TRANSFORMATIVE OUTCOMES: ASSESSING AND REORIENTING EXPERIMENTATION WITH TRANSFORMATIVE INNOVATION POLICY

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Abstract

The impending climate emergency, the Paris agreement and Sustainable Development Goals (SDGs) demand significant transformations in economies and societies. Science funders, innovation agencies and scholars have explored new rationales and processes for policymaking, such as transformative innovation policy (TIP). Here, we address the question of how to orient the efforts of science, technology and innovation policy actors to enable transformations. We build on sustainability transitions research and a four-year co-creation journey of the TIP Consortium to present twelve transformative outcomes that can guide public policy agencies in evaluating and reformulating their projects, programmes and policies. We illustrate the transformative outcomes in two empirical cases: transitions towards mobility-as-a-service in the Finnish transport system, and the emergence of speciality coffee in Colombia. We argue that the twelve transformative outcomes can guide public policy agents to fundamentally transform their ways of thinking and operation in advancing transformative change.

1. Introduction

Policymakers working in science, technology and innovation (STI) are facing pressures not just to focus on economic growth and competitiveness but to address contemporary challenges such as global environmental change, growing inequality, and now a socio-economic health crisis in the aftermath of Covid-19. This is most evident in governmental responses to recent global policy agendas, such as the Sustainable Development Goals (SDGs) and the Paris Climate Agreement, the European Union Green Deal and the 2020 World Economic Forum agenda on 'Fixing inequality'. In each case, reorienting the efforts of public science funders and innovation policy professionals is positioned as an important ingredient for initiating societal change in more sustainable directions. Various studies note a mismatch between traditional innovation policy and the actions needed to address environmental and social sustainability (Edler and Fagerberg, 2017; Boon and Edler, 2018; Borrás and Laatsit, 2019).

A new wave of STI policies labelled as transformative innovation policy (TIP) aims to address this mismatch (Steward, 2012; Weber and Rohracher, 2012; Schot and Steinmueller, 2018; Diercks et al, 2019; Grillitsch et al., 2019). Weber and Rohracher (2012: p. 1041) argue that this new generation of policies should address 'transformational system failures' that are 'preventing processes of transformative change from occurring in a socially and politically desirable way'. They identified four key failures that hinder transformative change: lack of directionality, wrongly directed demand articulation, lack of policy coordination and reflexivity failure. To overcome these failures and confront the mismatch between ambitions, approaches and achievements, Schot and Steinmueller (2018) and Diercks et al (2019) argued that TIP should be focused on socio-technical system change and be approached experimentally, building on sustainability transitions research, in particular, using concepts such as niche, regime and socio-technical landscape as a basis (Rip and Kemp 1998; Geels 2002; Grin et al 2010). While the idea and narrative of transformative innovation policy is established, it remains unclear how to implement such a policy.

Here, we therefore address the question of **how to orient the efforts of STI agencies to enable transformations and address societal challenges**. Our brief answer is by focusing on transformative outcomes. Rather than foregrounding the transformational failures, the focus is on enabling and navigating ongoing transformation dynamics. For that, we introduce twelve transformative outcomes (TOs) which encompass a new framework across three macro-processes that can guide the interventions and evaluation of TIP towards more transformative aims. We further introduce the notion of experimental policy engagements (EPEs) as a way to characterize these interventions. These two concepts taken together, can provide a basis for the implementation of TIP by STI agencies, offering an entry point for more reflexive and effective engagements with transformative change[1].

This paper distils the experience gathered in the Transformative Innovation Policy Consortium (TIPC), a five-year transdisciplinary research and action programme[2] where STI policymakers from several countries from the Global North and South worked with a research team to articulate the concept of transformative innovation policy, explore how to use it in practice, and build capabilities around it. TIPC positions itself as a learning platform for co-creating a new generation of approaches that experiment with advancing socio-technical system change and identify new ways of evaluating such experiments. We draw from a series of activities aimed at bridging academic and policy knowledge in ways that support intentional and reflexive policy praxis and respond directly to a demand from TIPC members for approaches to conduct and evaluate their transformation efforts.

We structure this effort as follows. In Section 2, we introduce our co-creation journey and how we have combined the co-creation process with literature review and two case-studies from the TIPC programme to refine the application of our approach. We also introduce the EPE concept as a rationale for our focus on transformative outcomes. Section 3 articulates and substantiates the twelve transformative outcomes, grounded in a literature review. Section 4 presents the two explorative case studies, concerning mobility-as-a-service in Finland and specialty coffee in Colombia, reinterpreted through the transformative outcomes framework. In Section 5, we draw lessons on how to apply a transformative outcomes framework for TIP. In Section 6, we conclude.

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[1] Such change processes are often called a transformation or transition. Here, we use the terms interchangeably. Both concepts refer to a system change, although the meaning of a system may differ, from socio-technical to socio-ecological systems.

[2] Current members are innovation ministries and funding agencies from Colombia, Finland, Norway, South Africa and Sweden. There are additional associate programmes in China, Brazil, Senegal, Ghana, and Kenya. The consortium is coordinated by the Science Policy Research Unit (SPRU) at the University of Sussex, in collaboration with the Centre for Global Challenges at Utrecht University and INGENIO, at Universidad Politécnica de Valencia. See www.tipconsortium.net.

2. Research approach: a co-creative journey with policymakers

The transformative outcomes presented here resulted from a co-creative[3] journey between several STI agencies[4] and researchers, in the Transformative Innovation Policy Consortium (TIPC). This journey was rooted in shared but context-specific efforts of national innovation agencies and research councils to address societal and ecological challenges, as expressed in the 2009 Lund Declaration and in 2015 UN Agenda 2030 Sustainable Development Goals. This was a transdisciplinary process (Mauser et al. 2013, Pohl et al. 2017): the research team worked with policymakers in framing the problem, to identify and define the research question, engaged with them in empirical research and involved them in drawing conclusions. Four steps of that journey are relevant here.

First, in a pilot phase (2016-2017) policymakers and researchers explored how TIP was understood and what processes may bring it about in distinct contexts of application, to better frame the activities of the consortium. The team conducted country reviews and pilot cases to elicit indications of transformations and to refine inductively the understanding of TIP. The results confirmed the emergence and proliferation of policies and programmes aimed at inducing transformations in the Global North and South and highlighted the important role for STI policies in addressing deep systemic problems. It noted the combined growing popularity of mission-oriented and transformation-oriented rationales among the members (see Mazzucato, 2018; Diercks et al 2019; Schot and Steinmueller, 2019). However, members reported difficulties in integrating these rationales into the practices and instruments at their disposal. The key problem, identified by the policymakers, was practical and conceptual difficulties about how to do and evaluate TIP or mission-oriented policies. This joint conclusion motivated the focus on developing a methodology for experimentation and evaluation in the subsequent five-year TIPC programme.

Second, during 2018-2019, TIPC conducted an empirical study of different modes of experimentation to conceptualise how attempts to experiment with new policies and approaches contributed to transformation at large, beyond the novelty creation and ad hoc experiments with little (policy) impact (Schot et al. 2019; Turnheim et al. 2018). This resulted in developing the notion of experimental policy engagements (EPEs) as "*the diverse ways in which (STI) policy makers engage with processes of societal experimentation for sustainable transformation: initiating, supporting or mobilising, and evaluating such initiatives for informing decision-making, enabling processes of social learning, developing alternative pathways and enacting desirable futures.*"

EPEs differ from transitions theory view of experimentation centred on creating novelty and building niches (Kemp et al, 1998; Smith and Raven 2012; Sengers et al., 2016). EPEs highlights how different forms of experimentation can also play a role in the expansion of niches and destabilisation of dominant practices or regimes (see Torrens et al., 2018). Moreover, experiments are not seen as isolated projects

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[3] The term co-creation is often refers to co-creation with citizens (e.g. Voorberg et al. 2015). We used this term to refer to the transdisciplinary process of TIPC, as it was the term policymakers themselves often referred to. It reflected the unusual situation where these actors, used to fund projects, were involved in establishing a joint search process with researchers on how to define and implement transformative innovation policy.

