoundly impacted by place-based factors ([Gulson et al., 2020](#); [Stone et al., 2020](#); [Wittmayer and Loorbach, 2016](#)), including by policy experts embedded in epistemic communities ([Kogut and Macpherson, 2011](#); [McCann, 2011](#); [McKenzie, 2017](#)) who guide translation and adaptation accordingly.

The more recent policy mobility literature ([Cook and Ward, 2011](#); [McCann and Ward, 2013](#); [McCann, 2008](#); [Peck, 2011](#)) emphasizes these points by underlining the mutability of policy when moving between locations ([Peck and Theodore, 2010a](#); [Rose, 1991](#)). This can be understood as policy assemblage. From this perspective, assemblage refers to “the process of arranging, organizing, fitting together...[where] an assemblage is a whole of some sort that expresses some identity and claims a territory” ([Wise, 2005, 77](#)).

This debate on mutability or immutability of policy as it travels is highly relevant for our discussion. Some instances of “immutable

<sup>3</sup> See the TIPC website for more detailed information including on past experiments (<https://tipconsortium.net/>), and see the TIPC Resource Lab website for the various tools that can be used for co-creating experiments (<https://tipresourceclab.net/>).

mobiles” (following Latour, 1987; and see Law and Mol, 2001) of policy have been important in case studies of sustainability. For example, specific renewable energy support measures like the German-style feed-in tariff<sup>4</sup> have proliferated globally over the last two decades (cf., e.g., Alizada, 2018; Baldwin et al., 2019; Zhou et al., 2019). Nevertheless, the way policies are applied can hide important alterations and changes that reflect differences in how systems have arisen. Strong collective identities mean places can respond differently to global trends. Therefore, transition dynamics can occur in different ways due to institutional variation and because of actors’ different abilities to express collective voices.

The assumptions underlying the technocratic and more relational framings of policy mobility therefore have profoundly different implications for how policy practices are designed. In the former, policy framings are fixed and bounded through standardized measurement (for example higher or lower application or rates of success according to ex-ante indicators) and therefore can be used to pigeonhole individual phenomena (Harvey, 2022). Complex social challenges are therefore reduced to single variables and have some parallel with critiques of binary ideas that reduce problems to single causes and one-dimensional solutions (Swilling, 2019). A relational conception of policy and space, in contrast, emphasises that one event or phenomenon cannot be understood without reference to everything else going on around it. The immediate implication is that, as there are choices of how we wish to frame our realities, so there are choices of how we wish to design policy and its evaluation.

### 3.2. Policy translation across network spaces

As discussed earlier, diffusion of ideas and practices in transitions studies also takes place through networks of actors. A second framing of policy mobility is therefore necessary that considers how policy is influenced by evolving networks of policy practitioners. The broadening of this notion of connectivity beyond not only a fixed place, but also to more flexible relational ties, has been a feature of new thinking in the geography of sustainability transitions literature through the concept of multi-scalar network rationalities (Binz et al., 2016; Fuenfschilling and Binz, 2018; Wieczorek et al., 2015). This theorizing is important for our understanding of policy mobilities and our earlier discussion of assemblages. Closed and rigid actor-networks can be interpreted as *immutable network spaces* where a specific group of actors has constructed, elaborated, and sustained knowledge in a stable network that is defined by certain identifiable commonalities such as profession, language and cognitive frameworks. A linear approach to policy would maintain these networks immutable. If we take the example of TIPC, the framework was elaborated by a group of academics from three universities in Europe: i.e., in a *network space* made up initially by academics.

The opening-up of this community to include non-academic actors, such as policy makers, requires a new metaphor that reflects not only a geographical movement but also a movement of ideas to a new more open and complex type of space. Law’s and Mol’s (2001) concept of a fluid space to describe something that is both more open and relational but also where objects (including frameworks) change shape seems apt. In terms of our study of TIPC, we shall therefore call this opening-up of a closed academic network to other actors a “fluid space”.

Our argument is illustrated in Fig. 1. In time  $t$ , there is an *academic network space* where the framework is created and comprises only academics. In time  $t+1$ , learning can take place by academics and policy makers in their own spaces but can also take place relationally where the circles overlap – the *fluid space* (Law and Mol, 2001). In  $t+2$ , we propose a more complex shared space between academics, policy makers and industry/civil society stakeholders, which we call the *plural space*. Here the framework assemblages are more complex because they involve broader groups of stakeholders. Fluid and plural spaces are also more relational spaces where different sources of knowledge are valued (theoretical, experiential, sensory) and can be expressed in different ways.

## 4. Methodology

### 4.1. Pathways of policy mobility for transformative innovation

We can now present the fuller dynamics through which a meta-framework for TIP might travel in terms of choices between technocratic and bottom-up policy practices (and somewhere in between these) and the opening-up (or otherwise) of new spaces to allow mutability of policy frameworks across different spatialities. Fig. 2 shows two hypothetical pathways for policy mobility where a dynamic complex interrelationship in between these paths can ensue.

Both scenarios begin in time  $t$  within a closed academic network space. Here, academics from the TIPC network develop a framework for TIP. In principle, as originally envisaged in TIPC, this is then applied in a policy maker space ( $t+1$ ) (and subsequently in an industry stakeholder space  $t+2$ ). The top pathway that we label as the “immutable pathway” is influenced predominantly by a non-relational representation of space defined by highly technocratic approaches in which universalist assumptions of policy transfer and its relationship to technology, infrastructure and systems-provision dominate. The application of the TIP methodology is based on a set of rigid principles that take limited account of different geographies. In this scenario, TIP moves to the policy maker space in an unreconstructed way that takes little account of spatial differences. Similarly, the network in which the framework was developed remains closed and so policies are largely immutable. Such examples are plausible and, indeed, are often the norm where funding is tied to narrow and restrictive evaluation criteria and tight deadlines.

<sup>4</sup> The German-style feed-in tariff might be considered an immutable mobile policy network (constituted by a stable configuration of heterogeneous elements), even though there are important mutations to be discovered beneath the headline adoption of the feed-in tariff in different geographies.

