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Directionality for transformation: Analytical dimensions and illustrations of selected 'policy tools'

Kivimaa, P., Pontikakis, D., Reimeris, R., Miedzinski, M.

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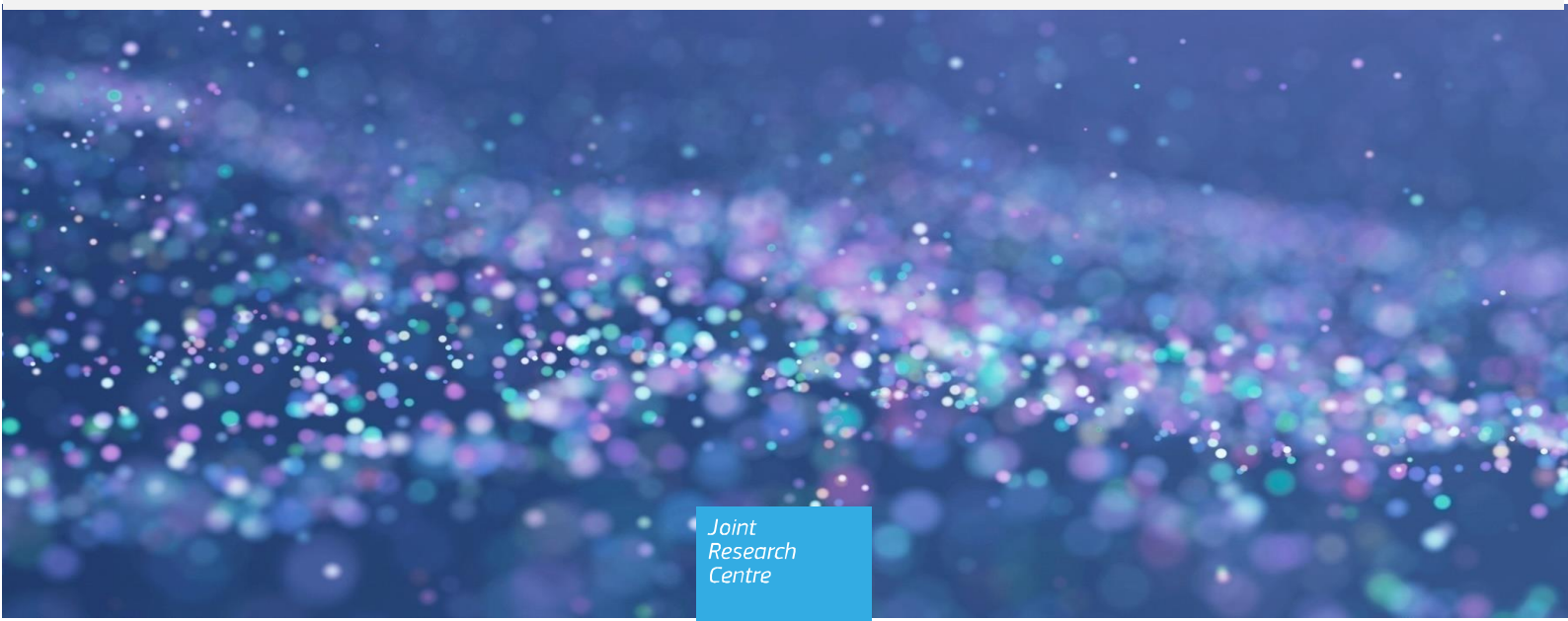

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Abstract

One of the key aspects of the transformation pursuits is 'directionality'. This means, for example, that when promoting science, technology, and innovation (STI) activities, these activities should respond to addressing the grand environmental and societal challenges the world is facing. Drawing on academic literature on innovation studies and sustainability transitions, this paper first examines what directionality for transformation can mean, creating a typology to characterise directionality which contains elements that can be used to analyse planned or realised policy instruments and policy mixes. Second, it explores how directionality is present in selected policy approaches (transition arenas, missions, the entrepreneurial discovery process, just transition initiatives, and policy coherence). It conducts a light analysis of these tools, and what might be there of use for the EU regional innovation policy initiative - Partnerships for Regional Innovation (PRI) - to advance transformation via increasing attention on directionality. None of the explored policy tools are perfect for directionality but hold much potential if their use is planned carefully.