[4] At the time of this research, Finland, Sweden, Norway, South Africa, Colombia, Mexico (and China, Kenya, Ghana and Senegal as an associated member) were active in the consortium.

but as interventions in larger multi-actor transformation processes. Accordingly, TIPC members expressed a need for a methodology to help them improve existing interventions. This need was translated into the questions *how STI projects, programmes and policies, redefined as EPEs, can be made more transformative*, and *how STI agents can know progress is made in terms of transformation.*

Third (largely in parallel to step 2), the authors co-created with TIPC members the transformative outcomes (TO's) presented here. Based on a literature review of sustainability transitions, the authors initially drafted the list of TO's in coordination with other TIPC researchers. To refine that list, the authors presented, discussed and used the TO's in several workshops with TIPC members in 2019 and 2020, such as the TIPC Learning journey (June 2019), TIPC training week in South Africa (September 2019), TIPC engagement week in Spain (November 2019) and a VINNOVA workshop in Sweden (February 2020). In total, these activities involved over 200 STI policymakers and researchers from a range of contexts. With hands-on exercises, we came to understand how TO's could be used to improve the design of EPEs and the reformulation and evaluation of existing policy approaches (in connection to TIPC activities on formative evaluation (see Molas Gallart, 2020)). The co-creative process allowed TIPC members to develop a shared understanding about the approach and illustrated its application in different contexts. The result of that process is the refined list of the twelve transformative outcomes (in section 3).

Throughout this journey, our approach is best described as abductive inference, which involves the interpretation, re-description and re-contextualisation of individual phenomena within a conceptual framework, that leads to understanding that phenomena in a new way and a better appreciation and refinement of theory (Danermark et al., 2002). For that, we constantly switch between theory and practice, with the multiple events mentioned above allowing for testing iterations. Preliminary versions of this paper were used as an input in those events. In each stage, we collated feedback from TIPC members and refined the TOs description and explanation.

Fourth, we used a more classical case study approach to explore the TO's relevance by revisiting and updating two case studies conducted during the TIPC pilot (2016-2017). This analysis was done without consultation with the TIPC members. The selected cases are the emergence of mobility-as-a-service in Finland and of specialty coffee production in Colombia. Four reasons informed this selection. First, the cases represented two drastically dissimilar contexts, which helped establish whether the preliminary list of transformative outcomes would be relevant beyond the European context. Second, both cases showed signs of a partial success in enabling a transformation but in different degrees of maturity. Third, there was a stark contrast in how proactive policymakers were in their engagements. In Colombia, there was little engagement that happened late in the process. In Finland policymakers' engagement was intense and from an early phase. Finally, in both cases the TIPC team had collected extensive data, or continued to collect data (Finnish case), and lead investigators could join our study. The original data collection included workshops, interviews and secondary document analysis (see Arond et al., 2017; Kanger and Kivimaa, 2017; Kivimaa and Rogge, 2020). We summarised main developments and policy interventions in a new narrative, including the coding for different transformative outcomes.

3. Transformative outcomes

In sustainability transitions theory, change is an evolutionary process characterised by a myriad of interacting variables that are co-evolving through time and space (Elzen et al. 2004, Grin et al. 2010). No

actor is in the position to control the process. Yet, many actors influence and navigate sustainability transitions (Voss et al 2006). In elaborating the transformative outcomes (TOs), we focus on how research councils, science and technology ministries and innovation agencies can improve their actions through a more systemic and continuous governance approach building on sustainability transitions thinking. This can be done by conceiving their projects, programmes and policies as experimental policy engagements for achieving specific TOs. We argue that if STI policy actors work towards achieving these TOs, they may overcome the transformational failures by inducing directionality, reflexive thinking, improving policy coordination and demand articulation (Weber and Rohracher 2012).

A key question is then, what are these TOs that actors may target to fulfil? Based on a review of the sustainability transitions literature and our interactions with policy makers in a TIPC setting (see Section 2), we propose twelve transformative outcomes across three macro processes that underpin socio-technical change through multi-level interaction: 1) building and nurturing niches; 2) expanding and mainstreaming niches; and 3) unlocking and opening up of regimes. We propose four outcomes in each of these macro processes (adding up to twelve) as a new theoretical framework operationalisable in formative evaluation of transformation innovation policy (Molas-Gallart et al 2020). Note that in our framework, the notion of 'outcome' refers to a semi-abstract goal to achieve, for example, a better network but also a process of networking that will develop over time. TOs are not prescriptive tasks and can be stretched for transformation purposes (see table 1 for a full overview of 12 outcomes and example EPEs).

Before explaining the TOs, it is crucial to explain four theoretical underpinnings that constitute the philosophy beyond TOs. First, TOs are conceptualised as processes or interventions that lead to deeper changes in sets of rules that guide actors (individuals but also groups and organisations) in their behaviour.[5] Actors can use these rules because of fear of sanctions (following from regulations), their cognitive beliefs and/or their values (Scott, 1995; Geels 2004; Ghosh and Schot 2019). In socio-technical systems, these rules are shared among regime actors, stabilised and manifested across the different system dimensions such as science and technology (artefacts, infrastructures), market structure (including user preferences), industry structure, policy and politics, and symbolic meanings that make the system culturally attractive. Therefore, sustainability transitions are not only about changing systems, but also about changing the underlying rules that actors use to build, optimise and maintain the system.

Second, the macro processes that encompass TOs emerge from a specific theory of change; one where sociotechnical change occurs through dynamic and complex interactions between niches, regimes and the landscape, as conceptualised in the Multi-level Perspective (MLP) (Rip and Kemp 1998; Geels 2002). This theory of change embraces the idea that transformations of dominant and unsustainable sociotechnical regimes (stable rule-set) follow distinct pathways depending on the emergence and maturity of alternative sociotechnical systems in niche spaces and the influence of trends and shocks (the climate crisis, increasing inequality, pandemics such as COVID-19; digitalisation) called the sociotechnical landscape in 'hollowing out' the regime and offering the context for alternatives to stabilise (Smith et al., 2005; Geels and Schot, 2007).

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[5] Note that the notion of outcomes is also used in formative evaluation and theory of changes approach that comes with it. There it refers to a change in behaviour or people and organisations. TO's can therefore be seen as a specific interpretation of what counts as outcomes in formative evaluation (Molas Gallart et al 2020).

Third, how TOs are enacted is a deeply political process, riddled with choices and conflicts between multiple actors with incongruent interests. This prompts the question which actors to involve. We propose to think about this in three ways. First, given the multiple system dimensions, transformation processes should include actor-groups corresponding to particular dimensions; this means inclusion of users, citizens, industry, government, knowledge institutions and actors of the cultural dimension such as artists, and media. Second, transformations need deliberations between diverse sets of regime and niche actors; regime actors are those people and organisations who belief and value the regime rules, while niche actors have alternative preferences, playing a crucial role in experimenting and enabling change as visionaries who are less constrained by the regime rules (Holscher et al., 2019). While both regime and niche actors are important, for a sustainability transition to happen regime actors should not dominate. Between the dichotomy of niche and regime actors, there are also 'intermediary' actors who play critical roles in bridging the differences between conflicting interest groups and 'orchestrate' a way forward (Kivimaa et al., 2019; Sovacool et al., 2020) Third, sustainability transformations involve addressing systemic inequality, injustice and marginalisation of actor groups, including unequal distribution of benefits. Sustainability transitions, particularly from a Global South perspective, should empower people and organisations who will be most adversely impacted by the current practises (Swilling, 2019; Ghosh and Sharmeen, 2021).

Fourth, transformative outcomes unfold not only over time, but also spatially. The implications of spatial sensitivity of the framework are two-fold. The system configuration, rules, actor-networks and the theory of change have to be situated in place-based conditions that have a crucial role in enabling or disabling transformational processes (Hansen and Coenen, 2015). Hence TOs should be applied to address context-specific institutional conditions and demonstrate the role of transformative innovation in many socio-spatial contexts (Dignum et al, 2020; Binz et al, 2020). Morevoer, the spatial dimension varies across the TOs. While TOs associated with building niches can be tracked in specific geographical locations, the ones associated with expanding and mainstreaming are rarely confined to local contexts, but encompass activities, actors and resources scattered over distinct scales and geographies. Expansion and mainstreaming need supportive networks that span to regional, national and international settings and mobilise experiences from several locations to enrich or justify local experiments (Avelino et al, 2019; Wieczorek et al., 2015). Multi-scalar work implies connecting local niches and regimes to global ones (Bauer and Fuenfschilling, 2019).

Next, we describe each TO and exemplify their applicability, providing sufficient granularity for evaluative and reflexive processes as developed in TIPC. In our experience, while implementing the TOs, there is no right or wrong sequence. Neither is it necessary to make a qualitative judgement of whether one is more transformative than the other. On the contrary, innovation policymakers should work on a selected portfolio of TO's to accelerate ongoing transformation processes. Which TOs to target, in what sequence and how many to achieve through an EPE is contextual and contingent on different capacities and constraints.