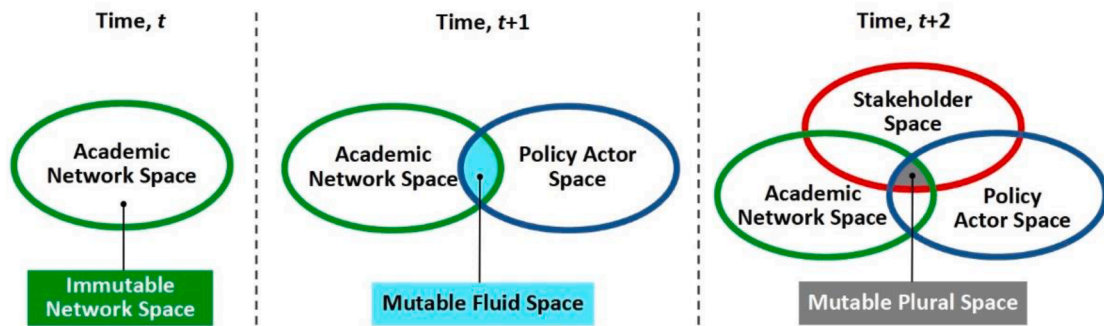


Fig. 1. Constructing fluid and plural space through policy mutability.

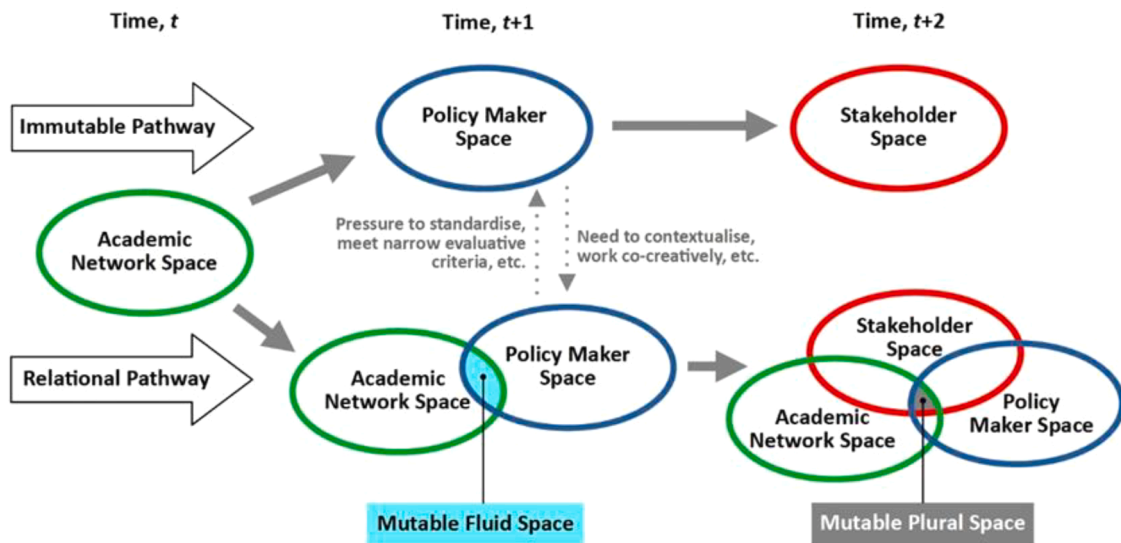


Fig. 2. Stylized pathways of TIPC meta-framework across national boundaries.

A second pathway, that we label “relational pathway”, conceives TIP as being applied in a “relational” policy frame. Relational frames emphasise broad choices that are dependent on place and interrelationships between actors. Policy is defined in an experimental way and variables can alter. Here a mutable *fluid space* may emerge and, although the framework (TIP method) is amended, it changes through a process of assemblage, thereby maintaining the overall objective of facilitating transition processes. As it moves into the stakeholder space, a *plural space* may emerge made up of academics, policy makers and industry or civil society practitioners. Fig. 2 depicts how TIP changes as it moves from the academic to the policy and industry/civil society stakeholder space. How actors respond to different stimuli of TIP will be influenced by both the geographical differences and the cognitive and institutional environment of each actor (academic, policy maker, industry/civil society stakeholder). These different definitions of spaces provide a basis upon which to think about how and why places respond differently to any specific set of policy stimuli and initiatives.

Although we present two different pathways, they are “stylized” for analytical purposes. We fully expect the reality to be somewhere between these. This approach is consistent with more constructivist approaches to spatial organization, such as Madsen (2022) who suggests we avoid fixed notions of space and “scalar traps” (situations where the desirability and importance of one scale is assumed over others); instead, “scale is understood to be actively produced and contested by actors... [through] a historical, contextual and relational process, which needs to be approached as an object of empirical analysis” (Madsen, 2022, p. 341). Our case studies, outlined in the next sub-section and described in Section 4, undertake the empirical analysis depicted in Fig. 2 and go some way to answering Sayer’s (2000, see p. 128) call for analyses to help understand how spatial relations matter. Here, we suggest, our approach follows Sayer’s proposed strategy of starting with assumptions of hypothetical spaces and then drilling down into concrete specifics.

#### 4.2. TIPC and case study selection

The empirical analysis is based around a study of three experiments undertaken within TIPC (<https://www.tipconsortium.net/>). TIPC was established in 2016 as a six-year collaborative programme between academics in the Science Policy Research Unit at the

University of Sussex in the UK, Ingenio at the Politecnico of Valencia in Spain, and five national science and technology policy making agencies: three in Europe (Sweden, Finland and Norway), and one each in South Africa and Colombia. During the programme, Climate-KIC, an important European non-governmental organisation (private-public partnership), working in close collaboration with the European Union to fund projects on climate change, also collaborated with TIPC on the topic of system change.