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1 Introduction

Sustainability transitions or transformations are increasingly a topic mentioned or addressed by policymakers on regional, national and European Union (EU) levels. Some of the attempts to steer transitions include proposals from the academic community regarding new framings of innovation policy as mission-oriented (Robinson and Mazzucato 2019) or transformative innovation policy (Schot and Steinmueller 2018). Other transition efforts include policies already in place which are framed around environmentally beneficial transitions, such as the EU Green Deal.

One of the key aspects of the transformation pursuits is 'directionality'. This means, for example, that when promoting science, technology, and innovation (STI) activities, these activities should respond to addressing the grand environmental and societal challenges the world is facing. Some also refer to directionality more as a quality of process kind of way, bringing attention to alternative orientations to progress (Stirling 2009). Directionality has also been described as a key component for placed-based innovation policies (Magro and Wilson 2019).

Apart from references to UN Sustainable Development Goals (SDGs), it is often unclear more specifically what directionality means and how it can be advanced or evaluated. Further, policy goals advocated by the SDGs are often contradicting with the mainstream policy goal of economic growth. Therefore, this paper will explore: How can directionality be defined and operationalised to support policy practice and evaluation? To what extent can selected policy approaches be used to advance directionality, and what are their benefits and drawbacks? This paper addresses these research questions drawing from sustainability transitions and innovation studies. Empirically, it explores the following policy approaches with the help of previous academic literature and policy reports: transition arenas, the EU's missions, the EU's just transition initiatives, the entrepreneurial discovery process (EDP), and policy integration and coherence.

Given regions in the EU are increasingly developing their own innovation activities and have a growing interest in sustainability transitions, they might benefit from some of the above or other transition-oriented policy approaches. This paper aims to give background information for the EU regional innovation policy initiative, entitled 'the Partnership for Regional Innovation (PRI)', regarding the potential usefulness of these selected policy tools in advancing directionality in this context. PRI is a new strategic approach piloted by European Commission's Joint Research Centre to bring forward new ways of working across government departments and levels focused on solving territorial challenges. The PRI "aspires to become a strategic framework for innovation-driven territorial transformation, linking EU priorities with national plans and place-based opportunities and challenges" (Pontikakis et al., 2022). JRC seeks to establish long-lasting and impact-based partnerships across EU regions to support sustainability transitions that create economic, social & environmental value.

The paper is organised as follows. Section 2 is focused on the conceptual foundations for directionality, by drawing from innovation and sustainability transition studies. Section 3 describes the analytical categories derived from the literature review and the method of analysis. Section 4 is focused on the analysis of the selected policy approaches. Section 5 discusses and concludes.

2 Conceptual foundations: Directionality in sustainability transitions and innovation studies

2.1 Insights from literature on innovation studies

Innovation studies are concerned with the drivers, mechanisms, and implications of scientific, technological and innovation activities. The treatment of directionality within the field of innovation studies has direct bearing not just on our understanding of directionality, but also on the legacy of still dominant conceptual models of innovation and their policy implications. Early literature on the economics of technological change, in the 1950s, was dominated by discussions on the determinants of overall investment in the search for new ideas (Solow, 1957; Romer, 1992) and on the conditions that influence their diffusion and adoption (Griliches, 1957; Rosenberg, 1976; Geroski, 2000). Nested in neoclassical economics, the societal purpose, or directionality, of technological change, implicit in early literature, was that of economic growth and development. In that context, the question of the direction of technological change concerned narrower choices over technologies (and by implication industrial sectors), rather than the overall societal purpose of technological change, which was unquestioned.

Examples of early studies concerned with direction in this narrow sense were the contributions on induced technical change, on the one hand (e.g., Kamien and Schwartz 1969), and the contributions on the determinants of the supply of new ideas (e.g., Schmookler 1966), on the other. In the literature on induced technical change, "the direction of technological change" usually referred to the choices faced by firms to choose technologies that either increase their overall productivity or substitute one factor of production for another (Kamien and Schwartz 1969). In this sense, changes in prices (e.g., energy prices) can have a strong inducement effect on the choices of firms over production technologies[1]. In the literature on the determinants of the supply of new ideas, Schmookler (1966) examined the rates of technological invention across sectors based on chronologies of important inventions and on statistics on patents granted, looking for an explanation to the varying rates of invention across sectors. Schmookler concluded that patenting was driven by patterns of demand across sectors (or of the economic value of inventions), rather than the cost of supply of ideas (e.g., some sectors exhibiting more plentiful technological opportunities).

