The policymaking process of transformative innovation policy: a systematic review

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The design and organization of innovation policy

The policymaking process of transformative innovation policy:
a systematic review

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1. Introduction

There is an emerging literature discussing the limits and boundaries to governing socio-technical change for addressing grand challenges through innovation policy (Fagerberg, 2018; Kuhlmann & Rip, 2018; Mazzucato, 2018; Schot & Steinmueller, 2018)(Fagerberg, 2018; Kuhlmann & Rip, 2018; Mazzucato, 2018; Schot & Steinmueller, 2018). One side in this discussion makes the argument that we still can benefit from accumulated research on innovation policy to design and implement transformative policy (Fagerberg, 2018). Other authors suggest that a new type of policy is needed and that this should depart either from previous research on sustainable transitions (Schot & Steinmueller, 2018) or from the mission-oriented framework (Mazzucato, 2018).

While there may be clear differences when discussing the point of departure and knowledge base of transformative innovation policy, there seems to be agreement on two points: that there is a need for knowledge on how innovation policy can be used to address grand challenges and that practices and associated changes in administrative and organizational capacities of public organizations will be key for delivering such transformative policies (Karo, 2018). In the literature, important steps have also been made towards formulating a new transformative innovation policy agenda and supporting the re-organization of the innovation policy process.

In this paper, we address the fact that the current understanding of what characterizes the transformative innovation policy paradigm, its roots and branches, and the actual contributions of the proposed frameworks on practical aspects of the policymaking process is rather unclear. One of many remaining questions is to which extent current writings contribute to our basic understanding of the policymaking process in terms of agenda setting, policy design, legitimation, implementation, evaluation and policy learning. The lack of clear answers to this question is not insignificant. Kern and Rogge (2018) argue that incorporating policy processes into analytical frameworks applied towards transformative policy can bring several contributions, such as determining and shaping the elements of the policy mix for technological change, clarifying the dynamics resulting from interventions targeting socio-technical change, and fine-tuning policy recommendations (Edmondson, Kern, & Rogge, 2018; Hoppmann,

Huenteler, & Girod, 2014; Reichardt, Rogge, & Negro, 2017; Rogge & Reichardt, 2016). Nonetheless, early investigations indicate a skewed focus within the literature, with a bias toward individual policy instruments and policy mixes at the expense of outcomes of policy processes (Kern & Rogge, 2018) and, apparently, other parts of the policymaking process.

The purpose of this paper is to take stock of the current understanding of the specificities and challenges of transformative innovation policy throughout the policymaking process and examine the actual contributions for practical policymaking. This is achieved through a systematic review of the received literature on transformative innovation policy (and related concepts). We first identify and describe three clusters of literature, which in different ways relate to transformative innovation policy, and then synthesize the contributions of the current literature to our understanding of how policymakers – in the context of transformative innovation policy – set agendas, design, legitimate, implement, monitor and evaluate policies; and learn from their experiences.

For structuring the second part of the review, we depart from the well-known five-stage policy cycle model (cf. Cairney, 2012; M. Howlett & Giest, 2013). Although it has been criticized for oversimplifying the policy process and underestimating its complexities (Cairney, 2012), it describes the "reconstructed logic" of the policymaking process (Dunn, 2008). This allows for identifying important aspects and challenges related to different stylized stages of the process, as described by the transformative innovation literature, as well as avenues for further research.

The rest of the paper is structured as follows. In Section 2, the method for conducting the literature review is outlined. Section 3 provides an overview of the literature according to three thematic clusters. In section 4, the contributions of the reviewed literature are synthesized in relation to the policy cycle and the paper ends with a concluding discussion in Section 5.

2. The review process

In order to select a relevant number of articles to assess the distinguish characteristics of TIP in each stage and understand the challenges TIP imply in the different stages of the policy cycle, we used the guidelines provided by Petticrew and Roberts (2008) to conduct systematic literature reviews.

The search was conducted in March 2019 using Elsevier's Scopus database, which is one of the largest databases of peer-reviewed academic productions. Based on an understanding of transformative change and socio-technical change, as framed in the literature of sustainability transitions (Geels, 2010), a number of search terms were generated in a brainstorming session[1]. We searched for all articles and articles-in-press in peer-reviewed academic journals with these search terms in the article title, abstract and keywords, covering publications from 1960 until March 2019 (all years included in the database). In this identification phase (see Figure 1), 200 documents were found.
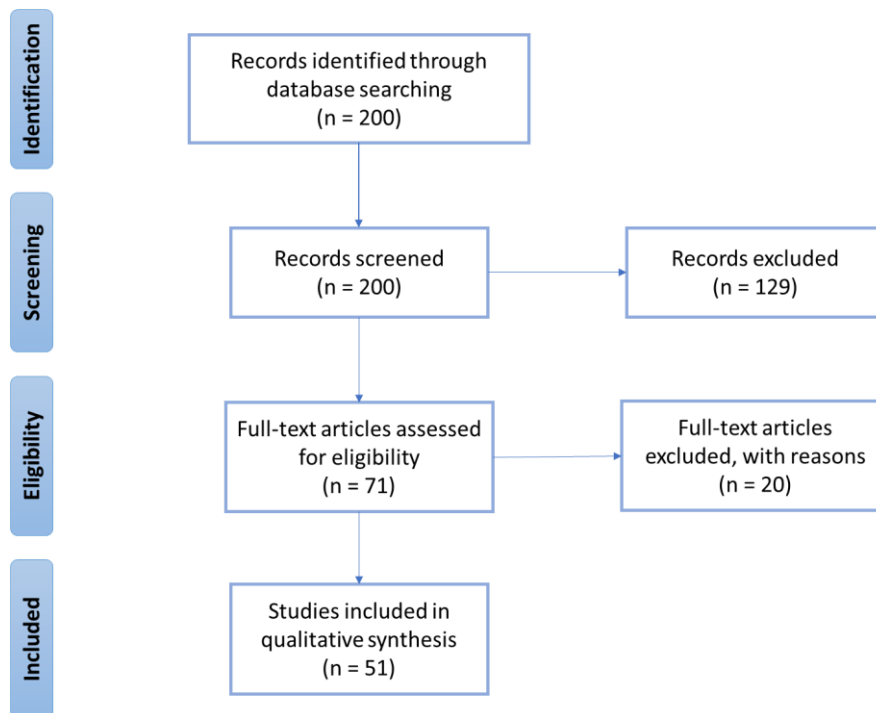

Figure 1: Publications selection flow.

In the second stage, i.e. screening, all 200 abstracts were screened in order to exclude articles that were not relevant to the study. The following inclusion criteria were used: the article had to (1) address or attempt to conceptualize "transformative change" and (2) be written in English.

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[1] The following search query was used in Scopus: TITLE-ABS-KEY("innovat* polic*") AND TITLE-ABS-KEY(("transformat*") OR ("Transformat*" "Change*") OR (("Socio$technical change*") OR ("Socio$technical transition*")) OR ("Mission-oriented") OR ("grand challenge*" OR ("great" W/5 "challenge")) OR ("system innovat*")OR(("sustainab* transition*") OR ("transition*" W/5 "sustainab*"))).

Moreover, we used the following exclusion criteria: articles that (3) only referred to "transformative change" in passing or (6) did not bring any insights on innovation policy. This resulted in a selection of 71 articles to be fully read.

Each of the selected articles was read by one of the authors. The eligibility of the articles was assessed together based on the previously mentioned criteria (third stage). This resulted in the exclusion of 20 articles and a final portfolio of 51 articles (inclusion stage) that were reviewed for this paper.

3. Overview of the literature: three thematic clusters

The received literature on transformative innovation policy can be divided into three thematic clusters: (1) articles that define transformative and mission-oriented innovation policy (or similar concepts) and discuss what distinguishes them from previous innovation policy generations, (2) articles that develop and/or apply some kind of analytical framework related to transformative innovation policy, and (3) articles that present studies of the transformative impact of different types of policy interventions.

3.1 Transformative innovation policy defined

There is an emerging literature discussing the limits and boundaries to governing socio-technical innovation through innovation policy (Fagerberg, 2018). This cluster explores the different concepts used in the reviewed articles to address this issue, such as "environmental innovation policy" (Taylor, 2008), "sustainable innovation policy" (Foxon & Pearson, 2008), "challenge-led innovation policy" (Raven & Walrave, 2018), "innovation ecosystems" (Russell & Smorodinskaya, 2018), "transformative innovation policy" (Steward, 2012), and "mission-oriented policies" (Foray, 2018b; Karo, 2018; Mazzucato, 2018). This latter concept will be discussed separately due to the number of articles addressing it.

3.1.1 Transformative innovation policy

This section reviews the literature on transformative innovation policy (TIP) and other concepts that address innovation policy for socio-technical transitions or grand challenges. Some authors claim that the discussion of the emergence of a third innovation policy paradigm that addresses the transition towards a "low-carbon society" or "green economy", i.e. transformative innovation policy, can be traced back to the first decade of the 2000s (Steward, 2012). However,

Soete (2019) points out that some works (e.g. Freeman, 1994; Kemp & Soete, 1992) had already addressed the policy challenges related to "green technologies" back at the beginning of the 1990s. Nevertheless, the current transformative innovation policy discourse emerges as an attempt to address the shift of the agenda for innovation towards "a range of situated sociotechnical transitions" (Steward, 2012, p. 331) or the change in discourse that combines a broader "understanding of the innovation process and a societal policy agenda" (Diercks, Larsen, & Steward, 2019, p. 884).

Early contributions to this discourse discussed it more from the perspective of a sustainable innovation policy regime (Foxon & Pearson, 2008) and environmental innovation policy (Taylor, 2008). According to Foxon and Pearson (2008, p. 148), sustainable innovation policy refers to "innovation towards more sustainable technological and institutional systems and processes – broadly understood as systems for which resource use and waste production remain within appropriate environmental limits and socially acceptable levels of economic prosperity and social justice are achieved". The authors develop this notion to address the so-called "third generation" innovation policy, which they argue calls for a broader agenda that need to align innovation policy with other policy objectives to address sustainable development. Taylor (2008) brings insights from the environmental innovation field and highlights that "the scale of the technological transformation required to reduce greenhouse gas emissions to 'safe' levels while minimizing economic impacts necessitates an emphasis on designing climate policy to foster, or at least not impede, environmental innovation" (Taylor, 2008, p. 2829). Therefore, she argues that the instruments needed to address environmental innovation policy need to go beyond traditional economic of innovation instruments to include instruments that focus on the role of the government in enhancing the innovative function of the actors within a "source chain".