3.1 Building and nurturing niches

Niches are valuable for transformations because they provide spaces for building alternative practices from which new rules and systems can emerge. They are seedbeds, harbours and battlegrounds for

transformation (Torrens et al., 2019). The conceptualisation of this process is based on strategic niche management theory (Kemp et al 1998; Raven et al, 2010). Within the process of building and nurturing niches, four TOs are identified: a) shielding, b) learning, c) networking, and d) navigating expectations. For each outcome we introduce a distinction between broadening and deepening. The former relates to expanding the scope, while the latter focuses on improving the quality and directionality of the process (Schot and Steinmueller, 2018).

3.1.1 Shielding

Shielding means creating conditions for niche innovations to thrive by fencing off incumbent interests. Shielding mechanisms may include direct support for radical niche innovations through R&D or deployment subsidies, preferential tax treatment, public or collective purchasing, voluntary agreements, regulation, and/or information campaigns (Raven et al., 2010). This is active shielding (Smith et al., 2014) to 'protect the niche' from being exposed to economic, political, institutional and exogenous pressures. Specific pre-existing geographical and spatial conditions such as 'remote locations', culture of resistance and activism may provide passive shielding to niches (Smith et al., 2014). Active and passive shielding can co-exist, but it is desirable that niches continue to receive passive shielding even after active cover is removed, and that shielding becomes a routinised niche actor behaviour.

We propose that deliberate interventions by policymakers and other actors *broaden shielding* by increasing the diversity of active strategies to protect multiple alternative niches in different system dimensions (new policy, business model, new scientific knowledge, user preferences and new symbolic meaning of the alternative). We further propose policymakers and other actors to *deepen shielding* by strengthening the various actor strategies and align them better across the system dimensions and spatial scales. Experimental policy engagements for how to broaden and deepen shielding of the niche in and beyond a specific context is important for facilitating transformative change at local, regional or national levels.

3.1.2 Learning

Learning is a cognitive process of knowing, understanding and reflecting. Such processes are the core to niche building and nurturing as radical innovation can only happen through continuous learning in strategic locations that shielding offers (Schot and Geels, 2008; Raven et al., 2010; Naber et al, 2017). According to strategic niche management, one can distinguish between first-order and second-order learning (Pellicer-Sifres et al, 2018; Smith and Raven, 2012; Van de Kerkhof and Wieczorek, 2005). While first-order (single loop) learning is about knowledge accumulation for determining solutions to specific problems in a specific context, second-order (double loop) learning is about thinking through the process of approaching the problem in itself. It is 'higher order learning', often associated with 'learning-by-doing' through which niche actors continuously reflect, adapt and challenge other actors' assumptions and perceptions of "problem solving, problem definition, dominant interpretative frame and worldview" (Sengers et al, 2019: 157; van Mierlo et al, 2020). Both first- and second-order learning are important for transformation. However, second-order learning is more important and is deemed more transformative, because it challenges the underlying regime rules (Poeck et al, 2018; Loorbach et al, 2011; Mezirow, 2000).

As a TO, policy actors and other actors involved in niches can design interventions for *broadening of learning* by enabling learning in more than one system dimension across multiple systemic actors (e.g.

engineers looking beyond technical knowledge), and ensuring that also second-order learning is happening. This means continuous reflection and challenging assumptions/biases to build a long-term, robust and collective problem-solving capacity for the whole system (Poeck et al, 2018). Policy actors can design specific interventions for *deepening of learning* by training multiple actors to stretch their thinking beyond existing routines and norms, and acquire a deeper, holistic and context-specific understanding of the sustainability problems faced by the socio-technical system they are embedded in (Raven et al, 2017). Deepening learning is an important TO as it enhances reflexivity, mutual trust between actors and collective retention of new rules, thereby facilitating easier translation of the first-order learning from niche into more generalisable, stabilised rules. This is a step towards setting transformative directionality through selective retention of rules in the formation of new regimes (Turnheim et al., 2018; Safarzyńska et al., 2012, Borghei and Magnusson, 2018; Sol et al., 2017; van Mierlo et al, 2020). For broad and deep learning to occur, the type and quality of actor-networks is a key factor.

3.1.3 Networking

Transitions, as an inherently multi-actor process, actors are bound to fail if these actors do not interact, share ideas, exchange resources and work together to complement and enhance each other's skills, knowledge and capabilities (Avelino et al, 2019). An explicit strategy for enabling networking between diverse niche actors is imperative to niche building processes.

Networking as a TO, can be achieved through broadening and deepening of social networks emerging and existing around niches. As niches are built, policy actors can contribute to *broadening of networks* by creating new networks composed of niche and regime actors from diverse backgrounds, knowledge and skills (Smith and Raven, 2012). This effort should include actors from various system dimensions (e.g. government, business, civil society, and scientific institutions), and different sections of the society (economic elites and marginal groups). Such broadening raises the transformative potential of niches through engaging with several perspectives that reduces the risk of social exclusion, discrimination and lock-in to a single transition trajectory. However, solely broadening networks might lead niche actors conforming to the dominant views of the regime. Hence, an effort into deepening of networks is important to mitigate this conformity. *Deepening of networks* can be achieved through building mutual trust and commitments within the newly emerging networks (Schot and Geels, 2008; Naber et al., 2017; Sol et al, 2018). Such effort might require specialist interventions of a new set of actors called "niche intermediaries" who are skilled at facilitating mutual connections, creating a shared narrative between actors and consolidating the niche (Kivimaa et al., 2019). They bring together multiple actors' experiments and strengthen the 'common voice' (Smith et al., 2016). The goal of deepening is therefore to improve the quality of actor-networks so that they can 'stretch and transform' the regime. Networking, through broadening and deepening is a TO that contributes to shaping new expectation dynamics within niches.

3.1.4 Navigating expectations

Niche actors' collective expectations about future trends and shocks at the landscape level, the ability of regimes to respond to exogenous and endogenous pressures, and the potential of innovations to address problems in the regime are a crucial determining factor of whether and how niches are built and nurtured (Truffer et al 2008; Smith and Raven, 2012). Expectation dynamics can be volatile and develop with hype and disappointment cycles (Konrad et al.,2012; Verbong et al., 2008). They may vary across niche and regime actors and across socio-political and cultural contexts (Budde et al, 2012; Coenen et al., 2010;

Brown and Michael, 2003). As a result, niche actors are required to *navigate* a 'sea of expectations' and the ambiguity it generates, before they may find some convergence into shared visions, eventually guiding niche development (van Lente, 2012; Raven et al, 2010; Borup et al., 2006). Therefore, an explicit effort in navigating the diverse expectations arising from broadening networks to arrive at shared and inclusive visions of the future is what makes the system transformative. Such navigation, supported by (but not limited to) reflexive learning, allows explicit negotiation between contested and contradictory visions (instead of hiding them) leading to more robust and widely shared expectations about the future of sociotechnical systems (Konrad 2006).

To mobilise the navigation of expectations as a TO, niche policy actors should first put efforts in broadening the pallet of expectations, by actively seeking to accumulate visions from multiple actors which involves acknowledging tensions and conflicts of interests in several articulated (and unarticulated) expectations (Delina and Janetos, 2018; Jørgensen, 2012; Borup et al., 2006). Broadening also refers to being open to diverse expectations about many issues such as landscape trends, the quality of regimes, and niche performance (Truffer et al, 2008; Budde and Konrad, 2019). Broadening expectations is an accommodation process. A complementary process, *deepening expectation dynamics*, is to find alignments between diverse articulated expectations, which sets the directionalities of future transitions (Truffer et al 2008; Budde and Konrad, 2019). Deepening also involves evaluating the quality, stability and credibility of expectations through mapping evidence underlying each expectation. This is part of the negotiation process which can help navigating hype cycles, contestations and open up possibilities of multiple radically different futures sensitive to local contexts.

3.2 Expanding and mainstreaming niches

For transitions to happen, niches need to expand in size and scale. The expansion process implies that the rules and practises emerging in the niche are 'mainstreaming' (Gibbs and O'Neill, 2015). Mainstreaming is a level of acceptance and credibility that assists in take-up or adaptation in contexts outside of the niche's immediate origin. Four TOs can be discerned from the literature on niche acceleration and embedding (Naber et al., 2017; Turnheim et al., 2018; Meelen 2018): a) upscaling, b) replicating, c) circulating and d) institutionalising. The latter three contribute to upscaling, while they are distinct processes that can be shaped by EPEs separately from focusing on upscaling as such. Figure 1 illustrates these outcomes with 'time' in the horizontal axis and 'stability of rules' in the vertical axis.