The practical framework involves construction of a theory of change and a methodology for policy evaluation, which was a central building block of the method (Luederitz et al., 2017; Molas-Gallart et al., 2021; Turnheim et al., 2015; van Mierlo et al., 2010). This “formative evaluation” methodology is based on the work of Molas-Gallart et al. (2021) and involves assessing the changes associated with or leading to socio-technical transitions, sharing commonalities with adaptive and systemic approaches to evaluation developed by Patton (2011). It encourages evaluation principles based on participation of stakeholders whilst providing evidence from policy stakeholders of the extent to which a policy is contributing to a systemic change in the desired direction<sup>5</sup>. The evaluation process of TIPC identifies how the expected changes can be mapped against twelve transformative outcomes (TOs) developed and explained in detail in Ghosh et al. (2021). The 12 TOs are grouped into the following three broad categories:

- Building and constructing niches: this includes processes of shielding, learning, networking and navigating new expectations
- Accelerating the growth and expansion of niches and embedding them in the regime: to the variable “upscaling” of niches, we add other forms of growth including circulation, replication and institutionalisation of niches
- Opening-up existing regimes, destabilising their practices, and unlocking path dependencies: this can involve strengthening regime-niche interactions and de-aligning regime practices

The criteria for the selection of the three case studies were based on policy organisations undertaking an experiment using the TIPC methodology in different national policy jurisdictions. The cases of Sweden (Vinnova, see Section 4.2) and South Africa (Department of Science and Innovation, see Section 4.3) were chosen as both have been members of TIPC since its inception and met the above condition. It was also decided to add a third case, Climate-KIC (see Section 4.1). The inclusion of this case allowed us to analyse the broadening of the network space to an intermediary organisation rather than a policy maker organisation, thus broadening and enriching our understanding of how fluid spaces are constructed with a diverse group of actors. This is particularly important given that policy intermediaries such as consultants, NGOs and other transnational experts are increasingly seen as critical for translation across spaces. Finally, and in addition to the points made above, at the time of writing, these three cases were considered well-developed compared to others within the TIP Consortium.

#### 4.3. Research questions and data collection

Based on the overarching question guiding the study - How does the TIPC meta-framework for transformative innovation policy evolve when applied across different and contrasting geographies? – the following research questions were developed to guide the empirical section:

- a. How do actors (policy makers, intermediaries, industry/civil society stakeholders) frame their space when working with transformative innovation policy?
- b. What modifications (if any) were made to the framework and what did these modifications respond to?

The questions follow the logic of Figs. 1 and 2 and emphasize the process of policy development. Our interest was to enquire how actors represent their spaces and, through these processes, how these may have influenced responses to TIP and how any modifications made to the framework may have reflected assemblage or other mechanisms. We were also interested if construction of fluid spaces played a role in the assemblage process.

Data collection was based on two sets of interviews. A first set of semi-structured interviews took place with policy practitioners in the three organisations working on the experiments: Climate-KIC (three interviews), Vinnova from Sweden (two interviews), and officials and project managers (three interviews) working with the Living Catchments Project (within the South African National Biodiversity Institute, but connected with TIPC’s South African member the Department of Science and Innovation). A second set of interviews took place with three TIPC academics who respectively played a leading role in evaluation and mentoring on each of the three cases. Also, we drew on two blogs based on interviews with policy maker participants in the South African case. Finally, a panel session was also organised at the TIPC conference in January 2022 where TIPC academics and policy makers involved in the cases debated the notion of spatiality and its implication for TIP.

## 5. Empirical results

### 5.1. The EIT climate-KIC case

EIT Climate-KIC (C-KIC) is a large public-private partnership that receives most of its funding from the European Institute of

<sup>5</sup> However, as discussed earlier, evaluation principles in TIPC projects will be a hybrid since they reflect previous funding schemes based on different evaluation criteria.

Innovation & Technology (EIT), an organization created by the European Union, and forms a key part of Horizon 2020, the EU's Framework Programme for Research and Innovation. The "KIC" stands for Knowledge and Innovation Community. The thematic focus of C-KIC is helping societies mitigate and adapt to climate change to speed up the transition to zero-carbon and climate-resilient societies through innovation. Strategically, the mission of C-KIC is about generating new ideas to mitigate and adapt to climate change and business development. Most of those who work with C-KIC are climate entrepreneurs and innovators. Therefore, climate change challenges are approached through the lens of business, practice and impact in the "real" world.

Climate-KIC's collaboration with TIPC has been around a programme denominated Motion, one of three projects associated to mobility. The objectives of SuSMo were how to change the way shared mobility systems are implemented across Europe and deliver a vision for cities to lead the way in decarbonising transport systems<sup>6</sup>, working with partners in Sofia, Stockholm, Bologna and Madrid (although Madrid dropped out of the project).

#### 5.1.1. C-KIC definition of spaces

C-KIC project managers tended to define their space in terms of their organisation's projects and C-KIC's method and mission. Two main features stood out in the interviews. The first is the role of the individual project manager as provider of an intermediation service to help provide the vision, strategy and coordination for different stakeholders in projects, such as shared mobility services. C-KIC project managers encourage stakeholders to build alliances, make long-term commitments for transitioning services and prioritise strategic actions necessary to implement these. In principle, this suggests a highly relational approach to policy making. Indeed, project managers felt there is much flexibility to adopt different alternatives and stakeholder actors can define how they perceive transitions according to their experience.

However, other project managers interviewed (particularly those with less background in community projects) emphasized "delivery of the tool". C-KIC puts a great deal of emphasis on tools and instruments to build stakeholder capabilities. For example, one tool, the "stakeholder engagement" exercise, aims to enhance the ownership of stakeholders in the process of system change by strengthening alignments. This is designed to reduce the potential for conflicts. Another tool, the "pentagonal map", looks at the interconnections and interests of those involved. These methods are inspired by management education philosophies that promote text-driven techniques that can, in principle, address most managerial problems. As such, tasks can be predefined rather than evolve and can be a dominant prism through which the success or otherwise of an intervention is defined (i.e., the correct use of the tool rather than addressing the core problem or challenge).

#### 5.1.2. C-KIC: Contribution of TIP

TIPC helped to build capabilities of C-KIC project managers on systems transformation through its formative evaluation methodology. This in effect created a *fluid* learning space where academics and project managers interacted, creating a mutual understanding of their place, the priorities, the language used and the deliverables. It is where in principle adjustments need to be discussed. Learning from the evaluation process was expressed in the articulation of guidelines for the development of new social practices for shared mobility, new evaluation proposals for municipalities, how to think about behavioural change for shared mobility and public procurement for shared mobility. Significantly, the transformative outcome chosen as most important by interviewees was "navigating new expectations", which reflects project managers' understanding of the quite deep shifts in behaviours of industry stakeholders that will be necessary to achieve transformations. Respondents also said that the flexibility of the TIP process occurred not through the modification of the formal tools of formative evaluation and transformative outcomes but rather through a flexible understanding of their application.