Many articles in this review approached the discussions underlying transformative innovation policy by linking the literature in technological innovation systems (TIS) and sustainability transitions (Alkemade, Hekkert, & Negro, 2011; Kivimaa & Kern, 2016; Raven & Walrave, 2018; Weber & Rohracher, 2012). Alkemade et al. (2011) discuss the potential misalignments between innovation policy and transition policy, relying on the TIS and the multi-level perspective (MLP) frameworks. They identify two major reasons of misalignment: the type of

innovation they focus on and the importance they give to existing industries. While innovation policy focuses on competence-enhancing innovations, which can strengthen the incumbent regime and reinforce existing lock-in, transition policy focuses on competence-destroying innovations, which usually require phasing out existing non-sustainable industries. Consequently, in order to align innovation and transitions policies, one should design innovation, energy, economic, industry etc. policies with a transition goal in mind, focusing on phasing out unsustainable industries. Weber and Rohracher (2012) combine insights from innovation systems and the MLP to propose a transformational systems failures framework. According to the authors, previous failures approaches such as market failure and systemic failures are not equipped to address grand challenges and the long-term process of transformative change. Therefore, the transformational failures, which includes directionality, demand articulation, policy coordination, and reflexivity failures, can better guide policy interventions for transformative change (see Section 3.2 for more information). Kivimaa and Kern (2016) argue that policy mixes for sustainability transitions should include policies for "creative destruction", which includes both the "creative" and "destruction" sides. In their proposed analytical framework, the "creative" side is mainly formed by the functions of the TIS, which gives a broader understanding of the process underlying innovation production, use and diffusion, while the "destructive" side includes policies aiming at destabilizing established regimes that are path dependent and difficult to change (see Section 3.2). Raven and Walrave (2018) combine the literature on TIS and MLP and refer to challenge-led innovation policy, in which innovation "is understood as a systemic and evolutionary process in which technologies, markets, user preferences, policies, infrastructures, knowledge paradigms, and culture co-evolve as a system in the context of major societal challenges that demand a fundamental restructuring of existing socio-technical systems". In consonance with Taylor (2008), the authors also argue that this new type of innovation policy should move beyond traditional technology-push and demand-pull orientation, since it is dealing with wicked problems, such as climate change.

Another perspective was brought up by Russell and Smorodinskaya (2018), who discuss innovation ecosystems in the context of complexity science. The authors argue that this perspective addresses some shortcomings of innovation systems, such as the increasing complexity of the innovation agenda and the orientation towards transformative change. In their

view, innovation ecosystem differs from the traditional systems thinking, which is considered as simplistic and linear, and puts forward "a set of new principles in economic thinking and economic policymaking, relevant for non-linear development" Russell and Smorodinskaya (2018, p. 123).

In 2018, Schot and Steinmueller (2018) put forward the concept of transformative innovation policy, which was introduced by Steward (2012), describing it as "a third frame linked to contemporary social and environmental challenges such as the Sustainable Development Goals and calling for transformative change" (p. 1554). According to Schot and Steinmueller (2018), this third frame differs from the previous innovation for growth (frame 1) and national systems of innovation (frame 2), which see innovation as always being positive and overlook the directionality underlying it, which can also lead to "destructive creation", i.e. it only benefits a few and create problems to others. In the same vein, Diercks et al. (2019) compare a narrow of the innovation processes (with an economic policy agenda) with a broader understanding (with a societal policy agenda) and Soete (2019) argues that an effort towards addressing the global challenges can only occur if STI scholars are keen to leave their "conceptual comfort zone and address in complementary fashion some of the major societal policy challenges confronting science, technology and innovation policy today".

However, the idea of a third frame of innovation policy has also been challenged. While agreeing that sustainability problems are complex and involve various dimensions and that economic development does not necessarily lead to better human wellbeing and global justice, Fagerberg (2018) and Giuliani (2018) criticize Schot and Steinmueller (2018) for misrepresenting the first two frames and, therefore, dismissing the existing knowledge base too quickly) and not providing concrete enough policy advice. Fagerberg (2018) points out that the knowledge base in innovation policy studies in useful for addressing and discussion today's "grand challenges" and provides five recommendations of how this knowledge base can better address transformative change by: (i) setting direction for innovation policies for the long-term goals; (ii) embracing the opportunity that comes with radical changes; (iii) mobilizing organizations for transformative innovation; (iv) having a holistic policymaking that is able to combine different factors of innovation; and (v) improving governance via policy coordination and alignment. In addition, Diercks et al. (2019, p. 880) argue that in practice the emerging

transformative innovation policy paradigm is "as layered upon but not fully replacing earlier paradigms of science and technology policy and innovation systems policy".

3.1.2   Mission-oriented innovation policy

The literature on mission-oriented policy approaches the issue of transformation from a different background and angle than the literature described above. While the latter primarily draws on the transitions literature, and to some extent literature on innovation systems, the mission-oriented framework departs from government-led development as well as mainstream economics, although they direct their critique against using the "market based failure framework" for designing policy intervention (Diercks, Larsen, & Steward, 2019).

Kattel and Mazzucato (2018) identify three generations of mission-oriented policies which are based on a different type of missions and require distinctly different organization of government. They argue that the idea of mission-oriented policies has its roots in ideas that emerged in the late 19th and early 20th century on modernization and the "developmental state", which relied on expert meritocracy in public organizations accompanied by constant renewal and rejuvenation of organizational configurations (Karo and Kattel, 2015; Kattel et al., 2018). The second-generation mission oriented has its origins in the 1940's to 1960s military and space projects in the US and major Western European economies. These projects were about "Big Science meets Big Problems" deployed in the national interest and the polices were often organized by single public authorities with a concrete mission to solve a particular technological problem.

In the current third-generation mission oriented policies, the missions depart from the notion of grand challenges rather than more narrowly defined problems (Kattel & Mazzucato, 2018; cf. also Diercks et al., 2019; Fagerberg, 2018; Giuliani, 2018; Kuhlmann and Rip, 2018; Schot and Steinmueller, 2018; Soete, 2019). This implies a shift from solving (technical) problems within a single governmental body to addressing grand challenges that require the collaboration of a multitude of actors (Kattel & Mazzucato, 2018). Consequently, the responsibility for addressing third generation missions is not restricted to governments (Kuhlmann & Rip, 2018, p. 448), but might involve a governance approach where other stakeholders are involved in shaping the innovation policy agenda and where top-down governmental investments are combined with activities by large philanthropies or bottom-up social movements (Kattel & Mazzucato, 2018).

The reviewed literature suggests that third generation missions should have certain characteristics. First, they should contain a clear direction (Kuhlmann & Rip, 2018, p. 448; Mazzucato, 2018), but also be open to being addressed by different types of solutions (Mazzucato, 2018). However, opinions differ with regard to whether this direction should be targeted, measurable, and time-bound and used to steer action, allocate resources and follow up policy (Mazzucato, 2018) or more "tentative" and aimed at enabling articulation, legitimation and learning and not at imposing options for new constellation of actors and institutions (Kuhlmann & Rip, 2018, p. 448). Second, missions should be bold, inspirational (e.g. aimed at developing solutions that can have an impact on people's daily lives), ambitious and involve some risk taking (Mazzucato, 2018). Third, they should spark activity across scientific disciplines (including social sciences and humanities), industrial sectors (e.g., transport, nutrition, health, and services), and different types of actors (public, private, third sector, and civil society organizations) (Mazzucato, 2018).

Mazzucato (2018) also draws out several lessons from previous mission-oriented studies on how government can relate to the issue of directionality. She emphasizes that policy makers have to leave the market failure approach behind and go from "the fear of failure" and fixing markets to welcoming experimentation and actively co-shaping markets (Mazzucato, 2018). Systemic mission-oriented policies should be based on a sound and clear diagnosis and prognosis (foresight), but since not everything can be known beforehand the role of experimentation and societal learning, including policy learning, thus becomes central. This requires not only the identification of missing links, failures, and bottlenecks – the weaknesses or challenges of a national system of innovation – but also recognition of the system's strengths (Mazzucato, 2018). By focusing on the role of government in "shaping new markets", rather than correcting market imperfections, it also becomes clearer why policies also need to focus on the required public investments along the entire innovation chain, not only upstream basic research. In that sense, there needs to be a shift in focus from the "quantity of finance to a focus on the quality". In addition, policy needs to go from "picking winners to picking the willing". Missions must, of course, be chosen somehow and in realizing these mission winners and losers will be created. For succeeding with given missions, it is required that the "willing" are identified and engaged, including both the public and private sphere) (Mazzucato, 2018).

This third-generation mission-oriented innovation policy is, thus, to a large extent a normative way of policymaking and thereby also put great pressure on organizing the state apparatus in a different way compared to one which is organized for addressing market failures. According to (Karo, 2018), this implies that real changes in policies, behavior and the state's ability to pursue a mission-oriented innovation policy depend on the possibility of erecting new state structures and to rethink ways in which public organizations design, implement, and evaluate (innovation) policies. Kattel and Mazzucato (2018) argue that just as the private sector requires dynamic capabilities (Teece, 2016), dynamic capacities are also needed at all levels of government, including administrative capacities to deliver mission-oriented policies.

3.1.3   Comparison and synthesis

Mission-oriented policies and transformative innovation policy can be seen as evolving in parallel, and overtime they also showed some convergences and distinctions. While they converge now in discussing and addressing the so-called grand societal challenges, their earlier versions also shared a similar policy agenda. For instance, Diercks et al. (2019) highlight that past innovation policy paradigms, such as the science and technology policy paradigm had both an economic and social agenda and this latter aspect was also discussed in mission-oriented research since the beginning of the 20th century. When it comes to innovation systems research, though, the focus moved from mission-oriented policies to the conditions necessary to enable innovation. Hence, less attention was directed to strategic priorities and broader social issues.