Although it went unchallenged previously, by the 1970s, the directionality of economic growth begun to come into question. One of the questions was whether economic growth could be sustained indefinitely in view of the exhaustion of materials and energy resources, a realisation that gained poignancy by the oil crises of the 1970s. Another question was whether environmental pollution resulting from economic growth might endanger the very future of humanity (Freeman and Soete, 1997). Freeman and Soete (1997) argued that these questions exerted considerable influence in the allocation of resources for science and technology in the 1970s.

Approaches to the study of technological change hailing from evolutionary economics in the 1980s heralded a fuller recognition of the importance of direction in the search for new ideas. Nelson and Winter (1982) observed that innovations co-evolve with institutions (still resonating with today's innovation studies (cf., Kivimaa and Rogge 2022)). Dosi (1982) argued that technological change happens within the bounds of 'paradigms' which are complex functions of the interplay between scientific advances, economic factors, institutional variables, and unsolved difficulties on established technological paths. An implication of this argument is that directions of technological change that are thematically close to the dominant technological paradigm of the time enjoy higher rates of return, are more likely to attract investment and to encounter plentiful technological opportunities, particularly at the early stages of paradigm emergence and consolidation. Perez (2002) emphasised the co-evolution of ideas and of finance in giving rise to techno-economic paradigms. Drawing on examples from economic history, Perez (2002) argued that the emergence of paradigms can be characterised by successive stages that appear in the historical record with some regularity. They often begin with the social-shaping of techno-economic paradigms, follow paths determined by the pairing of apparent technological opportunities and private finance, drive speculative financial bubbles, and culminate in epoch-defining technological irruptions.

The associated vein of innovation studies discourse on systems of innovation (Lundvall, 1992; Freeman, 1995) emerged more or less concurrently with the economic growth and competitiveness directionality of public policy discourse of the 1990s (Mowery and Rosenberg, 1994; Krugman, 1994). Although early

[1] We are grateful to Dominique Foray for this suggestion.

contributions to systems of innovation literature often adopted broader views of development that encompassed societal wellbeing (e.g., Lundvall, 1992; Kemp and Soete, 1992; Freeman and Soete, 1997), arguably the policy selection process favoured those approaches deemed more favourable to the by then dominant economic growth and competitiveness directionality. In keeping with this directionality, some of the most influential varieties of innovation system discourse adopted a framing that was considerably narrower than the entire economy. This framing focused attention on systemic failures on the production (Edquist, 1997) and circulation (Etzkowitz and Leyesdorff, 2000) of economically useful knowledge, especially those varieties deemed "pre-competitive" that would be under-provisioned by markets (Guzzetti, 1995).

Despite the recognition of the importance of the direction of technological change in early innovation literature, there was no consensus about the role of public policy. Public policy decisions affecting the choice of specific technologies, industrial sectors or individual 'winner' firms have been somewhat of a taboo, especially in the face of mixed experience with sectoral industrial policies post-WWII (Peterson and Sharp, 1998).

Difficult questions over the legitimacy of a particular direction - who gains from it, who assumes its cost and how decisions to commit to a direction are taken - have prevented an explicit policy focus on directionality. In practice, innovation policy has been straddling an often uncomfortable and volatile middle-ground between the prescriptions of two distinct approaches to the study of innovation. On the one hand, neoclassical economics literature emphasised factor endowments and the price mechanism as key determinants of the direction of technological development. In the face of limited information, entrepreneurs knew best where to invest, thus, leaving little (e.g., some contributions concede a role for public support for so-called General Purpose Technologies; Helpman and Trajtenberg, 1996) or no role for public policies in steering the process (Baumol, 2002).