#### 5.1.3. Discussion of the EIT climate-KIC case: balancing toolkits and bespoke intermediation

Fig. 3 shows how the framework that was initially developed in an academic network space in time  $t$  was then taken to the project managers ( $t+1$ ). Two trends emerged, signalled by the dotted lines. The first (the lower part of Fig. 3) continues along a relational pathway in which a fluid space was created through the evaluation process where new dialogues emerged. Two features were important for this to happen. First, the flexible use of the formative evaluation methodology provided a structured environment for academics and project managers to reflect and review transformative approaches, many of which lie outside their normal practice, and clarify methods. Second, the transformative outcomes provided a boundary object that facilitated a deeper structured reflection on the extent to which the outcomes (from the theory of change) were advancing transformations in systems. Significantly, the transformative outcomes concept was also used separately by academics to define a bundle of practices that can be used to evaluate progress on TIP (see Ghosh et al., 2021) and by Climate-KIC to develop tools to measure transformations at organisational levels.

Finally, the case does not indicate clearly whether or how the TIPC methodology was used at the project implementation stage (and so the stakeholder space is missing from Fig. 3). It appears that detailed practical application in the stakeholder space is a bigger challenge, at least within the time frame of this study. A senior C-KIC manager explained that "the interface between science policy and practice is underdeveloped by TIPC. There is no prototyping of the service, business development or innovation management tools. This means we don't move into the implementation phase". This suggests the move into the plural space requires methods that are not yet present, such as project management tools.

<sup>6</sup> <https://www.cenex.co.uk/projects-case-studies/susmo/>

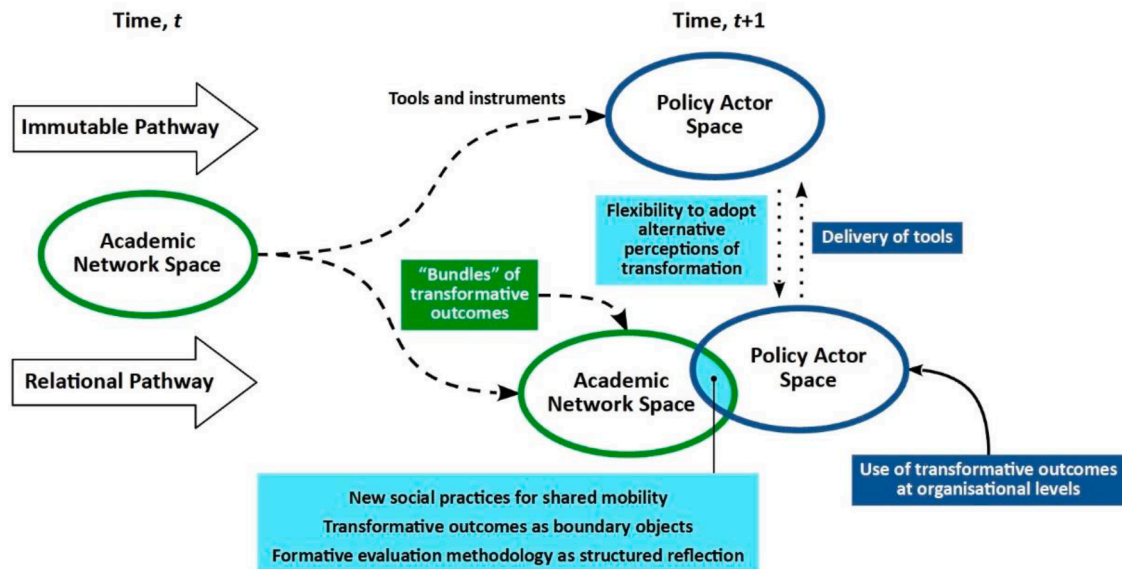


Fig. 3. The case of climate-KIC.

## 5.2. The Vinnova case

Vinnova is Sweden's state STI agency, formed in 2001, and is a core actor in the Swedish innovation system. Vinnova established itself as leader amongst European science and technology policy agencies by driving a new policy agenda that advocates a change in STI policy towards meeting "societal challenges". In 2019, Vinnova initiated an experimental procedure to formulate mission-centred strategies for addressing challenges in the realms of mobility and food security, aligning with the SDGs. Vinnova's leadership acknowledged that this undertaking necessitated a distinct approach to policy making. They embarked on experimenting with strategic design methodologies that incorporate inherent intricacies and uncertainties into the blueprint of policy instruments (Hill, 2012). Concurrently, as part of the research process, TIPC researchers engaged with policy makers from various governmental bodies, including the food and procurement agency, a design agency providing support, and stakeholders integral to the mission's formulation (Boni et al., 2023).

### 5.2.1. Vinnova definition of spaces

Vinnova policy practitioners describe the organisational mission and processes of Vinnova as highly influential in defining their space. This has been articulated as a "systems coordinator" and "consensus builder" in the Swedish innovation system. Working with TIP therefore challenges Vinnova to go beyond this and enact a more deliberate and purposeful role as an intermediary promoting sustainability transitions. The specific processes associated with the history of Vinnova and its routines are relevant. The project chosen to work with TIPC was their sustainable food systems area, which has been defined as a strategic priority around missions for sustainability. This incorporates production, industry, retail and public meals (consumption side) with a strong emphasis on establishing a "design process" with industry actors. During the experiment with TIPC, Vinnova policy practitioners dedicated a great deal of time to re-interpreting what "missions" meant for them within their organisational context. From this experience, it was concluded that mission statements such as "a certain percentage of proportion of the schoolchildren in Sweden will be offered sustainably grown food" did not appear to fit well with the principle of experimentation. A Vinnova policy practitioner commented that, "we have an experimental way of working with the food system in Sweden now where we try out things, we have certain aims and we try out new methods when it comes to interacting with actors and setting up projects". Approaches that "open up" options to re-define new forms of food provision at the level of municipalities – for example, by "asking fundamental questions around the way stores can re-conceptualize food and what types of function they have" – are preferred.

The interviews also drew out that the definitions of spaces were influenced by specific roles individuals play within the organisation. For example, for policy practitioners who work directly with industry stakeholders, the focus is on addressing the challenge of establishing the legitimacy of Vinnova with stakeholders (beyond the traditional role of funder). Here, the questions were of de-aligning regimes and institutionalizing niches facing entrenched regime actors such as large food and drink conglomerates. Therefore, adopting principles of transformation between the policy maker and the practitioner will clearly face a completely different and potentially tougher set of challenges to those between academics and policy makers, as incumbents may be more tightly locked-in. Hence, we see how the need for opening up plural spaces becomes important.