As such, mission-oriented innovation policy is becoming increasingly similar to transformative innovation policy. Mazzucato (2018) and Schot and Steinmueller (2018) both have a broad perspective and talk about a third-generation of innovation policies which is different from the past generations of growth-oriented policies or policies focused on solving narrowly defined mission. In doing so they are also converting in their ideas on what is needed from a third generation of transformative innovation policy paradigm, although having quite different points of departures. In this way, mission-oriented innovation policy and transformative innovation policy approach the question from different angles and where the mission-oriented framework emphasizes clear and measurable goals to a much larger extent than the transformative innovation policy, which emphasizes directionality but lack clear answers on how such a directionality would emerge other than based on bottom-up processes in which stakeholders

from different parts of the society experiment and interact. The third-generation of mission-oriented innovation policy also shares a set of characteristics with the transformative innovation policy framework (see Table 1). For instance, both frameworks emphasize the active role of government in not only "fixing existing market" but also creating new markets, niche markets and protected spaces for experimentation, etc. However, the mission-oriented perspective appears to go further in talking about "picking the willing", and thereby not including all actors in the missions. Moreover, while transformative innovation policy emphasizes the need for destabilizing policies when designing policy mixes, the mission-oriented perspective does not enter this discussion.

Table 1: Compiled characteristics of transformative innovation policy.

Characteristics	TIP	MOP	Source
Directionality: transformative change requires guidance towards desired societal goals, which shall be ambitious and realistic.	✓	✓	Schot and Steinmueller (2018), Fagerberg (2018), Kuhlmann and Rip (2018), Diercks et al. (2019)
Driven to societal or grand challenges: it addresses major societal challenges or grand challenges, such as those presented in the Lund Declaration, the Paris Agreement, and the Sustainable Development Goals.	✓	✓	Alkemade et al. (2011), Steward (2012), Amanatidou, Cunningham, Gök, and Garefi (2014), Lars Coenen, Hansen, and Rekers (2015), Schot and Steinmueller (2018), Giuliani (2018), Kuhlmann and Rip (2018), Raven and Walrave (2018), Kattel and Mazzucato (2018), (Mazzucato, 2018), Grillitsch, Hansen, Coenen, Miörner, and Moodysson (2019), Diercks et al. (2019)
Inclusive concept of growth: it goes beyond the traditional economic growth perspective, i.e. there is a need to overcome the narrower view of economic development and growth to address human wellbeing and global justice.	✓	✓	Foxon and Pearson (2008), Alkemade et al. (2011), Steward (2012), Amanatidou et al. (2014), Giuliani (2018), Soete (2019)
Wicked problems: by addressing socio-technical change and the problems underlying grand challenges, TIP is characterized by being complex and difficult in nature, as well as composed by complex interdependencies.	✓	✓	Amanatidou et al. (2014), Lars Coenen et al. (2015), Raven and Walrave (2018)
Multi-faceted policy intervention (policy-mixes): it includes a new range of policy instruments or policy-mixes that goes beyond the technology-push versus demand-pull typology and that encompass both policies aimed at creating the new and at "destabilizing" the old ("creative destruction").	✓	✓	Steward (2012), Kivimaa and Kern (2016), Fagerberg (2018), Kuhlmann and Rip (2018), Raven and Walrave (2018), Diercks et al. (2019)
Multi-disciplinary research: it requires the involvement of different fields and the development of new sets of skills and	✓	✓	Amanatidou et al. (2014), Schot and Steinmueller (2018), (Mazzucato, 2018)

should include the feedback effects from both basic and applied research.			
Multi-level governance: it demands better policy coordination and alignment due to new institutional arrangements and there is a need for anticipation, experimentation, reflexivity, reversibility and learning. This calls for a combination of bottom-up and top-down approaches.	✓	✓	Amanatidou et al. (2014), Schot and Steinmueller (2018), Fagerberg (2018), Kuhlmann and Rip (2018)
Multiple actors: it involves multiple actors that have different perceptions, perceive different solutions and negotiate alternative pathways.	✓	✓	Amanatidou et al. (2014), Lars Coenen et al. (2015), Schot and Steinmueller (2018), Fagerberg (2018), Kuhlmann and Rip (2018), Kattel and Mazzucato (2018)
Global collaboration: actors are more involved in multifold network partnerships that go beyond geographical boundaries.	✓	✓	Steward (2012), Russell and Smorodinskaya (2018), Diercks et al. (2019), Soete (2019)
Behavioral change: it implies behavioral change in terms of preferences, perceptions, consumption, habits, lifestyles, etc.	✓	✓	Steward (2012), Diercks et al. (2019), Soete (2019)
Long-term approach: the need for behavioral change calls for actions to balance short- and long-term visions.	✓	✓	Amanatidou et al. (2014), Schot and Steinmueller (2018), Diercks et al. (2019), Grillitsch et al. (2019)
New rationales for policy intervention: it goes beyond traditional market or system failures.	✓	✓	Weber and Rohracher (2012), Amanatidou et al. (2014), Lars Coenen et al. (2015), Raven and Walrave (2018), Schot and Steinmueller (2018)

3.2 Frameworks to describe and analyze transformative innovation policy

Building on the emerging transformative innovation policy discourse, scholars from different fields have sought to develop different types of frameworks to conceptualize and analyze innovation policy. In this section, two groups of frameworks will be described: frameworks which describe the rationale for policy intervention, and those which describe, analyze and evaluate policy mixes.

3.2.1 Policy rationales

Several of the frameworks presented in the reviewed articles focus on conceptualizing the underlying rationales (or "policy logic" (Diercks et al., 2019)) for policy intervention for innovation. The underlying argument of most of these is that earlier policy justifications, such as "market failures" and "system failures", do not fully reflect the characteristics of transformative innovation processes and therefore need to be revised or complemented to be useful as guides for policy makers.

One of the most cited articles is Weber and Rohracher's (2012) "failures framework". Their main argument is that sociotechnical transitions include a wider range of types of failures which

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justify policy intervention than those which are currently accounted for in most innovation policy frameworks. They acknowledge the traditional market failures (e.g. information asymmetries, knowledge spill-overs, externalization of costs, and over-exploitation of the commons), which remain the predominant policy intervention rationale, as well as structural innovation system failures (i.e. infrastructure failures, institutional failures, interaction or network failures and capabilities failures). In addition to these, however, they propose a new category, referred to as "transformational failures": directionality failure (i.e. innovation systems do not account for broader societal problems and/or do not undergo processes of interpretation and negotiation), demand articulation failure (i.e. an inadequate consideration of user needs), policy coordination failure (i.e. incoherent interaction between policy levels), and reflexivity failure (i.e. inadequate monitoring, anticipation and involvement of policy stakeholders and actors, between different societal actors and discourse areas) (Weber & Rohracher, 2012, 1042-1044). Raven and Walrave (2018) explore how these transformational failures can be mitigated through application of a TIS-based policy mix design. Using a computer model to simulate various policy mix compositions targeting TIS functions in different configurations, they demonstrate that policy interventions applied from a TIS perspective can bolster a niche's challenge to an existing regime and possibly replace it, provided that context-specific auxiliary resources are present. Further clarity is, however, needed as to whether adjustment of policy content or policy process contributed to TIS development.

Foray (2018b) and Chicot and Matt (2018) both propose frameworks which resemble the Weber and Rohracher (2012) framework. Foray (2018b) aims to contribute to the smart specialization literature. He identifies several failure rationales, such as market failures, collective action, and coordination, and argues for increased intentionality (i.e. directionality). He proposes two levels of policy intervention logics: a moderate level intervention logic describes programs which aim to stimulate innovation comprehensively, while a high-level intervention logic is non-neutral and targeted towards specific sectors and technologies. Chicot and Matt (2018) propose several types of system failure rationales for policy intervention, in the specific context of public procurement. These include demand-side failures (i.e. a failure in provision of useful public services or obstacles in adoption and diffusion of innovations), supply-side failures (i.e. inadequate incentives to invest in R&D or poor learning and capabilities development on the

part of the producers), and user-supplier interaction failures (i.e. a lack of an "interactive learning space" and uncertainty between actors on account of information asymmetries).

3.2.2 Policy mixes

Much has been written about the increasing relevance of policy mixes. It follows the reasoning that maintaining a focus on single instruments neglects the interactions between instruments which may ultimately affect the policy process. Drawing on previous work by Flanagan, Uyarra, and Laranja (2011), Borrás and Edquist (2013) and Michael Howlett and Rayner (2013), several of the reviewed articles argue that understanding the dynamics of policy instruments both at the individual and mix level is essential to maintaining a clear message to policy target groups (Crespi, 2016; Kivimaa & Virkamäki, 2014; Magro & Wilson, 2018; Scordato, Klitkou, Tartiu, & Coenen, 2018).

Innovation policy and transitions scholars alike have proposed various frameworks for understanding policy mixes, which differ in their scope, ranging from design principles for mixes, evaluation, strategies of incumbency, or general dynamics between policy levels.[2] For example, Peng and Bai (2018) and Johnstone, Stirling, and Sovacool (2017) both explicitly aim to contribute to the multi-level governance literature, yet differ significantly in their analytical scope, the former focused on understanding policy dynamics between different governance levels, and the latter focused on strategies of incumbency.

Several of the reviewed articles present frameworks that are intended for ex post or ex ante assessment and evaluation of policy mixes. Kivimaa and Virkamäki (2014) propose a framework for assessing policy mixes based on the functions of technological innovation systems framework (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008; Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007). The guiding rationale is that identified "gaps" in the TIS functions for a given sectoral policy mix – knowledge development and diffusion, entrepreneurial experimentation, market formation, influence on the direction of search, resource mobilization, legitimation and development of external economies – can indicate a

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[2] It should be noted here that one of the most cited policy mix articles, i.e. Rogge and Reichardt (2016), is not included in the literature review. Their framework, which draws on the sustainability transitions and multilevel governance literature, conceptualizes policy mixes as consisting not only of the policy instruments, but also the overall policy strategy and the policy processes that shape them. They use the Weber and Rohracher (2012) failures framework (as described in Section 3.2.1) to assess the comprehensiveness of a policy mix.

priority area for policymakers. Similarly, Janssen (2019) highlight the need to identify the main functional bottlenecks and blocking mechanisms and assessing to what extent and how effectively the policy mix targets the most important functions for advancing the TIS. In later work, Kivimaa and Kern (2016) build further upon the Kivimaa and Virkamäki (2014) framework, categorizing the TIS functions by whether they are "niche creating" or "regime destructive"[3]. They contributed a new concept which adds an element of directionality to the existing policy mix literature, that of "motors of creative destruction" (Scordato, Klitkou, Tartiu, & Coenen, 2018). Scordato et al. (2018) integrate the creative/destructive policy mix framework with the dimensions of the Rogge and Reichardt (2016) policy mix framework: policy strategy, instruments, and policy processes. Their resulting framework consists of three general evaluation criteria: coordination, timing, and scale of the policy mix, some of which are also emphasized by other authors (Crespi, 2016; Kivimaa & Kern, 2016; Weber & Rohracher, 2012).