3.2.1 Upscaling

Upscaling as a TO, can be associated with the adoption of the niche innovation by more users (Turnheim et al., 2018). The adoption is not of a technology, process or product, but of the entire system of the 'niche' and embedded rules. Drawing from the notion of 'system diffusion' (Geels and Johnson, 2018), upscaling is about societal embedding of niche innovations facilitated through developing policy measures, industry strategies and cultural meanings for more user adoption (Seyfang et al., 2014; Jolly et al., 2012). In a recent study on solar development in China, Yang et al., (2020) argue that, when 16 percent of the potential users adopt a niche innovation, system diffusion accelerates; new users adopt not just the technology (solar PV), but also accept the new rules embedded in the technology as a (future) mainstream option. In our framework, upscaling is geographically bounded by the size and location of the

market, embeddedness of users in the local-cultural context, even though actors and resources from elsewhere may also contribute to this expansion.

3.2.2 Replicating

Replicating refers to the geographical expansion of the niche, by recreating similar niche spaces in new socio-spatial and cultural contexts (Bos and Brown, 2012; Turnheim et al., 2018). An expected output of replicating is geographically disconnected yet similar niches emerging in their own local contexts with their own shielding and nurturing strategies. An example is the replication of bike sharing niches in different cities around the world with different strategies to protect the niche (van Waes et al., 2020).

Replication is heavily dependent on socio-institutional, political and cultural conditions (Raven et al, 2012; Coenen et al, 2012; Hansen and Coenen 2015). As a TO, replication needs to be specifically anchored to a context in spite of the accumulated learning and knowledge flow from other contexts (Carvalho and Lazzerini, 2018). This process involves decontextualisation from their source, and consequent re-contextualisation in the new context through consolidation and packages of learning for spatial transfer, followed by unpackaging, reinterpretation and embedding in the new context (Seyfang et al. 2014: 23). The success, failure and transformative potential of a replicated niche depend on these processes and local niche actors' awareness and estimation of context (Feola and Nunes, 2014).

Certain intermediary actors, such as international organisations, can help replication as they may have capacities to work in and knowledge about multiple local contexts (Hanen and Nygaard, 2013). Yet, examples of global intermediaries skipping the decontextualization and recontextualisation process to imitate the same niche in multiple locations also exist (Seyfang et al, 2014). Successful replication of niches may also be facilitated through empowering local actors to try out successful niches from elsewhere if they have shared problems, future visions and perceptions of landscape pressures, such as the need to shift to a low-carbon society (Seyfang and Haxeltine, 2012).

3.2.3 Circulating

Circulating as a TO is distinguishable from upscaling and replicating by its nature of spatiality and specific actors' contributions in enabling circulation. Circulating elements of a niche (e.g. ideas, people, values, products, texts and learning) elsewhere can be transformative if it enables niche building and expansions in multiple places simultaneously. It is beneficial as multiple niches from different spatial and cultural contexts connect, leading to the overall expansion of the global niche (Geels and Deuten, 2006; Gosens et al., 2020).

Circulation of a niche can happen through trans-local interactions between geographically dispersed, yet globally (virtually) or nationally connected user communities who serve as a 'central knowledge archive' and help in recontextualising systems to diverse local contexts (Meelen et al., 2019). 'Intermediaries' can facilitate circulation, for example, by transferring learning from multiple local projects or experiments to the global niche (Kivimaa et al., 2019). They may also bridge between niche and incumbent actors, developing themselves as transformation progresses (Sovacool et al., 2020). These actors may ensure that many elements of individual niches are circulating, decontextualised and recontextualised in various spatial contexts through designing dedicated interaction between multiple actors across multiple spaces which facilitates not only exchange of learnings across niches but also between global niches and regimes (Kivimaa et al., 2019; Bush et al., 2017). Recognising and enhancing structural and functional capabilities

of systemic intermediaries is an effective way of achieving this TO. Yet, it is important to note that circulation is many ways unstructured and fluid and can be only partially influenced.

3.2.4 Institutionalising

Institutionalising means stabilising shared rules that emerge in niches. It means the global niche is on its way to become a global regime (Fuenfschilling and Truffer, 2016; Geels and Deuten, 2006) through wide adoption of newly emerged rules that are formalised into rights, routines and obligations (Streeck and Thelen, 2005).

As a TO, institutionalisation can be supported by building consensus within the expanding actor-network and building legitimacy around shared collective definitions, narratives interpretations and behaviours (Genus and Iskandarova, 2020). This is a delicate process, since it threatens the diverse exploration associated with plural niche building processes. Establishing a global community of practice (Wenger, 2002) around collective and plural 'futures-making' (Wagner and Galuszka, 2020) can be an effective mitigation strategy. Policy actors my also seek support from 'institutional entrepreneurs' who are intermediary actors focussing on not just empowering niches, but also on creating and maintaining shared rules, and building up a constituency behind the new regime through 'institutional work' (van Doren et al., 2020).

EPEs focused on mainstreaming the niche are often resisted by regime actors. Thus, active engagement of regime actors is needed to build more institutionalised bodies and create space for new institutionalised rules for the niche (Kivimaa and Rogge, 2020).
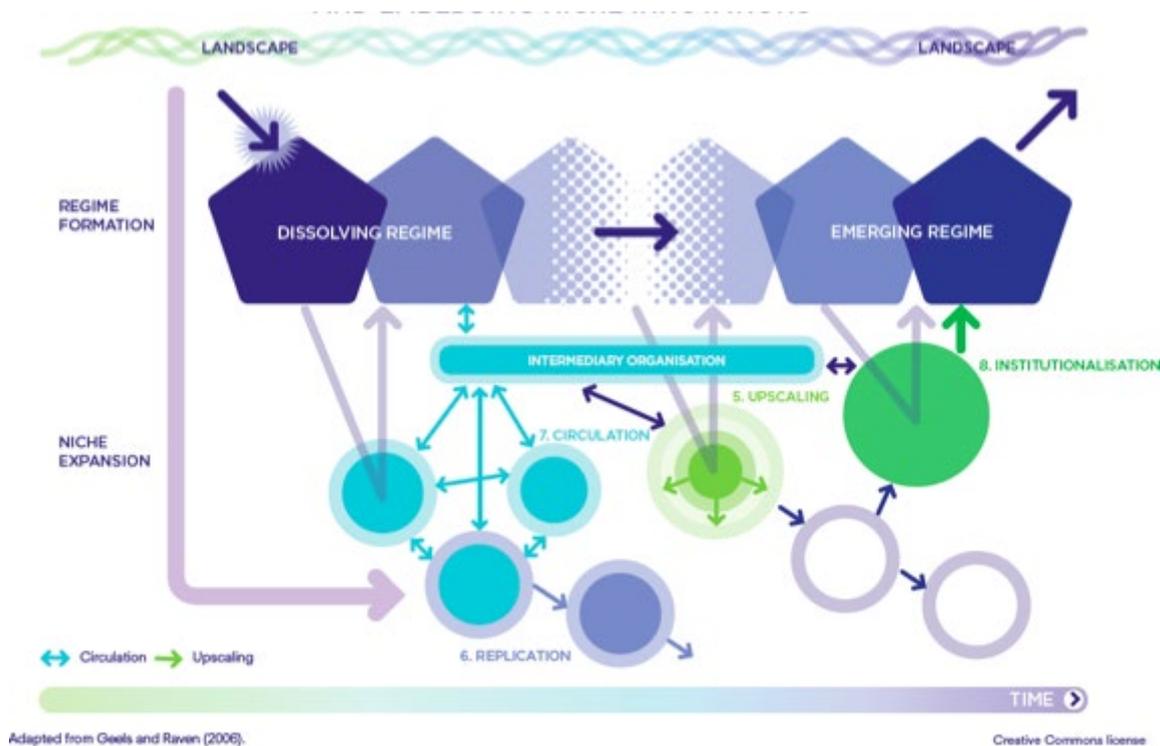

Figure 1 Transformative outcomes in niche expansion and mainstreaming (adapted from Naber et al, 2017)

3.3 Opening up and unlocking regimes

While much transitions literature is focussed on niches, recent studies have started to highlight the importance of understanding regime dynamics (Bosman et al., 2014; Leipprand et al., 2018). An important step for transitions is to open and unlock regimes so that niche innovations have 'windows of opportunity' to expand (Geels and Schot, 2007). The process of unlocking directly addresses the rigidity of stabilised regime rules which support incrementalism in existing trajectories, keeping the system configuration intact (Geels, 2005; Verbong and Geels, 2010; Mercure et al., 2016). Even when alternatives are proposed by regime actors, they tend to reaffirm the architecture of the system as it is. To respond to the dynamic sustainability challenges, it is necessary to rid the regime of this rigidity and open it for reconfiguration and destablisation (Turnheim and Geels 2012; Kainiemi et al., 2019).