### 5.2.2. Vinnova: The contribution of TIP

Embedding the TIPC methods into the established organisational routines of Vinnova was challenging, requiring many iterations



and months of work with the TIPC team. Our earlier discussion of network and fluid spaces becomes relevant. Although the primary intention of the engagement with Vinnova was to continue as an experimental policy engagement, there was some initial tension between Vinnova and the TIPC team, as a Vinnova practitioner commented: “I think we have been able to change the TIPC team’s perception of what we’re doing and what works, what doesn’t work. And that was quite tricky in the beginning”. Some of the initial problems appear to be associated with passing from an academic network space to the policy maker space. The expectation was that the TIPC method would be “ready to use” and could be taken “off the shelf” by policy practitioners. Yet, the approach was seen initially as quite “research-based” with few practical examples. This created tensions, as a policy maker commented: “I think TIPC changed from sort of being more of an observer – here is the theory, here is the workshop format, we’ll fit you in here.....and that’s sort of shifted a bit .... a lot of adaptations and a lot of small change has been done through this journey”.

Key to overcoming these obstacles were three main elements. First, having “safe spaces” to build up trust and mutual recognition was important. A second element involved merging techniques from Vinnova and TIPC. As a TIPC mentor recounted: “We performed lively workshops and many other digital formats to depict a modified version of the Theory of Change and we put efforts to capture the learnings that were emerging and develop two original tools (the binnacle and the learning history) to capture learning through the process”. The third key element was having an *inner translator* (or intermediary). This person helped to make the formative evaluation methodology more applicable and place-sensitive in this engagement. Also, she gave updated information on changes in the organisational context, on participants’ duties and time availabilities on a more practical level. These numerous interactions between the inner translator and the TIPC team were essential to establishing a trusting relationship with Vinnova.

The process of mentoring meant working to clarify and redefine some of the organisational routines of Vinnova “where we’ve actually managed to merge the frameworks”. The process of discussion around the theory of change was essential in this by helping Vinnova practitioners to identify their priorities: “The theory of change provided us a framework to re-examine the fragments of methods of the approaches being used, which was of huge value and challenging”. Deepening the concept of experimentation from the transformative outcomes was particularly influential because it helped to distinguish how to approach the work of missions. As a practitioner commented: “I think that now they seem to have actually let go a little bit of the whole concept of mission. And we have started talking more about an experimental way of working with the food system in Sweden. Moving from retail mission to retail experiment”. In this process, the initial assumptions of TIPC also changed: in particular, in the process of the construction of the theory of change.

### 5.2.3. Discussion of the Vinnova case: constructing “fluid” spaces through trust, instruments and inner translators

Fig. 4 illustrates the summary of the findings of the case. The movement from a network to fluid space was discussed largely in organisational change terms: re-thinking and disrupting some of the internal organisational routines of Vinnova. But, to create this fluid space, significant efforts were also required to break TIPC out of the academic network space it had built. This involved merging techniques, mutual recognition and finding actors (people) willing to intermediate and be bridges between Vinnova and the TIPC academics. It was also pointed out that working in this explorative manner was a highly labour-intensive process that may clash with internal pressures for quick scale-up and for the implementation of off-the-shelf tools and instruments to streamline processes that allow rapid scale-up of activity. Fig. 4 characterises the two pathways for the implementation of TIP in Vinnova: the relational pathway, in which concepts of experimentation were developed in a fluid space, and the immutable pathway, showing a pressure for ready-made tools and instruments. We also once again found no real evidence of TIP being applied with industry practitioners.

## 5.3. The South African national biodiversity institute living catchments case

The South African National Biodiversity Institute (SANBI) is a statutory body instituted in 2004 under the Department of Forestry, Fisheries and the Environment. It researches the state of biodiversity in South Africa as well as, among other functions, providing policy advice, piloting best-practice management models with stakeholders and restoring ecosystems. South Africa is a water stressed country and, as part of its strategy to achieve a more sustainable economy, developed a *Water Research, Development, and Innovation (RDI) Roadmap* to guide the water sector from 2015 to 2025. In line with the Water RDI and funded by the Department of Science and Innovation (DSI), SANBI implemented a Living Catchments project in partnership with the Water Research Commission (WRC).

In February 2020, the Living Catchments project developed a theory of change during an expert-facilitated workshop with participants from DSI, WRC and SANBI. This was developed from a logframe (goal-driven matrix objectives using standard indicators based on assumptions of activities, outputs and outcomes). During a subsequent WRC Reference Group meeting, it was agreed that the Living Catchments project would be the focus of South Africa’s first experimental policy engagement as part of its membership of TIPC (Boni et al., 2021).

### 5.3.1. SANBI definition of spaces

A common feature of infrastructure projects in the Global South is that the technology-push and narrow engineering principles on which these projects are usually designed clash with the reality of their execution that typically combines complex realities on the ground with formal and informal governance in combinations of regulated and unregulated environments. This calls for much improvisation. For a project such as this, building relationships with municipalities, towns, villages and farms is a critical feature but rarely recorded or recognized as part of the project delivery routines and remains in a type of “shadow space”, known about but rarely acknowledged. There is therefore a formal “visible space” that is defined by technocratic principles of project design (formal protocols of execution) and measurable indicators of “progress”, and there is another recognized but not formally legitimised space defined by relational principles that take into consideration informal governance arrangements and improvisation. Practitioners working on the