In contrast to these frameworks, Kern (2012) argues that the TIS framework is not useful for making policy recommendations, since it does not go beyond detection of issues. Using the concepts of niche, regime, and landscape, he defines several dimensions within each category which can be used for prospective assessment. The niche dimension includes learning processes, price-performance improvements, support from powerful groups, and establishing market niches; the regime level includes change in rules, technologies, and social networks; and the landscape level includes macro-economic and socio-economic trends, macro-political developments, and deep cultural patterns. He also introduces a scale to indicate the degree to which each dimension is met. He concludes by calling for further research on interactions between policies and diverting focus from individual instruments. Similarly, Naber, Raven, Kouw, and Dassen (2017) identify three niche-level processes that should be important for the upscaling of experiments and derive indicators which they use to determine the performance of each process: social network building (breadth and depth), articulation of visions and expectations (clarity, robustness and quality), and learning (breadth and reflexivity).

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[3] In Kivimaa and Kern (2016) analytical framework, the functions for creative support include: knowledge creation and development, market formation, price-performance improvements, entrepreneurial experimentation, resource mobilization, legitimation, and influence on the direction of search; and for regime destabilization include: control policies, significant changes in regime rules, reduced support for dominant regime technologies, and changes in social networks, replacement of key actors.

While the abovementioned frameworks are specifically oriented towards understanding the role of innovation policy mixes in TIS or MLP dynamics, Magro and Wilson (2018) propose several more general dimensions to consider in policy mix evaluation: verticality (i.e. the number of governance levels involved), directionality, and capacity for fostering experimentation. In a similar vein, Grillitsch et al. (2019) take Weber and Rohracher's (2012) transformational system failures as a starting point for developing a framework which includes four dimensions: directionality, experimentation, demand articulation, and policy learning and coordination. They use this framework to assess the extent to which each dimension is covered by the activities of a transformative innovation policy program's activities, using a pre-defined matching between policy activities and dimensions.

Other frameworks focus on the dynamics of policy mixes. Peng and Bai (2018) draw on the MLP in order to conceptualize the interactions between older emissions policies and low-carbon transition policies and to assess the means and motivations for regime contributions to niche-level experiments. This is done by sorting policies according to given purpose and time of emergence, identification of enabling mechanisms for policy (mainly coordination and financial mechanisms), governance layer of the policy, and tracing any potential linkages across policy areas. Also focusing on the regime, Johnstone et al. (2017) identify a political dimension relevant to innovation policy mixes for systems change, which questions the assumed neutrality of policymakers in selection of instruments in previous conceptualizations of policy mixes: the means by which incumbents preserve the status quo within different policy areas. In a case study of three sets of energy policy mixes in the UK, they apply a framework consisting of four mechanisms that cement incumbency: securitization, masking, reinvention, and capture. Moreover, they propose the concept of "policy apparatus for incumbency", which refers to "a collection or integration of disparate policy mixes into an overall environment that restricts what incumbent interests hold to be undesirable change" (Johnstone et al., 2017, p. 153)

Others propose a new system definition altogether, such as the notion of "Green Transition Systems" put forth by Crespi (2016). While maintaining a focus on systemic failures, as Kivimaa and Virkamäki (2014) and Kern (2012) did in earlier work, Crespi (2016) also explicitly includes directionality in his system definition, describing a Green Transition System as "a set of institutions and organizations whose collective system of interactions determine the

rate and direction of transition processes towards sustainable development" (p. 152). He proposes a framework in which the design of policy mixes between economic, labor, and societal spheres is considered. The three main design dimensions include (1) selection of specific instruments, (2) tailoring the instruments to better suit their actual application context, and (3) choice and composition of a policy mix aimed at tackling the defined issue.

It should be noted that whereas Magro and Wilson (2018), Johnstone et al. (2017) and Crespi (2016) all address complexity and sub-optimality within policy oriented towards systemic change, it can be questioned whether policy mix optimality exists, as various dimensions are constantly shifting (Magro & Wilson, 2018).

3.3   Studies of policy interventions

The overall question dealt with in the reviewed articles associated with this cluster is to what extent previous and current innovation policy practices (instruments, programs or entire policy mixes) are conducive to transformative change.

One way of approaching this question is to study to what extent overall policy discourses and suggested innovation metrics correspond to the conceptual notions of transformative innovation policy as described in Section 3.1. This approach is used by Diercks (2018), who study how the system innovation discourse was adopted by the OECD and to what extent it secured a serious foothold within the organization. Even though the new policy paradigm gained some momentum in the mid-2010s, it only had a marginal effect on OECD's core activities. There was neither any fundamental re-creation of innovation policy approaches and instruments, nor any restructuring of the recommended instrument mix. He, therefore, concludes that "system innovation remains at the fringes of OECD activities" (p. 9-10).

Another approach is to study the transformative outcomes of actual innovation policies. This approach was adopted by several of the reviewed articles. Some of these articles study the transformative outcomes of a set of different types of policies (e.g. Guo et al., 2019), others study how different (semi-)public actors contribute to transformative change (e.g. Berkhout & Westerhoff, 2013), other study how policy instruments are revised as a consequence of their sociotechnical impact (Hoppmann et al., 2014) and yet others study the transformative outcomes of specific policy programs or instruments. In the following, we will focus on the last of these categories.

The review found four articles written by partly the same authors and with similar foci and theoretical approaches. Three of these (M. Bugge, Coenen, Marques, & Morgan, 2017; M. M. Bugge, Coenen, & Branstad, 2018; Grillitsch et al., 2019) study policy programs in the UK, Norway and Sweden that explicitly aim at being transformative, using a similar transformational failures framework inspired by Weber and Rohracher (2012) and others (see Section 3.2.1), whereas the fourth (L. Coenen, Moodysson, & Martin, 2015) study a program from an earlier Swedish innovation policy generation but sectorally related to the programs studied by Grillitsch et al. (2019). To these, we can also add a study of two transition experiments in Korea (Seong, Cho, & Song, 2016) and an explorative study of six cases of public procurement of innovation (Edquist & Zabala-Iturriagagoitia, 2012)[4].

The studies show that all these programs had elements of *directionality* built into them, although in different ways. For example, the low carbon village project in Korea (Seong et al., 2016) and the "National Programme for Assisted Living" in Norway (M. M. Bugge et al., 2018), visions and goals for a transition were formulated top-down and in the latter case the program even identified specific technologies and adopted a joint IT standard. In contrast, the UK "DALLAS" assisted living program arranged bottom-up goal-setting processes involving a large group of different types of stakeholders (M. Bugge et al., 2017; M. M. Bugge et al., 2018) and, similarly, the Swedish "Well-lit corridor" project (which aimed at increasing the energy-efficiency of buildings) involved representatives from all main stakeholder groups in developing functional specifications for lighting systems (Edquist & Zabala-Iturriagagoitia, 2012). In the Swedish Vinnväxt initiative "Biorefinery of the future" and the two strategic innovation programs (SIPs) BioInnovation and RE:Source, there was a joint overall goal or common agenda for each program, but under this broad "umbrella" stakeholders still had very different interests and expectations (L. Coenen et al., 2015). In the "Biorefinery of the future" case, this changed over time with the joint framing of common challenges (L. Coenen et al., 2015) but in the BioInnovation and RE:Source cases it remained a problem. Providing too much direction can, however, also be a problem. In two of cases of public procurement for innovation – the Swedish

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[4] It should be noted, though, that even if Edquist and Zabala-Iturriagagoitia (2012) argue that public procurement for innovation is an important instrument for mission-oriented innovation policy, most of their cases concern the development of specific technological products and solutions rather than sociotechnical transitions or missions of the kind described in Section 3.1.

X2000 high-speed train and the Norwegian NødNett public safety radio network – too detailed technical specifications limited the suppliers' innovative ability and locked them into solutions that later proved to be uncompetitive (Edquist & Zabala-Iturriagagoitia, 2012).

All the larger programs and one of the public procurement for innovation projects were also set up to stimulate niche *experiments*, involving a wide set of stakeholders. In some cases, this worked as intended. For example, in Sweden the "Biorefinery of the future" initiative acted as an incubator and space for technological and social learning (L. Coenen et al., 2015), in Norway the assisted living program included pilot projects with both user and supplier involvement (M. M. Bugge et al., 2018), and in Korea the solar PV project was governed by a broad set of public and private stakeholders (Seong et al., 2016). In contrast, the two SIPs in Sweden experienced problems with involving incumbent firms as well as non-firm actor and found it difficult to open up the innovation networks to entirely new actors (Grillitsch et al., 2019). Similarly, the government failed to involve local citizens in the low-carbon village project in Korea (Seong et al., 2016).

Demand articulation was also handled in different ways in different cases. In the assisted living programs, the abovementioned pilot projects were important in Norway, whereas in the UK an important activity was to improve the knowledge and technology literacy of users and health experts (M. Bugge et al., 2017; M. M. Bugge et al., 2018). In the Biorefinery of the future case, market formation was insufficient and suffered from policy uncertainty that had a negative influence on customer preferences and societal legitimacy (L. Coenen et al., 2015). Ten years later, the two SIPs worked more actively through different approaches to develop public innovation procurement capabilities (Grillitsch et al., 2019). The importance of such capabilities was also highlighted in the case studies of public innovation procurement (Edquist & Zabala-Iturriagagoitia, 2012). In general, demand articulation is a key aspect of public procurement for innovation, where the formulation of functional specifications mirroring the (innovative) needs of the prospective users is an important step in the process (Edquist & Zabala-Iturriagagoitia, 2012). Finally, in the Korean solar PV case, funding was made available for the installation of solar systems at private houses, but the effect was limited due in part to the limited competence of the members of the solar cooperatives (Seong et al., 2016).