On the other hand, evolutionary and historical approaches to innovation emphasised the clustering of radical innovations and suggested **differentiated policy approaches according to the stage of paradigm emergence, development,** or **deployment** (Perez, 2002; Nelson, 2003). Since the 1990s, this ambivalence of prescriptions has driven the observed oscillation of policy between the alternating popularity of thematic and sectoral policies, particularly for general purpose technologies such as Information and Communication Technologies (ICTs) (e.g. technology platforms) and undifferentiated innovation policies for all firms such as the popularity of directing support for business innovation through blanket tax incentives (as opposed to project-based, merit-seeking or sectorally/thematically-targeted subsidies) (see Figure 4.4 in OECD, 2021, p. 100). In sum, during the past two decades, directionality of innovation has re-emerged as an important research topic in innovation studies, reflecting the growing interdisciplinarity of the field and a growing concern among economists with the growing prevalence of environmental and other externalities. This is especially investigated in an associated research field of sustainability transition studies, which overlaps somewhat with innovation studies.

2.2 Insights from literature on sustainability transitions

Research on sustainability transitions adopting a socio-technical lens on innovation and system-level change was originated in the late 1990s and heavily expanded since the 2010s. From the perspective of sustainability transition studies, generic STI activities seem in principle to take any 'direction' and are not in themselves directional. It has been argued that public discourse tends to mistakenly describe progress or development as unidirectional, as if there is only one direction, and might forget that specific visions around innovation – if pursued strongly – can dismiss other directions of change (Stirling 2009). Traditional, market-oriented innovation policy, while containing economic value propositions, has typically been implicit about the direction and it has unquestioned what progress can mean (Kivimaa and Torrens, 2023).

Direction and directionality are key concepts in sustainability transitions research, albeit frequently their definitions are left rather implicit. For instance, particular elements in seminal transition research frameworks relate to directionality. 'Direction of search' is one of the seven functions of the Technological Innovation Systems approach, and 'articulation of expectations and visions' is one of three processes of Strategic Niche Management. Schot and Steinmueller (2018) have referred to directionality as 'making choices over alternative pathways of development' where direction can be taken as a premise of policymaking and a process established to govern shared priorities. This means not only selecting the technological paths we pursue, but making decisions on the prioritisation of different values, such as economic growth, ecological sustainability, and social welfare.

During the past decade and since the work of Matthias Weber and Harald Rohracher (2012), the 'directionality failure' of public policy and innovation policy has gained increasing attention. For instance, Scordato et al. (2018) suggested that a failure in directionality means that governance has failed to direct 'innovation efforts and collective priorities in a certain direction to meet societal challenges'. Weber and Rohracher argued that new policy rationales inspired by transition studies emphasise an additional policy failure besides market and system failures: the missing direction of change contributing to a directionality failure in innovation policy. They posit that, while system failure arguments address the sub-optimal operation of innovation processes, addressing the directionality failure requires prioritising specific innovation activities 'in the direction of desired long-term transformative change' based on identifying major societal problems, adopting requirements external to the innovation system, and collective negotiated priority setting. The latter is made more problematic by the frequent absence of consensus about the direction (Weber and Rohracher 2012).

In transition studies, visions and missions are used as specific 'guiding tools' for directionality. This is well outlined in the report published by the European Environment Agency (EEA) in 2019 on the policy and practice of sustainability transitions (see Box below). According to the report, visions can act as collective narratives for actors (e.g., policy makers, businesses, citizens, the civil society); build legitimacy for certain directions; and outline 'what technologies and resources will be used, what kind of services will be offered to people, what institutions and policies will be needed, and how people could live their day-to-day lives' (Geels et al. 2019, 106). In turn, missions are more solution oriented. As Mazzucato (2018) states, they set clear and ambitious cross-sectoral objectives and targets that create a solution and an approach to address societal challenges. Missions are seen to be more specific than visions, involve greater commitment, and 'function at a middle level, between broad societal goals and ground-level projects and experiments' (Geels et al. 2019, 109).

Box 1: Visions, missions and targets

Visions articulate a desired end-state for a particular socio-technical regime (energy, mobility, food) supported by an actor network, to guide and motivate processes of technological, institutional and behavioural change (Berkhout 2006). Visions are a means for introducing directionality into policymaking. An example is a vision of 'a resource-efficient and low-carbon energy system' or 'a sustainable and flexible mobility system'.

Missions identify an opportunity and provide a solution and approach to address societal challenges (Mazzucato, 2018). Often used in the innovation and defence policy areas, they create directionality and a focus for coordinating activities by different actors, sometimes across sectors. A mission is more specific than a vision, often expressing urgency and the need for immediate action. Examples of missions include having plastic-free oceans, or 100 carbon-free cities by 2030 (Mazzucato, 2018).