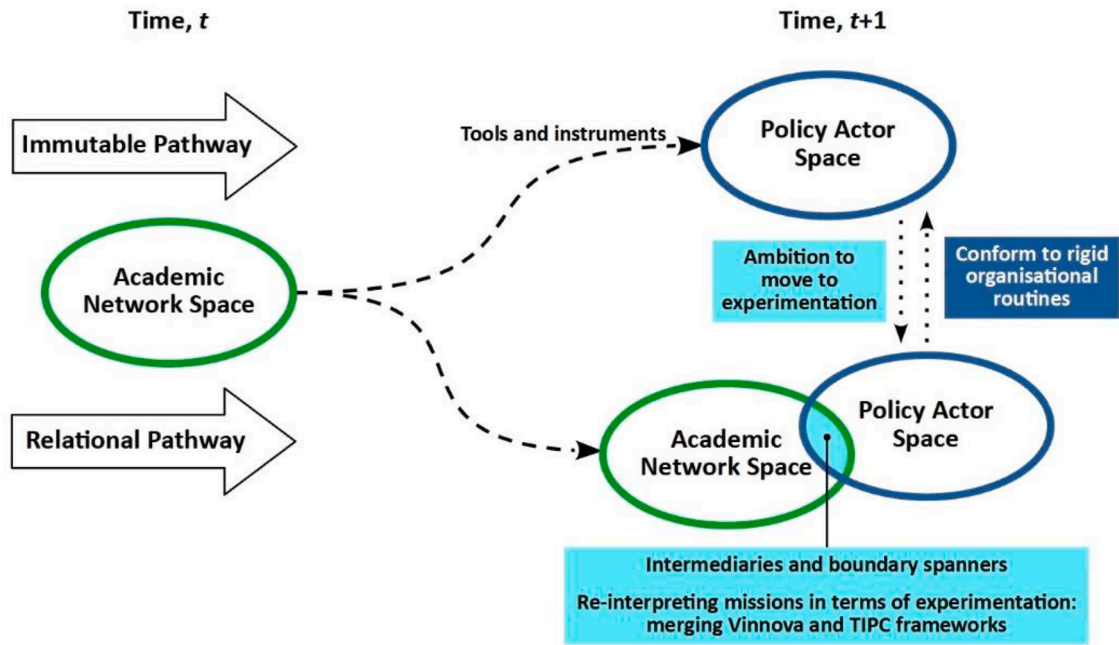


Fig. 4. The case of Vinnova.

Living Catchments project thus insisted that the mode of working begin with “practice”, an attempt to create a visible space to legitimise relational practices involved in building alliances with communities.

A second important representation of space picked up in the interviews was associated again with the move from the academic network space to the policy and practitioner space although, unlike in Vinnova, the representation of space was not through a dominant organisation but through a strong decolonisation discourse that is sensitive to the imposition of unreconstructed policy frameworks and recipes from institutions and organisations of the Global North. Although the engagement with TIPC was formally framed as one of co-learning and co-creation, there was some initial resistance to the heavily conceptual and theoretically dense approach to the presentations by academics. These were poorly understood and amplified apparent presenter-audience knowledge asymmetries. The impression of some of the Living Catchments team was that “northern experts would come and teach the South Africans how to do transformation”.

### 5.3.2. SANBI: The contribution of TIP

It appears that the initial application of the TIPC method was firmly situated within the academic network space: arrangements were experienced as an expert-novice dynamic. As one of the SANBI team expressed it in a reflective blog<sup>7</sup>, “the first meeting was like a roller-coaster in a thunderstorm! I didn’t understand the terrain I was in and then we were rolling”. However, following a meeting among the project team and managers from DSI and WRC, in which the SANBI members expressed their disapproval of the process (with some expressing a desire to abandon it)<sup>8</sup>, the TIPC team were asked to adjust the nature of the interactions. After making these adjustments, the interactive sessions became more “equal” and co-creative. As the TIPC academic interviewee recalled, “a key moment of change occurred where it turned into more of a conversation. Initially there was an expert-novice dynamic – so power is in the presenter’s hands ... the simple part of adjustment was to have more space for the South Africans to guide the content and conversation. This changed the emotional base and it became more of a conversation of equals and created greater willingness to engage with ideas”.

The exercises on the transformative outcomes between policy makers in the Living Catchments team and TIPC academics were identified as the most useful contribution of TIP. The transformative outcomes stimulated a lot of important questioning that pushed the team to think deeply about what they were trying to do and how they could achieve it. As a project team member articulated it in one of the reflective blogs,<sup>9</sup> “what is transformative is getting to good questions! To be able to always be going deeper and deeper. There has been space in the process to explore this.” These comments suggest that the transformative outcomes helped to systematise the relational aspects of the project and perhaps to bring the shadow spaces into the open “out of the shadows”. The transformative

<sup>7</sup> See <https://www.tipconsortium.net/blog-3-in-the-south-africa-water-experiment-blog-series/> [accessed 26/09/2021].

<sup>8</sup> This is according to one of the DSI officials interviewed.

<sup>9</sup> See <https://www.tipconsortium.net/transformative-outcomes-does-the-theory-stick-practitioners-view-from-south-africa/> [accessed 26/09/2021].

outcomes may have provided a language and a method to link the project to wider features and people in the system through an evaluation framework that has legitimacy and authority from an evaluation perspective. As in the previous cases, the basic methods didn't change. The skill of the teams was in their flexible interpretation, which at times led to different conclusions to those originally intended. As the TIPC participant commented, "this was more than translation" of the concepts.

### 5.3.3. Discussion of the SANBI living catchments case: the limits of closed networks and breaking out of the "shadow space"

Two clear issues emerge from this case. The first is the limitations of working with policy makers in South Africa from the perspective of immutable (closed) network spaces. This has emerged in the other cases but was far more accentuated here. Underlying greater physical distances lies different histories of development that have cultural meaning (e.g., colonial history), and types of established routines and practices, that can amplify the contrasts between geographical spaces. These differences can be addressed through improved "translation", whereby language, terms and tools of delivery are made more accessible, which can be critical to improve understanding of messages across spaces. An additional approach is to build and expand the fluid space in which co-construction of agendas and methods is practised. This goes beyond translation and into assemblage and mutation, opening up a space to ask which tasks should be prioritised and how.

A second significant point to emerge is the co-existence of technocratic and relational spaces and how to steer towards relational conceptions of policy making. In this case, the notion of relationality is associated with bringing practices that have not been recognised "out of the shadows" and to be acknowledged more explicitly. This may be important because some DSI officials consider the Living Catchments project as a laboratory for the development of tools and techniques for "scaling up and out". In other words, even as the policy experiment was explicitly defined in relational terms, actors in the project team who had not been exposed to the theory underlying the TIPC methodology saw the experiment as an immutable set of practices to be rolled out. This is despite the fact that the same officials recognise and appreciate the importance of transformation being a place-specific process. Clearly, the pressure for faster delivery leads to a preference for tools that can be scaled-up quickly (as represented by the immutable pathway). The main elements of the discussion are illustrated in Fig. 5 as a movement between immutable and relational pathways of policy making. As in the other two cases, TIPC was not clearly implemented in stakeholder spaces.