Finally, the programs had a different impact on *learning and coordination*. Regarding learning, several of the programs seem to have provided arenas for interaction, collaboration and mutual learning between stakeholders (M. M. Bugge et al., 2018; L. Coenen et al., 2015). However, other programs reported problems in achieving knowledge accumulation and learning between different experiments, either due to a bottom-up approach (M. Bugge et al., 2017) or to regional differences (Seong et al., 2016), and also described how a foundation for larger-scale diffusion was missing (M. Bugge et al., 2017). Regarding coordination, this seems to have been a major challenge for most programs, with the possible exception of the Norwegian assisted living program, which was able to coordinate the otherwise fragmented municipalities (M. M. Bugge et al., 2018). One particular problem reported in several cases was the lack of coordination between different policy areas and scales, for example between innovation policy and health policy (M. Bugge et al., 2017) or between regional innovation policy and national/international technology- or industry-specific innovation policy (L. Coenen et al., 2015).

In addition to these transitional failures, several cases also reported problems related to traditional system failures. Most notably, it was often difficult for programs to get different types of actors to come together and collaborate. For example, in the Norwegian assisted living case, there were tensions between municipal service providers and technology suppliers (M. M. Bugge et al., 2018), in the Swedish SIPs there were difficulties to bridge boundaries between industry and academia (Grillitsch et al., 2019), in the Swedish public procurement of the innovative AXE switching technology the procurer and the supplier had different demands on the technology (Edquist & Zabala-Iturriagagoitia, 2012) and in the Swedish Biorefineries of the future case the heterogeneous set of stakeholders had initial problems to collaborate (L. Coenen et al., 2015).

3.4   Summary

From the review we can see that the emerging discourse of transformative innovation policy draws on a combination of innovation policy, transition studies and mission-oriented innovation policy. Important contributions have been made by the new "failures" and "policy mix" and frameworks, in which scholars draw on innovation policy, transition studies and political science to motivate actions that go beyond the conventional "market failure" approach and guide policy in their decision making, and some studies have also been made of transformative

innovation policy programs and initiatives. However, to what extent these writings provide any insights into the policy making process remains unclear. This is the topic of the following section.

4. The policy cycle stages from the perspective of transformative innovation policy

4.1 Introducing the policy cycle

In this paper, we use the policy cycle model to structure our analysis of the policymaking process of transformative innovation policy. This model has been criticized for oversimplifying the complexities of the policy process and take policymaking as being fluid and cyclical. Moreover, it does not explicitly consider the feedback loops between the different stages. However, the policy cycle model is currently the most classic way to study and organize policymaking and hence it serves as an insightful analytical approach (Cairney, 2012). Even though many variations of the policy cycle model can be found in the literature (Cairney, 2012), our review relies on a six-stage cycle, adapted from M. Howlett and Giest (2013) and Cairney (2012). The stages are depicted in Figure 2 and can be described as the following:

- Agenda setting: identification of problems that deserve the attention of policymakers;

- Policy design: formulation and selection of solutions to the problems raised in the previous stage, considering its feasibility and effects;

- Legitimation: policymakers decide on a course of action and assure it has support;

- Implementation: the decision is put into effect and carried out as previously planned;

- Monitoring and evaluation: while monitoring provides information on the observed outcomes of the policy, evaluation assess the value of observed and expected outcomes;

- Policy learning: this last stage could lead then to the reformulation of problems and solutions based on policy monitoring and evaluation and hence leads to the restart of the cycle.
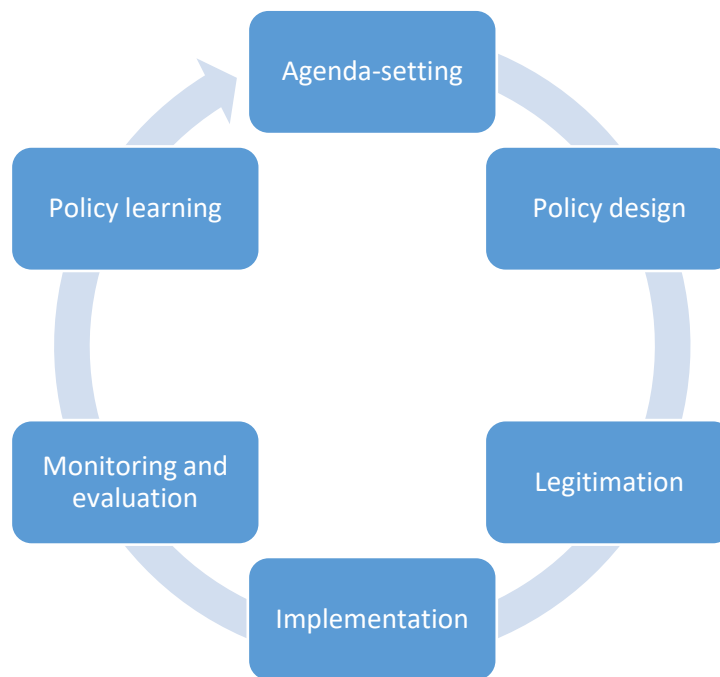
Figure 2: The generic policy cycle. (Source: adapted from Cairney (2012) and M. Howlett and Giest (2013).

4.2 Agenda setting

When it comes to agenda-setting, Diercks et al. (2019) argue that one of the great differences of transformative innovation policy when compared to previous science and technology policy and innovation systems approaches is related to their policy agenda. While previous approaches to innovation policy focus either on an economic agenda, which views innovation as being essentially good as it leads to economic competitiveness and growth, or on a narrow view on the societal agenda, motivated mainly by national strategic priorities (e.g. National security), transformative innovation policy brings a broader understanding on societal goals to include all its domains. In fact, Diercks et al. (2019) highlight that when analyzing policy agenda as a whole, one may consider three main dimensions: (i) policy objective, which includes the aims of the policy; (ii) policy domains, which specify which policy domain is relevant; and (ii) policy logic, which encompasses how innovation policy is rationalized.

Regarding the first dimension (policy objective), as highlighted in Section 3.1., several authors point out that the ultimate aim of transformative innovation policy is to address societal problems or grand challenges, such as those highlighted in the Paris Agreement and the SDGs, (Alkemade et al., 2011; Amanatidou et al., 2014; Diercks et al., 2019; Grillitsch et al., 2019;

Kattel & Mazzucato, 2018; Kuhlmann & Rip, 2018; Mazzucato, 2018; Robinson & Mazzucato, 2019; Schot & Steinmueller, 2018; Steward, 2012; Weber & Rohracher, 2012). In addition, Diercks et al. (2019) highlight that a societal policy agenda does not only focus on the economic growth aim but have "additional objectives such as national prestige, strategic priorities or societal challenges" (p. 83). Moreover, Robinson and Mazzucato (2019) argue that policies for transformative change aim at contributing "to facilitating innovation and socio-economic impact in a particular direction towards desirable transformative change" (p. 937), i.e. it is targeted towards societal grand challenges.

Whereas many authors discuss the broader goal of transformative innovation policy, others bring additional insights to set the policy objective. Based on an analysis of the UK energy sector, Johnstone et al. (2017, p. 157) show how the so-called "policy apparatus for incumbency" is being used to influence agenda-setting by modifying the policy objective towards "national security ('securitization'), obscuring the full social or economic costs of a regime ('masking'), reframing an old or polluting technology as new or innovative ('reinvention'), or placing incumbent stakeholders in positions of political or regulatory power ('capture')". This highlights the need for regime destabilization as argued by Kivimaa and Kern (2016), who point out that breaking up the traditional structures for incumbency could open windows of opportunity for setting the agenda towards more sustainable niche innovations.

In relation to policy domains, several authors highlight that a broader societal policy agenda encompasses several policy domains apart from economic and industrial policies, such as energy, health, agricultural, food security, environmental and climate change policy (Lars Coenen et al., 2015; Diercks et al., 2019; Scordato et al., 2018). Steward (2012) points out that while innovation policy practice remains focused on individual technologies, transformative policies should be embedded in other social domains, such as household living and personal mobility, which involves different technologies, multiple actors and several social and behavioral innovations.

Finally, in terms of policy logic, many authors point out that transformative innovation policy calls for an inclusive concept of growth, i.e. one that acknowledges that innovations not always bring good outcomes and that many of the societal challenges faced today are also a direct or indirect result of past innovations (Alkemade et al., 2011; Amanatidou et al., 2014; Diercks et

al., 2019; Foxon & Pearson, 2008; Soete, 2019; Steward, 2012). This implies a need to "promote a model of growth that limits negative environmental and social pressures" (Foxon & Pearson, 2008, p. 152) and shifting focus from economic growth to phasing out unsustainable regimes (Alkemade et al., 2011).

4.3   Policy design

Many authors have acknowledged that transformative innovation policy implies multi-faceted policy intervention or policy-mixes that goes beyond the traditional technology-push and demand-pull policies (Diercks et al., 2019; Kivimaa & Kern, 2016; Raven & Walrave, 2018; Steward, 2012). This focus on the policy-mix concept is referred to as the "third generation policy design" in both the literature of innovation policy and sustainability transitions (Magro & Wilson, 2018). While previous approaches for policy design involved the selection of different instruments and acknowledged the need to assess policy effectiveness and feasibility, the notion of policy mixes is even more complex and goes beyond the selection of concrete elements, i.e. policy instruments. Instead, policy mixes are also made up of processes and characteristics (Magro & Wilson, 2018) that challenge even more the fluid view of the policy cycle model. This section will discuss six implications of the emergence of policy mixes for transformative change identified in the reviewed literature.

The first implication that can be identified is related to the style of policymaking used to design the policies, i.e. whether policies for transformative change are suffering processes such as layering and drift or replacement (as in the policy design literature jargon). According to Diercks et al. (2019), the design of transformative innovation policy as a new paradigm can be "expressed through re-translations and new hierarchical rankings of the elements of an earlier paradigm, taking place through processes of bricolage or assemblage, reminiscent of insights from literature on policy mixes and related terminologies such as policy layering, replacement or drift". This is supported by Hoppmann et al. (2014) who show that policymakers adjusted the design of the German feed-in tariffs for solar PV several times to correct flaws on previously implemented legislation. Moreover, Magro and Wilson (2018) highlight the historical character of the design of policy mixes, which are usually a result of changes in existing instruments or the addition of new one to the previous policy mix.