Targets make concrete a vision or a mission, often in quantifiable and measurable terms. In contrast, visions and missions can include non-quantifiable or only partially measurable elements and are often less concrete. Examples of targets are reduction of energy demand by industry by 50 % by 2030, replacing 30 % of combustion engine vehicles with EVs by 2025, or halting the use of non-recyclable single-use plastics by 2020.

Source: Geels et al. (2019), EEA report 'Sustainability transitions: policy and practice'

It can, however, be difficult to set visions and missions in an inclusive and transformative manner. Power and agency influence the vision setting processes, where overcoming incumbent power positions is not easy (Weber and Rohracher 2012). Stirling (2009) argues that values and interests most often embedded in understandings of 'progress' are those held by incumbent institutions and privileged social groups. Yet, within transition studies, the understanding is still limited regarding how agency influences directionality and is argued to be more complex than merely competition between niche and regime actors; for instance, different regime actors pursuing different directions (Yang, Schot, and Truffer 2021). The latter can, for instance, manifest in incumbent companies beginning to pursue transitions, while politicians are still engaged in the old system rhetoric. In effect, 'directionality should be better understood as a bidirectional process shaped by both niche and regime actors' (Yang, Schot, and Truffer 2021: p. 765).

Directionality is not limited to visions and missions but is present in (almost) all transition activities. For instance, Kivimaa and Torrens (2023) illustrate how directionality is also built via processes of experimentation where new governance designs create insights for new directions; networking where actors come together to formulate shared interpretations of the future direction; Intermediation where intermediary actors broker networks where shared directions are created and shape these directions; and *institutional change* that can break or destabilise past directions and confirm new directions. The institutional effect on direction is also noted by Edmondson et al. (2019). Yang et al. (2021), drawing on institutional studies,

identify three types of institutional work at play in transitions: maintaining existing regimes, disrupting existing regimes, and creating new institutions for expanding niches. The latter two aim to form new directions for change. In turn, Magro and Wilson (2019) also describe how experimentation can contribute to directionality; they look at it via choices made over what kind of projects are funded.

The choice of projects, technologies or innovation trajectories to fund is indeed tricky for those in charge of public funds, as they are typically not privileged with insight into how technological development and other conditioning factors will occur in the future – and are also influenced by groups advocating certain solutions. Pel and colleagues have explored how to manage a directionality 'problem' of multiple possible socio-technical development paths embodied in transitions, where '[e]mergent innovation trajectories can branch into various pathways, with different future outcomes' (Pel, Raven, and van Est 2020). They outline three challenges for transitions directionality. First, *socio-technical multiplicity* refers to competing socio-technical configurations which are each pursued by their own actor coalitions. This is also noted in previous transitions research (e.g. Smith, Stirling, and Berkhout 2005) that identifies even radically different orientations for change based on differing values and interests (Stirling 2009). Multiplicity also links to the seminal debate about how technology neutral or specific should public policies be in aiming to promote transitions (Azar and Sandén 2011).

Second, *appraisal diversity* means that actors have different understandings of sustainability, and visions for, e.g., 'zero-carbon' mean different things to difference people based on differing normative assessments and priorities (Pel, Raven, and van Est 2020). In practice, appraisal diversity can be assessed, e.g., by looking at the **level of ambition** of different actors or policies regarding policy targets such as the share of renewable energy, emission reduction, or energy efficiency, and the **degree of 'disruption'**[2] proposed by the kind of system change envisaged (Lindberg, Markard, and Andersen 2019). For instance, a specific technology, such as solar panels, can constitute a completely new system directionality or it can be added to optimise the established system (Yang, Schot, and Truffer 2021). The former is more disruptive than the latter. These phenomena have also been described as stretch-and-transform or fit-and-conform processes of transitions (Smith and Raven 2012).

Third, directionality is sometimes (merely) approached as *a process-analytical challenge* which is more concerned about means than the outcomes of the process. For instance, Stirling (2009) associated directionality as openness to other, non-mainstream understandings of progress which should be connected with the distribution of democratic agency and social equity and diversity of plural discourses and cultures. Pel et al. (2020) used these three dimensions empirically to ask questions such as: Which configurations are pursued? Who guides and steers? What are the main evaluation criteria? Which impacts are considered relevant? Which turns in the innovation trajectory are experienced or anticipated? These questions should also be openly asked in innovation planning.