## 6. Synthesis of findings

The interest of the paper has been to understand the way a TIP meta-framework evolves when applied across different and contrasting geographies. Our case study, the Transformative Innovation Policy Consortium, evolved through a lengthy process in which different actors established links within and across different geographies. A summary of the findings outlined in Table 1 suggests that this was far from a smooth process, as different interests and contested views of policy governance emerged. We distinguish between the changing cognitive environment and changing geographies in which the experiments took place, along with some of the associated tensions, focussing on the attempts to create relational pathways and open the fluid spaces.

Our research posed the question of how actors framed their spaces. We chose to bound the answers through the lenses of the cognitive professional environments of respondents and if there were specific distinct geographical factors that were clearly present. This approach allowed us to identify common and specific features associated with diffusion of TIP across national jurisdictions. Geographically specific features were particularly important in the SANBI case. South African participants were concerned about perceived colonial imposition of policy frameworks from institutions of the Global North, including TIPC. Similarly, in the Vinnova experiment, nationally developed policy institutions historically constructed in Sweden to coordinate a national system of innovation influenced policy maker perceptions towards adoption of transformative innovation strategies.

However, in the Vinnova case, tensions associated with different policy maker and academic framings for TIP were also evident, especially in the initial stages of the project. Although both experiments evolved satisfactorily, the governance of the TIPC experiments had to allow for greater adaptation to embrace the organisational memory, routines, time scales and knowledge of policy makers and their organisation before the benefits of the methodology could be appreciated. Intermediary brokering roles were particularly critical in constructing (and re-constructing) these fluid spaces.

Cognitive and geographical lenses can also help to explain a more common feature of the cases, which was the ongoing tension between more managerial and technocratic (immutable pathways) on the one hand and emergent and adaptive approaches to policy intervention (relational pathways) on the other. The pressure towards upscaling is a feature of many policy maker/practitioner environments and was to some extent evident in the proclivity by some actors in Climate-KIC to use policy tools (including TIPC tools) as ends in themselves. This is reflective of a tendency towards "projectification" that Packendorff & Lindgren (2014) explain is attractive because it promises clarity, order and control via standardised procedures but has limited efficacy when dealing with complex problems. SANBI's case on the other hand demonstrated how some policy practitioners improvise to overcome these more technocratic inspired principles of project design by incorporating real life experiences and practices, although this had to be undertaken in a "shadow space" where more informal governance arrangements and improvisation were possible.

A third remark concerns the mutability and modifications (if any) that were made to the framework, the second question posed in the paper. An important feature of the experience of TIPC was that, from the perspective of the policy makers, what was required involved continual re-interpretation and re-examination of abstract concepts applied to the different concrete experiences that reflect more accurately the situation on the ground, rather than modifications to the framework. But, for this to occur, a TIP methodology is required that provides the space for reflexivity, fluidity of strategies and co-construction. In this sense in the three cases, the use of the Transformative Outcomes was understood as a relevant "boundary object" for academics and policy makers to dialogue and interact within these fluid spaces even though they came from different cognitive backgrounds. Also, the formative evaluation approach

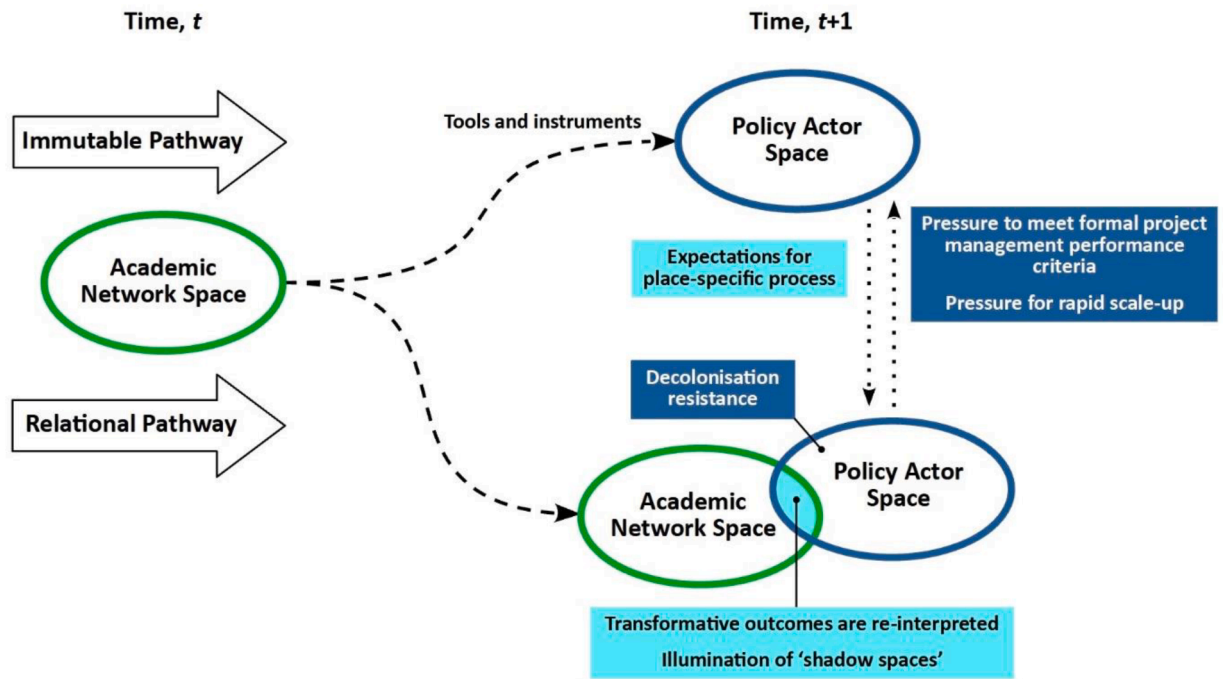


Fig. 5. The SANBI living catchments case.