Second, some authors point out the need to consider the interactions of different policies already in the policy design stage. Crespi (2016) argues that when designing the policy-mix, one should have a better understanding of the interactions and trade-offs between the policy instruments that are selected within three dimensions of the Green Transition System (see Section 3.2), as well as the complexities underlying policy coordination. This would enhance learning and enable adaptive mechanisms between the actors involved in the transition. In addition, Johnstone et al. (2017) highlight the need to consider the interactions between policies designed to promote renewables and destabilize incumbents. Moreover, Magro and Wilson (2018) argue that when designing policies for smart specialization, one should consider different policy dimensions and possible contradictory objectives that can emerge within the policy portfolio and due to policy interests.

Third, some authors consider the role of incumbents and destructive policies in the design of the policy mix. Kivimaa and Kern (2016, p. 213) argue that "designing policies attempting to undermine existing regimes is challenging because they present a contradictory ideology to that of traditional innovation policies, often aimed to contribute to economic growth". Moreover, Johnstone et al. (2017) show how the so-called "policy apparatus for incumbency" is being used in the UK energy sector to promote incumbent's own policy agenda and hence influence the design of renewable energy policies. This process of strengthening the incumbent regime rather than the emerging niches of innovation is known as "destructive recreation". Furthermore, Scordato et al. (2018) point out to the need to include destabilizing policies in addition to technology-push and demand-pull instruments.

Fourth, while some authors touch upon the politics underlying the design of policies for transformative change, an in-depth discussion on this seems to be lacking. Despite not being their focus, Kivimaa and Kern (2016) acknowledge some of the political challenges of transformative policy choice, such as the presence of actors coalitions that inhibit alternative pathways towards more sustainable options and the political cost underlying policy choice and maintenance when it comes to structural change. In addition, Johnstone et al. (2017, p. 149) point out that "the degree to which there is a balance between creative and destructive policies is likely to be influenced by broader political struggle".

A fifth implication is linked to the rationales behind the design of policy mixes for transformative change. Building on Weber and Rohracher's (2012) framework (see Section 3.2) and the TIS framework, Raven and Walrave (2018) experiment with the design of mixes of policy interventions addressing the transformational failures. In addition, Crespi (2016) reflects on the limitations of the market failure approach as a rationale to design policies to solve environmental problems and the need for more systemic perspectives. Moreover, Chicot and Matt (2018) propose an analytical framework that highlights how public procurement for innovation can address demand-side, supply-side, and user-supplier interactions failures (see Section 3.2). Furthermore, Magro and Wilson (2018) point out that the design of smart specialization strategies implies the selection of multiple policy instruments that address different policy domains and rationales.

Finally, a sixth implication regards design principles. According to Foray (2018a), policy design principles can minimize the risks underlying policy risks emerging with a shift from what he calls neutral to non-neutral policies. In discussing principles for sustainable innovation policy processes, Foxon and Pearson (2008) argue that its design calls for the development of an integrated policy-mix to promote sustainable innovation, by: (i) applying sustainability indicators; (ii) balancing benefits and costs related to environmental, social, and economic impacts; (iii) using a risk assessment tool in developing policy support instruments; and (iv) assessing instruments according to its appropriateness to the stages of the innovation process. Moreover, Foray (2018a, 2018b) discusses design principles for policies that focus on radical transformation of current structures and have a "higher degree of intentionality, centralization and prioritization". He proposes the following design principles that should help governments in selecting such non-neutral policies: (i) securing specialized human capital supply and demand for specific R&D increases; (ii) the coupling between innovation and adoption, by encouraging entrepreneurship and addressing both high-tech and traditional sectors; (iii) the Tinbergen assignment theorem that gives guidance on the number of instruments and programs to be deployed; (iv) recognizing the experimental nature of the policy which requires an entrepreneurial orientation rather than of a principal-agent logic; (v) the general nature of the policy design is neither entirely bottom-up nor top-down (Foray, 2018a). Furthermore, Janssen (2019) also addresses policy design principles for transformative policy, as part of the development of his framework for assessing the design and impact of policies, as explained in

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Section 3.2. Based on insights from the new industrial policy field, the author describes two sets of design principles: policy organization and policy orientation. Regarding the former set of principles, the following principles are mentioned: information retrieval (embeddedness), discipline for policy adaptation, accountability, and leadership competence. The latter set of principles involves the following: inputs instead of transfers, open architecture, genuine novelty and contrive spillovers.

Other authors also bring insights to the design principles. In line with Foxon and Pearson's (2008) principles, Crespi (2016, p. 147) highlights that "policies designed to promote the transition towards the green economy should be able to achieve environmental goals as well as sustaining technological competitiveness, economic recovery and employment growth as interrelated objectives". In addition, Hoppmann et al. (2014) point out that in order to develop effective policies towards technological change, one should account for both the governance mechanisms based on the current knowledge base and the dynamics of the systems under intervention. Kuhlmann and Rip (2018, p. 451) suggest that policy design "can build on 'creative corporatism', a concept in which governments (and/or related international alliances) will adopt the crucial role of facilitating broader, more diverse 'varieties of cooperation' in advanced capitalist economies". Moreover, Mazzucato (2018) propose some principles for designing third generation mission-oriented policies (see Section 3.1.2).

However, we can also identify some contradictions within different authors regarding some principles. For instance, while Foray (2018a) propose the use of the Tinbergen's theorem as a principle to provide guidance on the number of instruments policymakers should select, which should match the number of targets or goals a policy has, Magro and Wilson (2018) argue that this theorem no longer holds in policy design literature. In this way, Magro and Wilson (2018) point out that one instrument can address one or more target, or you can have several instruments addressing only one target. Another point of contradiction is between Foray (2018a) and Janssen (2019). Whilst Foray (2018a) addresses mission-oriented policies and as such argue that it implies designing policies that are essentially sector-specific, Janssen (2019), based on new industrial policy, point out the need to design policies focusing on target activities and self-organizing groups instead of sectors (open architecture principle).

4.4 Legitimation

Few articles in this review explicitly discuss the legitimacy process of transformative innovation policies in detail. Authors approaching legitimation from a micro-level perspective do so by departing from the legitimation function in the TIS framework, where the legitimation process concern the development of new technological fields rather than explicit policies or transformative innovation programs (Scordato et al., 2018). Hence, in face of this review, there is a clear lack of TIP studies that takes a micro-level perspective on the dynamics of how legitimacy is created, developed, maintained, etc.

However, Schot and Steinmueller (2018) and Mazzucato (2018) implicitly suggest that legitimacy is created through a broad stakeholder involvement where the relevant actor groups in society are activated and motivated to contribute to the transitions' agenda. In Schot and Steinmueller's (2018) view, the basis for this is the process of experimentation and learning, while Mazzucato (2018) links the legitimacy process more clearly to the goals and missions that are at focus. In addition, a key point made by Mazzucato (2018) is that legitimacy is created by activating "the willing" and not necessarily by trying to activate or convince those that are skeptical. However, Johnstone et al. (2017) illustrate that such a strategy may easily backfire and that there may be a need for legitimating a transition policy in much wider circles or more effectively circumvent incumbent actors. With strong ties to the political establishment, UK incumbents have managed to put nuclear and gas fracking back on the agenda at the expense of renewables.

Karo (2018) is one of the few authors in our search that explicitly examine the legitimations process of TIP, but still on a very high level of aggregation. In a paper on how the global–Western discourse has entered the East Asian mission-oriented innovation policy rhetoric, he illustrates how the new policies are legitimized through the old "developmentalist" logic. The author concludes that although transformative innovation policies are embedded in public values, such as sustainable development, they also seem to require more of a nontechnocratic mode of governance, which is not yet in place. At a more detailed level, Hoppmann et al. (2014) illustrate that the legitimacy of the policy changes as it succeeds but also how new legitimation challenges arise when new unanticipated consequences emerge.

4.5 Implementation

In the reviewed literature, several authors acknowledge that the specific character of transformative innovation policy as compared with previous generations of innovation policy (see Section 3.1), implies that there is a need for new policy implementation mechanisms and processes (Foray, 2018a; Foxon & Pearson, 2008; Kuhlmann & Rip, 2018; Seong et al., 2016; Weber & Rohracher, 2012). However, while some discuss the general challenges involved in realizing the specific characteristics of transformative innovation policy (Diercks, 2018; Foxon & Pearson, 2008; Grillitsch et al., 2019; Janssen, 2019), describe how programs have been implemented and what the results they have generated (see Section 3.3) or describe the challenges involved in translating (implementing) national transformative policies at a local level (Berkhout & Westerhoff, 2013; M. M. Bugge et al., 2018; Peng & Bai, 2018), it remains rather unclear how the implementation of specific innovation programs and instruments would differ in the context of transformative change.

Some insights can, however, still be derived from the received literature. A first observation is that there is rarely any clear distinction between policy design and policy implementation in the articles. One reason for this might be that the literature on transformative innovation policy is still in its infancy, which means that there are many conceptual articles but not yet many transformative policies in place and, consequently, very few empirical studies of real implementation processes. Another reason that in the transformative innovation policy discourse, implementation to some extent seems to be viewed as an integral part of policy design. This relates to a new view on the role of government and governance in innovation and transition processes, where top-down policy interventions are complemented, or even replaced, by bottom-up governance approaches. In these new and "open" approaches, (part of) the responsibility for policy implementation is delegated to other stakeholders (Foxon & Pearson, 2008; Grillitsch et al., 2019; Seong et al., 2016; Weber & Rohracher, 2012) and policymakers combine centralized "dirigisme" with a more embedded and decentralized governance mode (M. M. Bugge et al., 2018; Foray, 2018b; Mazzucato, 2018).

A second, but related, observation is that while the involvement of a broader set of stakeholders can have positive effects on the legitimation of policies and transformative change processes (as mentioned in the previous section), it also creates some implementation challenges for

policymakers. Studies of the implementation and outcomes of transformative-oriented policy programs and initiatives show that stakeholder enrolment and motivation require policymakers to act as a brokers between different stakeholders, to initiate dialogue and joint activities, build trust and align interests, and encourage collaboration (M. Bugge et al., 2017; Grillitsch et al., 2019; Mazzucato, 2018). This takes time and is not always successful, and lack of stakeholder involvement can, therefore, become a barrier to implementation (M. Bugge et al., 2017; Peng & Bai, 2018; Seong et al., 2016). Moreover, the emphasis on self-organizing and networking might come at the expense of the strong leadership and guidance required for transition processes to be realized (Berkhout & Westerhoff, 2013; M. Bugge et al., 2017; Grillitsch et al., 2019; Janssen, 2019; Scordato et al., 2018).