For opening and unlocking regimes, we explore transformative outcomes that need to be achieved by regime actors a) de-aligning and destabilising, b) unlearning and deep learning, c) strengthening regime-niche interactions and d) changing perceptions of landscape pressures.

3.3.1 De-aligning and destabilising regimes

Unsustainable regimes can be destabilised when regime actors abandon behaviours, beliefs and values that hold together the system configuration through "semi-coherent" rule sets. As formal and informal rules mis-align, between system dimensions, the stability of regimes is reduced due to weakened reproduction and flow of resources to keep the system intact (Kainiemi et al., 2019).

Dealigning and destablising regimes can be a TO, when actors adopt new (innovation) policies (Kivimaa and Kern, 2016) or industrial strategy (Karltorp and Sanden, 2012) that deliberately challenge and destabilise the existing systems. As a result, the new strategies/policies may not align well with other existing system dimensions such as business models or infrastructures. Such dealignment forces the regime to further open and unlock. Phase-out or exnovation policies link to this TO (David, 2017; Rogge and Johstone, 2017) alongside deliberate attempts to disrupt dominant actor-networks or significantly change regime rules (Kivimaa and Kern, 2016).

A specific challenge for de-aligning system dimensions can be a strong interconnection between regimes, evolved over time (cf. Konrad et al., 2008). For example, the car-dependent mobility system in the United States is deeply intertwined with the housing system, and the nature of urbanisation and affordable housing in suburbs. De-aligning and destabilising those couplings is difficult due to existing path-dependencies.

3.3.2 Unlearning and deep learning in regimes

In locked-in regimes, individual actors become entrapped in system dynamics (Sydow et al., 2009). They strongly believe in the viability of the regime for confronting problems and its legitimacy among wider population (Geels, 2010). Regimes are stabilised through the conformation of the behaviours, beliefs and values of regime actors across multiple dimensions. Unlearning of dominant rules by regime actors, in a way that they start questioning existing behaviours, beliefs, values and norms that are embedded in their existing skills and capabilities is an important element of opening regimes.

Van Mierlo and Beers (2018: p.261, 264) define unlearning as abandoning obsolete practices and leaving behind old ineffective habits.   Unlearning includes an acceptance of risks and uncertainty, and the costs of the reorganisation of the regime in short-to-medium term. Deep learning by regime actors includes experiential social learning about challenges faced by the regime, building on their knowledge of the system and, as a result, their willingness, motivation and ability to change the system through formal policy processes (van Meirlo et al., 2020; van Poeck et al, 2020; Vinke-de Kruijf et al., 2020). It can be shaped by local, context specific challenges or global sustainability discourses (Scholz and Methner, 2020). Unlearning and deep learning are complementary processes that innovation policy actors may pursue as a TO for unlocking regimes.

3.3.3 Strengthening regime-niche interactions

Regimes can also open by interacting with niches and other regimes (Raven and Verbong, 2007; Konrad et al., 2008; Sutherland et al, 2015). Strengthening regime-niche interaction, as a TO, can be achieved through regime actors enabling niche empowerment, intermediary actors challenging incumbents by creating new connections between niches and regimes (Matschoss and Heiskanen, 2018), and same actors operating in different but interconnected regimes (Pekkarinen and Melkas, 2019; Sutherland et al., 2015; Slingerland and Schut, 2014). The initiative of regime actors to reach out to multiple niches is crucial. Being open to alternative ideas proposed by niche actors, the regime actors facilitate change within regimes, ideally resulting in new actor-networks comprising both niche and regime actors. This building of connections can go into two directions. It can seek to support niches to integrate them into the prevailing regime (i.e. 'fit and conform' type of niche empowerment); alternatively, regime and niche actors can mutually support each other for changing the selection environments in favour of disruptive niche innovations ultimately changing the regime (i.e. "stretch and transform" type of niche empowerment Smith and Raven, 2012).

Regime-based transition intermediaries are a specific type of intermediary, empowered to change regimes from within (Kivimaa et al., 2019).   They can help linking emerging niche narratives with the socio-political agendas set by regime actors. These intermediaries, despite their regime-based mandates, are influential in building strong and long-lasting relationships between niches and regimes by "brokering and coordinating partnerships beyond the niche" (Bush et al.,2017: 139; Kivimaa, 2014).

3.3.4 Changing perceptions of landscape pressures

The landscape comprises macro-level, exogenous, long-term and slow-moving trends, such as climate change, or rapid external shocks, like Covid-19, which single actors do not seem to directly influence (Van Driel and Schot, 2005; Geels, 2011; Kungl and Geels, 2018). Landscape pressures considerably influence how, in which direction, and with what speed systemic transformations unfold because of their stabilising and/or destabilising power on regimes and niches (Geels, 2011). Regime actors are known to react in different ways to 'landscape inertia' (trends, opportunities and threats), depending on their political ideology, cultural understandings, societal preferences and lifestyle (Li and Strachan, 2017; Simpson, 2019). In that way, dominant regime shapes what is perceived as landscape pressures. For example, the automobility system has changed the landscape by contributing to trends towards individualisation, urbanisation and industrialisation, and the severity of climate change and the state of the environment. Thus, landscape pressures are also exacerbated and created by regimes (and not exogenous).

The ways in which landscape pressures are perceived by regime actors is uneven and varies across contexts (Hansen and Coenen, 2015). It may comprise multiple and diverging trends. When regime actors begin to see alignments between multiple external pressures, it could create an 'overwhelming effect', leading to altered perceptions (Turnheim and Geels, 2012) and what is deemed 'relevant'. Explicit attention to changing perceptions about diverse landscape pressures is a TO, with significant implications on decision making, (re)distribution of resources and commitments to unlocking regimes.

Table 1: How do experimental policy engagements (EPEs) contribute to achieving transformative outcomes (TOs)

Macro-process	Transformative Outcome	EPEs contribution
1. Building and nurturing niches	1.1. Shielding	Offering protection for niche experiments and normalising these protection measures. *Broadening:* identifying, testing and developing strategies to protect niches covering multiple system dimensions, encompassing a wide range of experiments and more diverse alternatives. Examples: providing subsidies for innovation projects (STI dimension), parking benefits to electric vehicles (market dimension), or media campaigns to promote organic food (cultural dimension). *Deepening:* align various shielding measures, across system dimensions and across geographies. Examples: providing a permanent VAT exemption for organic food, integrating organic food consumption into standards for food provision in schools, making specific (parts of) cities only accessible for electric vehicles.
	1.2 Learning	Induce first- and second-order learning in niche experiments. First-order learning focuses on improving what actors are doing while second-order learning questions frames and assumptions of structures and activities. B*roadening*: including more dimensions of the system in first- and second-order learning processes and incorporating different forms of knowledge (e.g. beyond technical knowledge from a single discipline), involving multiple actors (diversity and trust) and aspects of sustainability. Examples: not only focus on how to develop solar technology but also address opportunities and barriers for viable business models, and consumer behaviour integrating various knowledge aspects and actors in the learning process. *Deepening*: creating opportunities for challenging assumptions (about preferred solutions, problem definitions and whether and how they contribute to sustainability). Examples: doing a study with multiple actors about the question whether and how biofuels contribute to the SDGs; organising a workshop with diversity of actors about question whether electric vehicles are just a solution for the rich, and whether and how they will reduce car mobility substantially.