Table 1

Insights on the relevance of spaces in TIPC experiments.

| Mutable fluid space   |  |  |   |
|---|--|--|---|
|   | C-KIC  | Vinnova  | SANBI   |
| <b>Actors involved</b>  | TIPC researchers<br>C-KIC managers<br>Project managers   | TIPC researchers<br>Vinnova’s managers and policy analysts   | TIPC researchers<br>South African National Biodiversity Institute<br>Water Research Commission  |
| <b>Goal of the experiment</b>   | Develop and test an innovative methodology to advance transformative change  | Enhance the transformative potential of Vinnova’s approach to the food mission-oriented innovation policy  | Enhance the Living Catchment project’s design and implementation based on formative evaluation guided by the TIP principles   |
| <b>Relevance of changing cognitive environment (CE) in the experiment</b> | CE) Flexible use of the formative evaluation methodology   | CG-CE) Having “safe spaces” to build up trust and mutual recognition between academics and policy makers   | CE) Policy makers recognise immutable and relational pathways defined by technocratic and relational principles of project design respectively  |
| <b>Relevance of changing geographies (CG) in the experiment</b>           | CE) Transformative outcomes provided a boundary object to reflect on advancing transformation<br>CE) Proclivity to use tools as ends in themselves and fixed where protocols are preferred | CE) Merging techniques from Vinnova and TIPC<br>CE) Having an inner translator or intermediary<br>CG-CE) Flexible use of the formative evaluation methodology (Theory of change) | CG-CE) “Shadow spaces” recognized but not formally legitimised that take into consideration informal governance arrangements and improvisation<br>CE) the mode of working begins with “practice”, an attempt to create a visible space to legitimise relational practices involved in building alliances with communities<br>CG-CE) Decolonisation discourse that is sensitive to the imposition of unreconstructed policy frameworks and recipes from institutions and organisations of the global north<br>CG) The transformative outcomes stimulated a lot of important questioning that pushed the team to think deeply about what they were trying to do and how they could achieve it |

Source: Authors’ elaboration.

provided the flexibility to adapt to the theory of change methodology, and this was critical and highly valued by the participants. The subsequent modifications in the TIP “theory of change” then evolved as part of the evaluation method through a flexible interpretation of geographies. The importance of understanding processes in the construction of a policy meta-framework and the ability to adapt to different geographies whilst ensuring that the framework maintains its coherence is underlined.

## 7. Discussion

At the outset we underlined the importance of understanding the processes of change (or mutabilities) that need to occur when applying transformative innovation policies across national jurisdictions and we introduced concepts of translation and assemblage to help examine this. The discussion in the paper brought out three features of this process that helped to enrich this analysis.

The first is that actor-network theory drew attention to the need to deeply reflect and where necessary re-construct some closely held assumptions of researchers around concepts, tools and configurations when applying these in different national jurisdictions before an effective translation process can take place. The sources of these differences can be many (ideological, organisational, cognitive), but the reconstruction of assumptions is inherent in the idea of the “construction” of a new fluid space.

Secondly, translation processes in policy need to incorporate specific aspects of the policy process and policy learning that have not been discussed in the sustainability transitions literature to a great extent, especially the role of methods of policy evaluation. [Molas-Gallart et al. \(2021\)](#) point out that, unlike traditional evaluation exercises, in which assessments take place at the end of the policy cycle without being part of the policy process, formative evaluation is designed to work alongside projects where “learning is an essential justification” ([Kivimaa et al., 2017](#)). Therefore, we interpret the objective is to create combinations or assemblages of policy that encourage learning at different stages and levels. In consequence, although full control of the policy processes is not always possible (and we see contrasting types of policies layered one upon another), it is important to build a reflective space in which there is deep engagement (mutual recognition, cultivation of safe and respectful spaces, valuing the role of an inner translator) in the evaluation process from which multifaceted learning can occur.

Thirdly, on the question of policy governance, we found in practice that technocratic and relational approaches to policy will likely co-exist. Some authors in the innovation policy literature, for example [van der Loos et al. \(2022\)](#), suggest that different governance arrangements will emerge in multiple areas with ad hoc patchworks of decision-makers. The concept of polycentric governance suggests that, within a particular system, multiple centres of decision-making exist that operate semi-independently from one another and yet interact to varying degrees and in different ways ([Ostrom, 2010](#)). This can provide a lens to look at multiple centres of decision-making and a patchwork governance framework. But there is also a rationalistic streak in this approach. We found less consciously designed philosophies of governance in the same projects and, in fact, the outcomes that emerged were more likely to be explained from the tensions between these two very different ways of implementing policy. Consequently, the idea of “hybrid pathways” may better reflect more complex outcomes that emerge from different narratives, visions and/or philosophies between different actors in different positions of power.

## 8. Conclusions

By examining three transformative innovation policy (TIP) experiments, implemented in different countries and organisations, this article has contributed to debates around spatiality of sustainability transitions and practices through a focus on policy mobility for transformative innovation. The discussion underlined questions of policy governance ([Cook and Ward, 2011](#); [Peck and Theodore, 2010a](#)) as a policy meta-framework designed by a consortium of academics and policy makers (TIPC). The case studies demonstrated how the vision and methods laid out in TIPC at times struggled to make an impact. The harsh reality and obstacles of doing real-life transformative policy were brought down to earth. Geographically specific factors were evident in the SANBI case in South Africa, differences between academic and policy framing emerged more strongly in the Climate-KIC case, and both the geographical and professional analytical lenses were present and difficult to disentangle in the case of Vinnova. The important point to make here is that these framings and their interaction helped reveal some of the factors influencing how TIP was taken up. This helped address an important gap in the literature of mobility of transformative innovation policy.

Building on the above, the concept of “fluid spaces”, used initially as a metaphor for a transdisciplinary cognitive space (shared by academics, policy makers and industry/civil society stakeholders), in the discussion, evolved into the description of a process by which an initially closed network was opened up into a relational space to support assemblage, in which transformative principles are combined with place-based driven approaches. Understanding mutability of policy lies at the heart of this.

Finally, insights from actor-network theory provided a useful analytical lens for bringing together and exposing the differences between two topological forms – the *network* and the *place* and therefore why “where” transformative innovation policy takes place is actually important. This is because, although national policy makers receive information from diverse places, they do not in general make universal policy; this happens in a space and place, in institutions and networks that link histories, ideas and people. Therefore, if translation and mutation are critical, does it matter where and how the policy architecture emerges? We argue that it does because there is still a stable and immutable element of policy that defines how different components come together, at least in theory ([Law and Mol, 2001](#)). Therefore, fluidity as a concept of space brings together stable and moveable features of the policy architecture.

### CRedit authorship contribution statement

**Matias Ramirez:** Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Alejandra Boni:** Writing – review & editing, Writing – original draft. **Imogen Wade:** Writing – original draft, Methodology, Formal analysis, Data curation. **Rob Byrne:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Funding acquisition, Formal analysis, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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