Broad stakeholder involvement can also create coordination failures (Weber & Rohracher, 2012). Implementation can also require coordination between the (national) government and the implementing agency (Weber & Rohracher, 2012), between different government agencies (e.g. finance, industry, environment and energy) (Peng & Bai, 2018; Seong et al., 2016),between different policies (Crespi, 2016; Scordato et al., 2018), and between the government bodies that invest in transitions and those that benefit from them (M. Bugge et al., 2017).

A third observation is that appropriate funding is required, but not always supplied within transformative policy programs and initiatives. In several cases described in the literature, additional government funding or mechanisms to collect and distribute funding from other sources had to be supplied or developed, often at a local level, to enable implementation of (national) policies (e.g. Berkhout & Westerhoff, 2013; Janssen, 2019; Peng & Bai, 2018; Seong et al., 2016).

A fourth observation concerns the importance of institutional factors and the local context for successful policy implementation. Existing institutions can enable or hinder implementation depending on whether they are aligned with the policy being implemented (Berkhout & Westerhoff, 2013; Peng & Bai, 2018). Stakeholders might find it difficult to understand and navigate the current institutional set-up (e.g. present and pending legislation), and changing misaligned institutions to enable implementation (e.g. stimulate market formation) might not be within the scope or latitude of a specific program or the implementing agency (Berkhout &

Westerhoff, 2013; L. Coenen et al., 2015). Moreover, adapting policies to the specific characteristics of the local context might be a necessary step in implementation, especially when local experiments are being scaled-up and diffused to other contexts (Seong et al., 2016).

Finally, a fifth observation is that implementation is conditioned by the capabilities of the actors. This concerns the knowledge of intended adopters and users of new technologies and solutions (M. Bugge et al., 2017), the governance capabilities of stakeholders involved in implementation (Grillitsch et al., 2019), and the competence and implementation capacity of governments and policymakers (Berkhout & Westerhoff, 2013; Foray, 2018b; Janssen, 2019).

4.6   Monitoring and evaluation

There seems to be general agreement in the reviewed literature that the special character of transformative innovation translates into new challenges for policy evaluation – challenges that current evaluation practices are ill-suited to handle (Amanatidou et al., 2014; Grillitsch et al., 2019; Janssen, 2019; Magro & Wilson, 2018). As Magro and Wilson (2018) put it, transformative innovation policy will lead to new answers to questions such as why, what, when and how to evaluate, as well as who should be responsible for evaluating.

While the traditional *why* or purpose of policy evaluation is mainly connected to accountability and control, the evaluation of transformative innovation policy, characterized by directionality involvement of multiple stakeholders and conflicts of interests, highlights the increasing importance of monitoring and evaluation in learning and reflexivity (Janssen, 2019; Magro & Wilson, 2018). Indeed, evaluation is both a governance tool and a learning tool, through which policymakers can learn important lessons for the future (Amanatidou et al., 2014). It is therefore important to find ways to reconcile the two perspectives while moving towards a more learning-oriented perspective on monitoring and evaluation (Magro & Wilson, 2018).

When it comes to *what* to evaluate, the new rationales for policy that come with transformative innovation policy, such as transformational system failures, imply that evaluation practices have to be adapted to new aims and tasks (Amanatidou et al., 2014). Most notably, because of the new directionality dimension, it is no longer enough to measure innovation outcomes but instead the impact of policy on selected challenges, missions and transition processes has to be assessed (Janssen, 2019; Magro & Wilson, 2018; Robinson & Mazzucato, 2019). Moreover, policy evaluation needs to consider a broader set of impacts than before (Amanatidou et al.,

2014). Depending on which challenge, mission or transition is in focus, evaluation might have to consider both additional impacts within the traditional science, technology, and economy domains, for example impacts throughout the entire innovation value chain (Robinson & Mazzucato, 2019), and impacts related to new domains, such as sustainability or other societal impacts (Amanatidou et al., 2014). Due to the complexity and uncertainty of transformation processes, policy evaluation might also to a larger extent have to take unexpected or indirect impacts into account (Amanatidou et al., 2014). Taken together, this broadened scope implies a need for evaluation to consider "behavioral additionality", i.e. how policy changes the behavior of actors involved in or affected by the policy measure in question, as well as system-level effects such as experimentation and learning (Amanatidou et al., 2014; Magro & Wilson, 2018).

At the same time, attributing the effects of policy is more difficult when transformative innovation is concerned. One reason for this is the uncertainty and long duration of transformation processes, which make it difficult to determine the influence of a particular policy (Amanatidou et al., 2014); spillovers and other systemic effects confuse the input-output logic and make it difficult to define a counterfactual, and the final outcomes of a policy might not be fully observable for many years (Janssen, 2019). Another reason is that transformative innovation policy, as mentioned in Section 3.2, tends to involve quite complex policy mixes. This implies that policy evaluation has to account for synergies, conflicts and other type of interactions between instruments – something that traditional evaluation methods are not necessarily well suited for (Janssen, 2019; Magro & Wilson, 2018).

With regard to *when* policy should be evaluated, some articles suggest *that ex-ante* evaluation might be too complicated when transformative innovation policy is concerned, because of the high level of experimentation and risk and the limited capacity and foresight of policymakers (Foray, 2018a, 2018b; Hoppmann et al., 2014). However, this does not mean that summative *ex-post* evaluations are encouraged. As mentioned above, evaluation is mainly a tool for learning, which means that it should be conducted when there is a need for information, for example when there is a window of opportunity to modify or replace a particular policy, and when enough time has passed for information about results to be available (Amanatidou et al., 2014). According to several articles, this implies that formative evaluation in the form of

repeated and timely monitoring should be prioritized over summative evaluation, to allow for re-evaluation and adaptation of goals, strategies and policy instruments (Fagerberg, 2018; Janssen, 2019; Magro & Wilson, 2018; Mazzucato, 2018; Weber & Rohracher, 2012). Considering the longevity and uncertainty of transformative innovation, this is a prerequisite for a dynamic and flexible policy approach, where feedback is used to make adjustments throughout the policy process (Foray, 2018a, 2018b; Hoppmann et al., 2014; Mazzucato, 2018; Weber & Rohracher, 2012).

How this should be achieved is not clearly spelled out in the reviewed literature. There is an apparent need for policy makers and evaluators a new system to build "strategic intelligence" related to how a desired transformation is progressing and the emergent effects of policy on it (Weber & Rohracher, 2012). According to the reviewed literature, current evaluation methods and indicators are not going to be of much use in this regard. Most notably, the static tools used in traditional cost-benefit and input-output analyses do not capture the dynamics of transformative innovation and policy experimentation (Amanatidou et al., 2014; Janssen, 2019; Mazzucato, 2016). However, there does not seem to be any clear consensus on how evaluation should be done instead, and evaluation practices also seem to lag behind. Indeed, traditional, and often static, policy evaluation criteria based on the market failure approach are still very much in use (Janssen, 2019; Magro & Wilson, 2018; Mazzucato, 2016; Robinson & Mazzucato, 2019), and even impact assessments that claim to have a wider scopes and more transformative ambitions tend to be rather unsophisticated (Amanatidou et al., 2014). Some authors therefore argue that there is a need to go beyond general ideas about the novel character of transformative innovation policy and develop new analytical frameworks and indicators that capture more of the system-level dynamics of transitions and allow evaluators to not only incorporate behavioral additionality and a broader set of impacts (as described above) but also describe why and how things are happening in a system and how policy influences the conditions for realizing transformative change (Amanatidou et al., 2014; Grillitsch et al., 2019; Hoppmann et al., 2014; Janssen, 2019; Mazzucato, 2016, 2018). Some attempts have already been made in this direction. As described in Section 3.2, some evaluation frameworks have been suggested, based on existing innovation and transition studies frameworks, such as the multi-level perspective, strategic niche management and technological innovation systems (Grillitsch et al., 2019; Janssen, 2019; Kern, 2012; Kivimaa & Virkamäki, 2014; Naber et al., 2017).

Finally, when it comes to the question of *who* should handle the evaluation, the reviewed literature clearly indicates that there is a need for new forms of organization and governance of evaluation (Magro & Wilson, 2018; Mazzucato, 2018). First, due to the complex and fragmented nature of transformative innovation, there is an increasing need for coordination between different scientific and technological fields, policy levels and areas, and sectors (Amanatidou et al., 2014; Magro & Wilson, 2018). Second, just as it is argued that policy design and implementation should become more inclusive (see Sections 4.3 and 4.5), the reviewed literature advocates a more open and collective governance of policy evaluation to make evaluations relevant and useful. While this is not necessarily unique for transformative innovation policy evaluation (Amanatidou et al., 2014), suggestions range from addressing the needs of different stakeholders in evaluation to putting these stakeholders at center stage of evaluation processes and empower them to govern and evaluate themselves (Amanatidou et al., 2014; Magro & Wilson, 2018; Weber & Rohracher, 2012).

Such broad and deep stakeholder participation involves new challenges for evaluators. Different stakeholders, within and outside of government, have different interests and as well as different stakes in policy. This means that there will be conflicts of interests of different kinds to manage – especially if the same stakeholders have been involved in designing and implementing the very same policies they are evaluating (Magro & Wilson, 2018). In addition, for stakeholder involvement to work there has to be trust, both between the evaluator and the stakeholders and between different stakeholders, in order for stakeholders to share sensitive information and commit to the evaluation process (Amanatidou et al., 2014; Magro & Wilson, 2018). This is also crucial for the legitimacy of the evaluation and its results (Magro & Wilson, 2018). However, for stakeholders to be able to commit and become engaged, they have to be empowered to do so, for example by training and facilitation of interactions (Magro & Wilson, 2018).

4.7   Policy learning

As described previously in this paper, learning is a key feature of transformation processes. However, the focus of attention in this section is on *policy* learning. This distinction can be questioned. Indeed, some authors argue that the policymaker should not be seen as someone who can take an outsider perspective, but instead as deeply embedded in a collective

sensemaking and learning process (Weber & Rohracher, 2012). Still, though learning in general might be a shared purpose of all stakeholders, policy learning usually is not (Magro & Wilson, 2018). This review is therefore concerned mainly on the literature's perceptions of the specific question of how policy makers can use the lessons they learned to improve individual policies or the policymaking process in general.