Sustainability transitions scholarship emphasises collective construction of directionality, as opposed to top-down set directions (Kemp et al. 1998; Ghosh et al. 2021). It is, however, important to note possible conflicts of interests of actors that participate in more bottom-up governance processes where directions are set and, at the same time, are subjects to the new policy strategies (Magro and Wilson 2019). It is also increasingly evident, that actors create regionally divergent directions by being selective about which national context conditions (policies, visions and infrastructures) they apply for regional transition directions (Yang et al. 2021). Therefore, it may be difficult to construct collectively accepted visions across multiple regions within states. Also, transition directionalities may imply quite different qualities across different socio-technical systems. For instance, systemic change in transport aims for directions that shift from individual to collective and more centralised ownership; in turn, energy transitions incorporate changes from centralised to more distributed ownership (Kivimaa et al. 2021). This means that directionality for so-called multi-regime or 'deep' transitions may be difficult to co-create.

2.3 Policy mixes and directionality

While public policies are by no means the only influencing factor on innovation processes and transitions, transitions scholarship has also addressed directionality specifically in the context of policy mixes. Policy

[2] More insight on how disruption can be considered in the context of sustainability transitions is provided by Kivimaa et al. (2021).

mixes are defined as collections of policy objectives, instruments and processes that together influence innovation processes, either as intentionally-designed policy portfolios or as mixes of real-world policies (Rogge and Reichardt 2016; Kivimaa and Kern 2016; Flanagan et al. 2011). It has been argued that, over time, the development of policy mixes is likely to have a major effect on the direction of transitions (Reichardt et al. 2016). This means, for example, that (too) rapidly changing policy mixes are less likely to influence transitions positively, because investors face uncertainty about how policies will shape the markets, than more consistently developing policy mixes (Kern et al. 2017). In a sense, too frequently changing policy mixes fail to create long-term directionality.

Two central ways in which policy mixes influence sustainability transitions are public resource allocation and regulation. For instance, **resource allocation** by public policymaking can influence transitions in terms of both direct monetary influence on certain technologies and solutions, public procurement, and more indirectly in terms of support for human resource development in particular fields. Edmonson et al. (2019) call this as the 'resource effect' of the policy mix. This can be manifested, for instance, in the type of projects funded in research and innovation programmes (Magro and Wilson 2019), or the kind of special education or training targeted. Reduced flows of resources to transition efforts may indicate a dwindling or less certain direction for change (Rogge and Dütschke 2017), while reduced flows of resources for incumbent and unsustainable technologies will support the zero-carbon transitions (Kivimaa and Kern 2016). However, recent research also shows the potential transformative direction of resource allocation to established industries to repurpose their skills and assets (Mäkitie 2020). Discourse on just transitions emphasises the need to create policy mixes which also entail re-education and re-training as part of the just transitions policy mix.

Besides resource (re)allocation via subsidies and taxation, policy mix studies note the importance of **regulatory instruments**, and to a degree also voluntary agreements, in setting direction for the future development of socio-technical transitions; yet, more substantial effect from regulations requires significant changes in overarching regulatory frameworks (Kivimaa and Kern 2016; Kivimaa and Rogge 2022) instead of smaller and more incremental developments, which can still help the overall policy mix. This connects to the aspect of institutional change noted above.

Another relevant aspect for policy mixes regarding directionality is **policy coherence**, i.e., the alignment of different policy objectives, instruments, and processes. Incoherence means lack of alignment and existence of policy tensions and conflicts, which typically hinder the effectiveness of transition-oriented policies – while may in rare cases stimulate innovation (Huttunen et al. 2014). Policy incoherence connects to what has been called as lack of unidirectionality of policy mixes that has been detected, for instance, in Spanish energy policy (Sanz-Hernández et al. 2020) but is also common elsewhere. Evolvement away from unidirectional policy mixes has also been described in cases when industries mature (Huang 2019). Yet, both directional instruments (Magro and Wilson 2019) and improved policy coherence (Kivimaa and Sivonen 2021) have been called for.