	1.3 Networking	Create high quality opportunities for collaboration between actors, strengthening their networks.
		Broadening: convening joint activities with enough flexibility around which multiple actors can congregate and mobilise, acknowledging diverse beliefs, values and concerns.
		Examples: including a diversity of patients, civil society actors, food shops, fitness centres, and schools next to healthcare professionals, policymakers and insurance companies in an experiment with a new way of local healthcare provision that integrates healthcare with life style.
		Deepening: enhancing the mobilising power, mutual trust and coordination among the actors involved in niches ensuring the stability of actors-networks over a longer period.
		Examples: establishing intermediary niche actors that build platforms for more permanent interaction among various actors.
	1.4 Navigating expectations	Create spaces for articulating expectations around societal challenges and appraising these expectations to enhance their credibility (among niche actors), quality (providing more evidence) and stability (expectations are not questioned anymore).
		Broadening: allowing a diversity of actors to voice their expectations around landscape challenges, regime ability to respond, and promise of niches to provide solutions. Requires accepting and making explicit tensions and conflicts of interest among expectations.
		Examples: by organising futuring processes that articulate several expectations about the future of water management in a specific region addressing conflicting demands by farmers, ship owners, consumers and nature conservation, and allows for deliberating these futures.
		Deepening: developing credible expectations by aligning landscape, regime and niche expectations of niche and regime actors and supporting this alignment with concrete evidence.
		Examples: by organising a transition arena where actors have to create a shared vision and proposals for a set of experiments for new water management practices they will collectively develop and fund.
2. Expanding and mainstreaming niches	2.1 Upscaling	Increasing adoption by users of the new emerging system; this is not only about adoption of a new set of user preferences and technologies but also wider adoption of policy measures, industry strategies, and cultural meanings and symbols.
		Examples: by setting up a user club that organises an internet platform on heat pumps, or a communication and marketing campaign for use of fuel cells in townships in South Africa advocating decentralised energy provision without access to the grid.
	2.2. Replicating	Intentionally facilitating the replication of specific niche experiments in other contexts.

		Examples: by creating a funding program, or any other mechanism (intermediary actor, education and capability building program) for replicating an experiment with local and direct food provisions from one city to many cities.
	2.3 Circulating	Identifying and promoting circulation of ideas, people, blueprints, technologies between niches on a more continuous basis. Examples: creating an intermediary actor responsible for the circulation among a range of experiments for retrofitting houses in a specific country, or larger region. This action could include organising training to exchange ideas, mutual visits, and promotion activities.
	2.4 Institutionalising	Mainstreaming the rules of the niche (behaviour, beliefs and values) among existing and new niche actors. For example, creating a handbook, a certification scheme and standards for how to fish salmon in a sustainable way.
3 Opening up and unlocking regimes	3.1 De-aligning and destabilising	Facilitating the development of disruptive policy frameworks and governance arrangements (such as organisational and administrative reforms) that challenge existing systems. Examples: developing a phasing out policy for coal burning plants, mobilising social protests, or going to court to challenge non-compliance with internationally agreed targets on reducing CO_2 emissions.
	3.2 Unlearning and deep learning in regimes	Facilitating unlearning and deep learning among regime actors, helping them re-assess the regime rules in comparison to new alternative rules for solving systemic problems. Examples: organising a policy lab to discuss a variety of policy barriers for using insects as a food product in the Netherlands, or a policy lab to discuss the barriers for procurement of sustainable food by schools or hotels.
	3.3 Strengthening regime-niche interactions	Creating linkages between niche and regime actors, and their ideas and resources with the aim to empower niches and make them more competitive. Examples: developing a new impact investments tool that will crowd in investment into niche activities by traditional banks and investors and crowd-out investment in unsustainable technologies and systems.
	3.4 Changing perceptions of landscape pressures	Facilitating processes to challenge individual and collective perceptions about landscape pressures of diverse groups of regime actors: policy makers, producers, businesses. Examples: by organising specific foresight activities with regime actors about whether and how digitalisation could contribute to climate action.

4. Case studies

We present two cases of currently ongoing transformative change: mobility-as-a-service (MaaS) in Finland and speciality coffee in Colombia. We sought to make visible the emergence of transformative outcomes, while it must be noted that these are part of longer narratives of events reported elsewhere (Kivimaa and Rogge, 2020; Arond et al 2017). Let us introduce both cases briefly. Results of our analysis are summarised in Table 2. Subsequently we provide an analysis of the results.

MaaS has since 2014 developed as a niche in Finland, with support from both regime and niche actors. They have perceived a need to move from individual ownership of cars to personalised mobility services to reduce the environmental impacts of transport and improve access for people who cannot afford to own a car. The concept of MaaS, proposed by a championing niche actor, focused on optimising the connection between private vehicles and public transport via shared mobility services. The idea has benefitted from refocusing and reorganising national-level public governance since the early 2000s in response to landscape developments such as digitalisation, urbanisation, ageing population and climate change, while innovation and transport policy actors have actively supported the early stages. In Finland, MaaS is typically defined by key niche actors as specific 'packaged offerings' with intermodal planning, booking and payment components, comprising multiple transport modes. As such, the MaaS niche challenges the dominant transport regime built around individual motorised transport.

In some Finnish cities, public transport operators have been unwelcoming for MaaS providers to appear on their "turf". They have been reluctant to allow third-party ticket sales, hindering the upscaling of MaaS. Taxi providers have opposed change, where multiple companies can provide taxi services in a given area, increasing competition. The enforcement of the Transport Service Act has been strengthened by threats of penalty payments issued by the Transport and Communications agency, but the underlying tensions have not yet been solved. Covid-19 has slowed down the further development of MaaS.

The coffee industry is among the most important export sectors in Colombia, providing a living for approximately 800,000 people. Until the 1990s, the Colombian coffee sector was firmly wedded to a commodity model of production: farmers receive a fixed price for a standardised quality of coffee bean which is mainly used for exports, with smaller and off-colour beans sold for domestic consumption. This system was thrown into disarray in the 1990s with a number of landscape developments, in particular the breakup of the International Coffee Organization, the associated International Coffee Agreement and the commodity-based international system for coffee production and supply. Consequently, the speciality coffee niche emerged, promoted by international organisations such as Fairtrade and the Rainforest Alliance, representing an alternative international system of certification for coffee production. Its transformative feature is a vision of coffee that is in harmony with the environment and has a strong commitment to local social development.

Preceding the crisis, research into alternatives by the incumbent actor in Colombia, the National Federation of Coffee producers (FNC), remained marginal and the FNC did not undertake serious investment into building niches for what is referred to as specialty coffee. Consequently, the Colombian coffee system remained locked into a commodity model (Echevarria et al 2014:5). Under the commodity system, the farmer was largely disengaged and alienated from his/her produce with little opportunity to improve the quality of the product and few incentives to improve environmental practices. With building

the specialty coffee niche, producers moved from "producing a coffee bean to producing a drink". Farmers learnt to become tasters and developed knowledge about different preparation methods. They also developed skills around coffee washing, fermenting and drying and to follow certifications that demand careful implementation of environmentally sound practices. More disruptive conceptualisations of the value chain have yet to emerge.

Table 2 shows our analysis regarding the extent to which we have detected TOs in these two processes. We do not seek to provide a definitive and comprehensive appraisal of the cases and the extent of their transformation. Even with stylised cases, the salience of the transformative outcomes we identified is clearly visible. For the case studies the authors made assessments of the quality of the transformative outcomes, by calling them substantial for example, based on all collected case material (see section 2 for overview). When applied in real-time EPEs, these quality assessments should be done together with the actors in a formative evaluation process. In that process, the focus is on organising a discussion about outcomes to reflect and induce learning among actors on how to improve (Molas-Gallart et al., 2020).

The MaaS case shows that many TOs are worked upon by several actors, leading to a robust process of *niche development* on all four outcomes: shielding, learning, networking and expectation dynamics. Robust means that all processes were of sufficient quality to lead to a niche that is clearly recognisable as such by all actors. This process of niche building was enabled by a process of *regime opening and unlocking*, mainly by transport and innovation policy dimensions at the national level. However, this process has not extended significantly to city-level policymaking in Finland. The case is characterised by early and active participation by national regime actors, in particular the national innovation agency (Tekes, subsequently Business Finland) and the Ministry of Transport and Communications. These actors had created several EPEs such as the New Transport Policy Club, the Traffic Lab and Tekes's MaaS Programme. The development intertwined with major organisational changes in the administration for transport and communications and led to a significant regulatory change in the transport sector. These changes began to destabilise the operational context for many transport sector actors and removed barriers for niche expansion. However, while the policy changes aimed to influence many regime dimensions, changes in the other regime dimensions, especially in the preferences of mobility users, and the mobility culture have not yet substantially changed. Most *niche expansion* outcomes were also insufficiently covered.