In this regard, several articles mention that policy learning can take place at different levels: (1) the operational level, i.e. using information and lessons learned to improve the effectiveness, efficiency and quality of policy design, management, implementation and evaluation, (2) the policy level, i.e. using information about the outcomes and impacts of the policy intervention on the larger objective as an input to future program design, to question the assumptions behind the intervention or to adapt to changing conditions, and (3) the system level, i.e. answering broader questions such as when different type of interventions are appropriate, how to design complementary policy mixes etc., and whether to adopt new emerging policy paradigms (cf. different variants described by Amanatidou et al., 2014; Foxon & Pearson, 2008; Grillitsch et al., 2019; McKelvey & Saemundsson, 2018). As described in the previous sub-section, evaluation is closely connected to learning at all these levels, although the operational level is the one that is most developed so far (Amanatidou et al., 2014).

The reviewed literature also identifies different mechanisms by which policy learning occurs. All these are based on an understanding of innovation and transformation processes as complex and uncertain and of policy processes as characterized by large needs for trial-and-error learning. However, they differ in terms of what the underlying logic and determinants of learning are and also in terms of whether they are described in a descriptive or prescriptive way, i.e. as how policy learning occurs versus how policy learning should be set up. The first mechanism has been described as "the science of muddling through" (Lindblom, 1959 as cited by Hoppmann et al., 2014) and refers to a rather ad hoc-type of learning-by-doing with regard to both problem formulation and selection of solutions. The underlying idea is that when complex processes are concerned, policy makers do not have the capacity to make complete problem analyses and identify optimal policy solutions before taking action. Instead, they tend to focus on a few main issues at a time and then move on as previous issues are handled or new ones appear on the agenda. They also tend to pick any policy solution that suits their direct

needs – or based on fashion rather than experience (McKelvey & Saemundsson, 2018) – and then adjust it if and when it turns out to be inappropriate or insufficient).

The second mechanism has been named "compulsive policy making" by Hoppmann et al. (2014). It refers to an iterative type of learning-by-doing, where the effects of a policy instrument in terms of technological change (e.g. rapid diffusion) forces policy makers to revise the instrument to adapt to new conditions. In contrast to the previous mechanism, policy adjustment is, thus, a reaction to real (and often unanticipated or underestimated) changes in targeted sociotechnical systems. The policy makers can very well have the capacity to design and implement a policy that solves initial problems or bottlenecks, but the impact of the policy itself also results in new problems that policy makers subsequently have to address by revising the policy design (Fagerberg, 2018; Foray, 2018a; Foxon & Pearson, 2008; Hoppmann et al., 2014).

Finally, the third mechanism is referred to as "adaptive policy making", "tentative governance" or "reflexivity" (Amanatidou et al., 2014; Crespi, 2016; Grillitsch et al., 2019; Schot & Steinmueller, 2018; Weber & Rohracher, 2012).[5] It is for the most part described in prescriptive terms, i.e. as something policy makers much achieve in order to pursue successful transformative innovation policy and achieve transformative change, and it is very closely related to monitoring and evaluation (as described in the previous sub-section). It refers to the deliberate use of bottom-up policy experimentation and discovery, where policy makers and other stakeholders continuously monitor, review, adjust and reverse policies and activities based on what happens in each experiment, with a focus on directionality and behavioral changes rather than on final outcomes (Amanatidou et al., 2014; Foray, 2018a; Foxon & Pearson, 2008; Magro & Wilson, 2018; Mazzucato, 2016; Schot & Steinmueller, 2018). It requires a system for continuous monitoring, reflexive and adaptive arrangements involving multiple stakeholders (e.g. public consultations), and a portfolio approach to technologies and policies (i.e. to keep several options open in order to avoid too early selection and lock-in) (Crespi, 2016; Weber & Rohracher, 2012).

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[5] Some argue that adaptive policymaking is more reactive than reflexive policymaking (Grillitsch et al., 2019), but most articles do not make that distinction.

It is by no means easy to achieve policy learning in general, and adaptive policy in particular. In contexts characterized by high degrees of uncertainty, all feedback and learning is by necessity partially blind (McKelvey & Saemundsson, 2018), and there are many potential sources of "reflexivity failure" (Weber & Rohracher, 2012), such as weak leadership, lack of absorptive capacity, conflicts of interests and closed networks (Grillitsch et al., 2019; Mazzucato, 2018). Moreover, policymakers tend to follow routines, and this can make it difficult to adapt to new rationales and the associated policy practices (Grillitsch et al., 2019).

5. Concluding discussion

The purpose of this paper, as set out in the introduction, was to take stock of the current understanding of the specificities and challenges of transformative innovation policy throughout the policymaking process. More specifically, the paper set out to review the received literature on transformative innovation policy (and related concepts) in order to identify to what extent and how current writings contribute to our basic understanding of six key aspects of policymaking, namely agenda setting, policy design, legitimation, implementation, evaluation and policy learning, in the specific context of transformative innovation.

In a summary of three main clusters of literature, we first showed that the emerging discourse of transformative innovation policy draws on a combination of innovation studies (Diercks et al., 2019; Fagerberg, 2018; Giuliani, 2018; Soete, 2019) transition studies (Kivimaa & Kern, 2016; Kuhlmann & Rip, 2018; Raven & Walrave, 2018; Schot & Steinmueller, 2018; Weber & Rohracher, 2012) and writings on mission-oriented innovation policy (Foray, 2018b; Mazzucato, 2018). To a large extent, authors have a shared understanding of the key characteristics of transformative innovation policy: a focus on directionality (in particular in terms of a focus on broadly defined societal ("grand") challenges, a more active and demanding government role (e.g. new requirements on providing direction and coordination), broad stakeholder involvement throughout the policy process, and increased attention to processes of creative destruction and destabilization of current sociotechnical regimes. Several authors describe this as the third generation of innovation policy, which differ substantially from past generations of growth-oriented policies or policies focused on solving narrowly defined mission (Mazzucato, 2016; Schot & Steinmueller, 2018). However, most of the literature in this cluster

does not go beyond trying to distinguish the "new" from the "old" and outlining rather broad guiding principles.

In contrast, in the second cluster, we identified some attempts to develop more concrete frameworks to analyze and understand transformative innovation policy. In particular, we noted the contributions made by the literature on policy mixes, where scholars draw on innovation policy, transition studies and political science to develop and apply a framework for analyzing the interaction between different policies and instrument choices within a certain institutional setting (cf. e.g. Johnstone et al., 2017; Rogge & Reichardt, 2016; Scordato et al., 2018), as well as an emerging field of "failures-oriented" frameworks aimed at guiding policymakers in their decision making and justify government interventions beyond the conventional "market failure" approach (Chicot & Matt, 2018; Kivimaa & Kern, 2016; Raven & Walrave, 2018; Weber & Rohracher, 2012). Compared with the writings in the first cluster, these frameworks are more focused. They are primarily tools to analyzing specific aspects of transformative innovation policy (at the level of specific technologies, sectors, regions or countries) rather than all-encompassing transformative innovation policy frameworks. While this might imply that they have more limited application, they also seem able to provide more practical lessons for policymakers, judging by the empirical studies also included in this cluster.

Finally, in the third cluster we saw some empirical studies of allegedly transformative innovation policies in practice. While the studied programs addressed the transformational failures identified by Weber and Rohracher (2012) and also had some other transformative features, these studies also show that there are many different approaches and no clear best practice as of yet. Moreover, it was clear that there are many challenges for policymakers with regard to how to successfully design and implement transformational innovation policy.

We then proceeded to synthesize the findings and recommendations from the literature for different phases of the policy cycle. A first observation with regard to this was that much of the discussions in the literature are held on a different level of analysis than the traditional policy literature. For example, the discussion about policy design mainly concerns policy mixes rather than individual policy programs and instruments.

A second observation was that it was sometimes difficult to distinguish different stages of the cycle, as the literature tended to talk about for example design and implementation or evaluation

and learning at the same time. In part, this might be due to the fact that the policy cycle, as mentioned in the introduction, does not describe "the logic of policy-in-use" but a more stylized process (Dunn, 2008). However, it also seems like the literature on transformative innovation policy has a fundamentally different perspective on – or rather ideal of – policymaking and the role of governance, as evidenced for example by its view on monitoring and evaluation where learning is emphasized over accountability (see Section 4.6). Many transformative innovation policy scholars would, thus, probably reject the policy cycle as a model for the policy process. However, in our experience policy cycle thinking is very much part of policymakers' reality, and what role the new transformative innovation policy ideal implies for them – and whether they will have the latitude to take on this role – is an important issue for further research.

A third observation was that stakeholder involvement is recommended in all phases of the policy cycle – from agenda setting, over policy design and legitimation to policy implementation and evaluation. Indeed, the role of governments in transformative innovation policy is described not so much as a policy maker as a transition intermediary, orchestrating, facilitating and coordinating collaboration and interaction between other stakeholders. In light of this, it is noteworthy that there is little reference to the literature on stakeholder management and multi-stakeholder processes (cf. e.g. Edelenbos & Klijn, 2005; Hemmati, 2002; Riege & Lindsay, 2006; Roloff, 2008), which tends to have a more nuanced perspective on the potential benefits, drawbacks and challenges with broad and deep stakeholder participation as well as much more concrete advice on how to organize and manage participatory processes. Not least, it has important insights to share with regard to the willingness and capacity of stakeholders to participate in multi-stakeholder processes (cf. Riege & Lindsay, 2006; Waligo, Clarke, & Hawkins, 2014; Warner, 2006).

Fifth and finally, a general impression from the review was that there are many visions, opinions and even prescriptions about the third generation of (transformative) innovation could and should be, but very little concrete advice or things to hold on to for policymakers. For example, in spite of the literature's emphasis on policy experimentation, learning and reflection, not much is said about how this can be achieved in practice. While much of the literature seems to suggest that governments and traditional policy makers have to take on a new role when dealing with transformative innovation, what this role exactly implies, how it should be planned and

executed, what types of competencies and capabilities will be required and how those should be obtained remains unclear. Although some promising frameworks are being developed, which have the potential to support policymakers in setting agendas and designing and evaluating policies, these frameworks are (as mentioned above) limited in scope and applicability. We would, therefore, argue that if the transformative innovation policy discourse should have any chance to replace current innovation policy paradigms, it cannot only provide food for thought but has to be able to provide governments and policymakers with some real sustenance in terms of concrete advice and support.

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