> *"[P]olicy-mixes in the smart specialisation context have tended to be considered more a portfolio of instruments from which to pick and choose, than a policy setting that might be strategically used to affect the directionality of innovation, fostering a structural transformation of the economy through experimentation. This is somewhat incongruent given the aim of smart specialisation strategies to generate structural transformation through targeting specific innovation activities over others." (Magro and Wilson 2019)*

The discussion on directionality and policy coherence leaves open the question about on which level should directionality be set. The European Commission (EC) has more knowledge about world developments influencing opportunities for different pathways, while regional conditions and opportunities may differ greatly. Therefore, EU innovation activities, such as the PRI, should aim for guidance which allows vertical coherence between the EC and regional as well as national STI policies. Sustainability transition studies, in turn, emphasise bottom-up directionality setting processes coupled with the role of public policies steering in the right direction. Some of the tools we will analyse in this paper might act as mechanisms for improving coherence.

3 Analytical categories and method of analysis

Building on the literature review above, we propose the following elements to examine directionality in a policy context (Table 1). They can be applied in the level of policy mixes, policy programmes or individual instruments and approaches. Here, we have selected a few potentially interesting policy approaches as the focus of analysis that resonate with recent innovation policy developments in the EU. We identified selected key academic publications and policy reports (programmes, and especially evaluations) that apply these approaches within the EU, provided a brief background for each, and then assessed how it relates to each of the dimensions.

Table 1: Analytical dimensions of directionality

Dimension of directionality	Element of directionality	Question	Literature sources
1. System-level scope	Presence of a system-oriented approach	Is there a system-oriented approach to change assumed in the policy tool?	Freeman 1985; Freeman and Soete 1997; Geels, 2002;
	System dimensions addressed	Which of the system dimensions for change does the policy tool address: technology, markets, ownership models, regulations and policy, and/or practices and behaviour?	Johnstone et al. 2020; Kivimaa et al. 2021
2. Transformative (rather than incremental) ambition towards environmental and social sustainability (UN SDGs)	Focus of core aims to transformation / transition	Does the policy tool aim at enabling or accelerating transformation/transition, legitimacy creation for transformation/transition, or compensating for transition effects?	Schot and Steinmueller 2018; Diercks 2019
	Prioritisation of transformation	How is prioritisation between different values conducted? What weight is given to transformation among other aims?	Stirling 2009
	Transition-phase awareness	Is policy tailored to the needs of distinct transition phases?	Perez 2002; Nelson 2003; Kivimaa et al. 2019
3. Pathway neutral or pathway selective/reinforcing	Orientation to transition pathways	Does the policy tool create specific transition pathway(s) or leave space for multiple (potentially competing) pathways to emerge?	Stirling 2009; Pel et al. 2020;
	Shaping of pathways	How are the pathways shaped (e.g., by experimentation, network-formation, intermediation or institutionalisation)?	Kivimaa and Torrens, 2023
4. Distributed and inclusive (as opposed to concentrated) agency	Shared vision formation	Is there a process of shared vision or mission formation? How inclusive is this process to actors not holding incumbent power positions or across	Berkhout 2006; Geels et al. 2019; Mazzucato et al. 2020

		regions or sectors?	
	Appraisal diversity	How are different understandings of the sustainable vision, of the level of ambition or of disruptiveness addressed?	Lindberg et al. 2019; Pel et al. 2020)
5. Multi-scalar scope	Scope of transformation	At what scale is directionality pursued (regional, national or EU)? To what degree does the policy 'tool' address vertical policy coherence between governance levels?	Huttunen et al. 2014; Magro and Wilson 2019; Yang et al. 2021
6. Reflexive social learning	Type of learning	Does the 'policy tool' encourage unlearning and reflexive learning, that goes beyond technocratic learning and existing assumptions?	Ghosh et al. 2021; van Oers et al. 2023;
7. Policy mix support	Connection to the broader policy mix	How does resource allocation or regulation support the directionality of the aims or objectives?	Kivimaa and Kern 2016; Magro and Wilson 2019; Rogge and Dütschke 2017; Edmondson et al. 2019

4 Illustrative cases of directionality in selected 'policy tools'

This section presents an illustrative analysis of selected policy approaches that could be employed to support regional transition-oriented innovation policy mixes in improving directionality, and perhaps already are in essence possible manifestations of directionality in practice. We, thus, examine selected transition-oriented approaches - (1) transition arenas, (2) the EU's missions and (3) the EU's just transition initiatives - and more generic policy tools, (4) the entrepreneurial discovery process (EDP) and (5) policy coherence - to see how they address the directionality-elements identified above. The purpose is to provide insights to interested policymakers and policy planners regarding the usability of these policy approaches for advancing directionality. The instruments were selected by the authors as relatively new developments linking to transitions-oriented innovation policy, and with some practical experiences of implementing these already in existence.