The MaaS case illustrates how development in multiple TO's can happen in parallel and is not a linear, sequential process. The process was initiated in dialogue between niche and regime actors, who searched for new opportunities in response to intensifying landscape pressures on climate change, digitalisation and automation, and economic developments. Gradually a more transformative path developed fuelled by expectation and network dynamics. Niche actors working from within the dominant regime managed to carve out a niche for a radical substitute for the dominant mobility regime, challenging the clear separation between public and private transport provision and individual car ownership.

The Colombia specialty coffee case shows all TOs leading to robust *niche building*: shielding, networking, learning and expectation dynamics. The shielding, however, was not provided by national or local policymaking, but by influential niche actors working at different multi-scalar levels (production, consumption, logistics) to develop an alternative sustainable vision of the value chain that is capable of integrating local producers at the grassroots level. The subsequent learning was deep, because many assumptions about coffee production were challenged and expectations were opened for new futures,

questioning a business-as-usual response. Farmers changed their behaviour, beliefs and values during the process. For the farmer, in many ways the journey followed a 'stretch-and-transform' pattern.

Due to landscape changes, it had become clear that the existing regime was clearly no longer fit for purpose and regime actors were willing to reorient their beliefs and behaviours following a shock fall in prices. New national and international networks emerged among farmers and supporting institutions. This led to a process of *niche expansion.* Farmers circulated their ideas and experiences, building new platforms. They replicated experiments that could be institutionalised through international certification schemes. Although the traditional coffee *regime opened* for change, many farmers had to unlearn existing practices and change their perception of landscape developments. While regime actors invested in the specialty niche, this did not replace the dominant regime. Currently, after 15-20 years of development, specialty and commodity coffee coexist, the latter serving other markets. The case is characterised by bottom-up actions by farmers, but lacked major policy involvement and engagement with STI policy actors to support the new specialised coffee niche.

The two cases illustrate very different context and application of TOs. Whereas in the context of MaaS, TOs involved coordinated government activities and collaborative networks, the coffee case is more about bottom-up and market-driven change combined actors working at different international scales in the opening up and unlocking process.

Table 2: Transformative outcomes in the two case studies

Transformative outcome	Mobility as a service in Finland	Colombian coffee production
Building and nurturing niches		
TO1 Shielding	*Innovation funding* A year after the MaaS idea was conceptualised, in 2015, innovation agency Tekes established a MaaS programme, including a two-stage call to fund MaaS operators: (1) pre-studies that plan real MaaS pilots and co-design them with potential partners, and (2) concrete test beds where the projects included collaborators and external investors. Maas businesses regarded this funding instrumental. Some Tekes officials called it experimental, being initiated bottom-up and by-passing the usual bureaucratic process of programme-setting. In 2018, Business Finland (previously Tekes) awarded subordinated loans via its new Growth Motor Funding, an experimental policy for funding networks of companies, in total 28.4 million euros to five different companies, two related to MaaS.	*A certified niche market* The first Rainforest Alliance farm was certified in Guatemala in 1995. By 2000 the specialty coffee market had grown to $8bn. This market was an important passive shielding for small farmers who would adopt speciality coffee as an alternative to the commodity model of production.

TO2 Learning	*Collaborative learning via supportive experimental policy engagements*	*Learning via bottom up search process*
	In 2014, the ministry established a Traffic Lab operating as an umbrella for public-private experimentation around intelligent transport systems. It was a space for learning about technical solutions and how to change people's mobility assumptions, preferences and practices. It nurtured a variety of niche developments, being was coordinated by the transport administration.	Niche actors in other countries had been experimenting successfully with alternative sustainable visions of coffee value chains.
		This adoption process became a search process for nurturing the speciality coffee niche. In this process, existing farmers experienced deep learning individually and collectively. For small farmers this was critical in helping to reset expectations concerning their role in coffee production.
	Tekes's MaaS programme was succeeded by a network among multiple companies (including large companies in the telecoms sector, Helsinki Regional Transport and the taxi union) that explored what an actual MaaS operator would look like.	
	An incumbent telecommunications company, Telia launched a MaaS app in one region combining national rail services and local taxi services (broadening learning).	
TO4 Networking	*Public-private networking followed up by new company networks*	*Incentives to form networks of small farmers around specialty coffee*
	In 2004, the ministry encouraged the establishment of a collaboration network, Intelligent Transport Systems Finland (ITS Finland), an association, including civil servants, companies and researchers. Its director and chairman developed the MaaS concept in discussion with members.	At the collective level, farmers were incentivised to organise themselves into cooperatives that are crucial to integrate knowledge and build trust. These cooperatives built new networks with intermediaries, consumers and other farmers.
	In 2014, a group of actors, including ITS Finland and the City of Helsinki and the Ministry began creating a vision for MaaS. This was a next step in the niche building process, building on regime actors working with niche actors. It consisted of a limited set of interactions.	
	Expanding networking in 2015 via Tekes's MaaS programme and the succeeding network of companies.	
TO4 Navigating expectations	*Active role of public agencies and public-private networks in navigating expectations*	*Emerging expectations with a range of benefits*
	ITS Finland voicing expectations of future transport systems from 2004.	The emerging expectation of cooperative leaders and some other actors along the speciality coffee value chain (eg. some certification setters and users) was that speciality coffee would prioritise

	In 2014, collaboration between ITS Finland, City of Helsinki and the ministry to create a vision and a proposal for MaaS. Initially, in 2014 in Tekes, MaaS was a small, informal initiative; a campaign to activate new companies to begin developing new technologies and services. A joint campaign of Tekes and the Ministry organised round tables on themes linked to MaaS, inviting companies to discuss the vision for MaaS, needs of municipalities, public transport providers, designers to think about service design, and some focused on logistics. Some niche actors viewed Tekes as a thought leader who made sure MaaS advanced. Tekes's MaaS programme in 2015	small-scale producers and help articulate the importance of greater access by smallholders to training, education, finance and access to market trade shows. This would trigger a sense of belonging of small producers with their sector that would engender a greater stake in the future of the sector, which then would lead to greater stewardship of the land and education of the children in the new methods of the industry. Thus, new expectations were expressed for regime development (inability of dominant practice to come up with a solution) and the potential of the specialty coffee niche were knit together, which initiated a self-fulling prophecy. Formation of cooperatives prompted new collective voices to express more disruptive notions of coffee value chains. These include re-imagining coffee chains where farmer knowledge/need in the coffee value chain are legitimised. Value chains are re-thought, where farmers have a major say in defining criteria of certifications (leading to experimentation whereby farmers can choose who buys their coffee).
Expanding and mainstreaming niches		
TO5 Upscaling	*Growing companies and supportive funding* From 2016, different companies began operating with MaaS pilots. A new start-up, MaaS Global, began pilots in Helsinki, Antwerp and Birmingham. Business Finland Growth Motor Funding supporting upscaling.	*Upscaling support from a niche association* In 2004 the first smallholder coffee farmer association was established in Huila with the support of the FNC. This was a result of a process of actively circulating and replicating knowledge from different experiments, leading to substantial upscaling.
TO6 Replicating	*Public funding for replication* Business Finland Growth Motor Funding supporting replication.	See above
TO7 Circulating	*Organic circulation via people* Circulation of knowledge via people changing jobs between ministry, ITS Finland and MaaS operators.	See above
TO8 Institutionalising	*International niche organisation and regulatory change institutionalising the niche* In 2016, the European MaaS Alliance was	*Initialisation via a regime actor support and certification*

	created, aiming for the consolidation of niche efforts at the European level (beginnings of Institutionalising). The founding members included regime actors, such as the Finnish Ministry of Transport and Siemens, and niche actors, such as MaaS Global and the ITS Europe network. A major regulatory renewal, the Transport Service Act in 2017, required public transport providers to open data and electronic access to timetables, prices and ticket sales, allowing third parties (MaaS operators) to sell transport tickets.	In 2002, the FNC created Procafecol and Juan Valdes coffee, providing a boost to speciality coffees. The niche was institutionalised through the adoption of certifications: the Utz Kapeh in 2002, the Nestle's AAA Sustainable Quality Programme with the Rainforest alliance in 2003 and the participative agricultural innovation farms certification in 2014. Colombia's speciality coffee production grew from 2 percent of the total coffee exports in 2000 to 28 percent in 2013 (Echevarria et al 2014). In 2014 Huila reported a total of 101,000 coffee farms producing 17.4 percent of the Colombian coffee harvest passing the 16 percent threshold for niche acceleration adoption (FNC 2014)
Opening up and unlocking regimes		
TO9 De-aligning and destabilising	*De-aligning to a changing administration* After the MaaS programme ended, funding for MaaS-related projects was integrated into Tekes's ongoing Smart City Programme (2014-2017). During 2016-2019, public transport administration went through two stages of organisational changes, first, the full integration of transport and communications in the Ministry and later its agencies. Transport Service Act (2017) was described by many actors as ground-breaking and unique transport sector legislation globally, disrupting the regulatory-side of the transport regime.	*Destabilisation emerging from the ground up* Pressure on the FNC to scale up the search for alternatives to the existing system emerged from the collapse of international coffee prices and from social movements and protests of more than 100,000 farmers with small lands in the late 1990s. These took place in ten regional departments with marches and blockage of principal roads. The protests sent a clear message that the system was misaligned (Cruz-Rodriguez 2013: 145) and speeded up the search and implementation of changes to the governance arrangements, thus opening up and unlocking of the national coffee regime.
TO10 Unlearning and deep learning in regimes	*Focused unlearning via experimental policymaking* During 2007-2011, transport policy underwent new developments, e.g. two strategies for intelligent transport and organisational changes leading to multi-modal agencies. In 2012, the Minister for Transport established the New Transport Policy Club, an experimental arena for years 2012-2014 to renew transport policy and address the challenges of climate change, automation and servitisation. It aimed at generating deep learning across sectors, extending beyond the	*A regime actor organising unlearning* FNC created new extension agents that were crucial in actively phasing out (unlearn) unsustainable practices such as non-sustainable discard of coffee shells. Previous practices were re-assessed and new production techniques that are sustainable with the environment were introduced.

	public sector, leading to the beginnings of opening up and unlocking of the mobility and communication regimes. In one of the meetings, the Director of ITS Finland introduced the idea of MaaS drawing from thinking in the telecommunications sector. This roused the interest of a regime actor, a high-level civil servant and many others, who began advancing the idea. As a result, in 2014, the Ministry launched a proposal on MaaS.	
TO11 Strengthening regime-niche interactions		The main regime actor in the Colombian coffee sector, the FNC, eventually also scaled up work on speciality coffee. The coffee sector increasingly changed and became a more diverse value chain with NGOs, specialised growers (e.g. women's groups) and buyers establishing their own local distribution chains and working with the FNC. In 2006 the FNC established the "Women's Coffee programme" by means of an integral programme of gender equality to support empowerment of women in all areas related to coffee production, participation in the FNC and community leadership.
TO12 Changing perceptions of landscape pressures	Visible in the work of the New Transport Policy Club and strategy development (see TO10)	Collapse of international coffee prices and rise of social movements (see TO9)

5. Lessons from cases for transformative innovation policy

Both cases deliver clear lessons for transformative innovation policy and the use of transformative outcomes. We below summarise these lessons in five points.

First, the cases confirm our proposed starting point on transformative innovation policy: transformation is ongoing, also in cases where innovation policymaking is absent or connects only later to the process. Innovation policy and STI actors should actively engage with such ongoing transformation processes, and innovation policy should be designed, implemented and evaluated from this perspective (cf. Kuhlmann and Rip, 2018). A focus on transformative outcomes can help to make such policies more transformative.

Second, transformative outcomes place explicit attention on (i.e. make visible) the processes required by transformation and enable STI actors to actively work with transformation. Missing outcomes can be identified and addressed. When transformative outcomes are used in designing, implementing and evaluating STI projects, programmes and policies, we expect actors to deliberate which outcomes they want to prioritise and when. This is a reflexive process which requires actors to collectively reflect on their own actions and possible and desired consequences (cf. Weber and Rohracher, 2012). In this process, STI actors need to realise that these outcomes do not result from one or two policy interventions. As our case-studies clearly show, they emerge from a complex set of actions unfolding over longer periods. Yet they may help STI actors to stay focused on a systematic approach, building on an understanding that they may have to coordinate with other policy actors to realise outcomes. This coordination may be partial and selective, but overall coordination is elusive and may also lead to a fit-and conform pattern.

Third, the engagement with outcomes is not only about having specific outcomes developing but also about stretching them. For example, learning may be deep, but perhaps it can be made deeper. Or networks can be broadened by making them more inclusive. To assess whether and how this is true, STI agents should engage in a reflexive deliberation process with all actors improving the quality of the outcomes.

Fourth, the transformative outcomes proposed here emphasise the importance of adding mechanisms to innovation policy that address the opening and unlocking of socio-technical regimes. This resonates with earlier propositions for innovation policy to consider also destabilising or disruptive effects alongside niche building and expansion (Kivimaa and Kern, 2016). Both cases provide insights into the relationship between regime destabilisation and experimentation. For example, in the MaaS case the Ministry for Transport and Communications developed into an STI actor also engaging with the outcomes associated with regime unlocking. The specific circumstances in which regime destabilisation happens is, however, unpredictable, unforeseen and often triggered by endogenous or exogenous crises that escape the authority of any actor. Yet, the willingness of STI actors to engage in those circumstances by framing changes as windows of opportunity and using them to create policies for regime openings is important.

Fifth and finally, the ways in which transformative outcomes can be achieved are highly context specific. Both cases presented are heavily embedded in their local, regional and national socio-economic and political settings. For instance, in the context of Colombia, shielding was provided by the agency of local

coffee producers who were included in a global value chain and were acting across multiple scales. In contrast, experimentation with MaaS was a national policy-led process that fitted the policy agenda, which had emerged in Finland after the future of Nokia had deteriorated. Finland needed to look for other use of its ICT capabilities.

6. Conclusion

In the face of persistent social and ecological challenges, new approaches to science, technology and innovation policy are necessary. Globally, STI and other agents of change are already experimenting with challenge-led innovation policies, which are ambitious in achieving SDGs, yet lack appropriate implementation and evaluation processes in order to mitigate the issues of coordination, lack of reflexivity and inclusion. The transformative innovation policy lens offers a critical entry point for guiding the operations of STI and other change agents towards more transformative results.

Sustainability transitions literature, on which the theorisation of TIP is based, offers a wealth of knowledge about systemic transformation and transition dynamics. Our framework offers a new synthesis in a way that is accessible to policy practitioners. The framework of twelve transformative outcomes operationalises key insights from that literature to guide the practices of STI agents working towards enabling transformations. The outcomes are categorised across three spatially bounded macro-processes that can facilitate transformations: 1) building and nurturing niches, 2) expanding and mainstreaming niches and 3) opening up and unlocking regimes. Within the process of building and nurturing niches, shielding, learning, networking, and navigating expectations are the transformative outcomes. For expanding and mainstreaming niches, upscaling, replicating, circulating and institutionalising are the outcomes. The final four transformative outcomes within opening and unlocking regimes, are de-aligning and destabilising, unlearning and deep learning, strengthening regime-niche interactions and changing perceptions of landscape pressures.

These outcomes can be achieved through experimental policy engagements (EPEs) that foster continuous monitoring, evaluation and reflexivity in the conduct of actors for transformative change. In this way, transformative outcomes should be used as a reflexive action framework, rather than a prescriptive step by step guide of how to achieve transformations.

The application of the transformative outcomes framework to reinterpret two case studies - mobility-as-a-service in Finland and specialty coffee in Colombia - confirmed that, to transform systems, STI agencies need to attend to opening up for more radical transformations 'within' the regimes, instead of just initiating new niche projects and hoping they would scale. Our results suggest that these activities are also experimental and require specific provisions not easily attainable through conventional policy. This is a significant departure from both traditional transitions theories and innovation policy assumptions that experiments are primarily relevant for novelty creation in building niches. Here, we advocate for an explicit experimental culture that recognises and engages the various societal experiments within and beyond government, and which leverages specific forms of evaluation to make the outcomes of policy practises to be more transformative.

Practically, which sub-set of transformative outcomes to prioritise with a given policy engagement depends on the status of the unfolding transformations. Given their complexity, we assume that it may be impossible to 'assess' this status objectively ex-ante. TOs, therefore, serve as a process-oriented

heuristic with which to interrogate transformation processes through the co-creation process of TIPC in order to support and improve the transformational efforts of current and future TIPC members. In future research and policy actions, it would be important to identify and test which transformative outcomes are relevant in a particular system and in particular context, how to improve the quality of the outcomes and how to stretch existing actions to achieve more transformative outcomes.

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Funding

Acknowledgments