4.1 Transition arenas

Transition arenas (TA) are a method designed in the context of Transition Management (TM) - a practice-based model for advancing sustainability transitions (Kemp et al. 2007; Loorbach and Rotmans 2010). TM is in essence a deliberated process that intends to accelerate transformation to the direction of sustainability (Kemp et al. 2007). Transition arenas have been described as specific networks of frontrunners that aim to co-produce directions for change: "The very idea behind transition management is to create a societal movement through new coalitions, partnerships and networks around arenas that allow for building up continuous pressure on the political and market arena to safeguard the long-term orientation and goals of the transition process" (Loorbach and Rotmans 2010, 239). The idea was initially to distinguish an arena separate from the political one that can conduct long term visioning (Loorbach and Rotmans 2010).

TA's include several phases where directionality comes into play (Loorbach and Rotmans 2010; Hyysalo et al. 2019):

- Initial joint problem definition
- Deliberated creation of long-term visions and goals
- Selection of sub-themes and their transition pathways, and
- Identification or design of transition experiments to support the realisation of the pathways.

The direction(s) created are very much dependent on the participants to the process. Hence, TM aims to include actors that are frontrunners or change agents, while empirical studies of the application of TAs also reports cases of 'incumbent capture'. In such cases, for instance, the process has been halted by powerful incumbent players when they have not been happy about the direction (Voß et al. 2009; Kern and Howlett 2009). Further, the effects on directionality are influenced by the uniqueness of each TA process and the emotions and potential tensions generated between the participants to the TA (Loorbach and Rotmans 2010).

First element: system-level scope. TA benefits from a system-oriented approach due to it being grounded in the research on socio-technical transitions. Arena-exercises have been conducted to advance transitions, for example, in energy and water systems (Hyysalo et al. 2019; Lukkarinen et al. 2022). Some of the conducted transition processes have, however, been more oriented to, for instance, urban districts, instead of specific socio-technical systems. Nevertheless, some of TA exercises have been specific about changes needed regarding different system elements, such as markets, policy and research (Hyysalo et al. 2019) and documented lessons and methodologies from these exercises can be used in future applications.

Second element: transformative ambition. At the core of TAs is the creation of visions and pathways for sustainability transitions. The process does not prioritise between values necessarily, but TA has placed a high value on social and environmental sustainability. The focus is specifically on rather early phases of transitions, where visions for the future are created, potential pathways identified, and experimentation promoted.

Third element: pathways. Many TA processes identify several pathways to the overall broader vision but then also aim to build specific pathways that lead to the desired outcomes. It is, thus, pathway neutral in the beginning but likely to come more specific during the process.

Fourth element: Agency. While the TA recognises the value of involving different types of stakeholders and change agents to the process, it is not very inclusive. The process may be constrained by incumbent capture

as noted above, or it may be oriented to selecting change-leaders (as opposed to the broader society). Therefore, explicit attention needs to be paid to how to add inclusivity to transition arena processes.

Fifth element: Multi-scalar scope. Often transition arenas have been focused on one scale, either local, regional, or national. The empirical examples show TA applied principally on city and regional levels, hence, making it by design applicable to regional innovation policy (Hölscher et al. 2019; Frantzeskaki 2022). An interesting question for PRI would be how to create TA processes that consider the multi-scalarity of systems from local conditions to impacts from broader European development and global resource flows.

Sixth element: Reflexive learning. The TA process has a lot of potential for deep and policy learning, but the outcome depends on how the process is effectively conducted. TAs are a part of transition management processes that describe learning-by-doing, learning from experimentation and learning between actors as central (Kemp, Loorbach, and Rotmans 2007; Voß, Smith, and Grin 2009). In a Finnish TA process, the participants did not learn so much about the energy system but more about broader transition dynamics (Hyysalo et al. 2019), while a case of Melbourne's water transition arena described policy learning (Ferguson et al. 2013).

Seventh element: Embeddedness to the broader policy mix. TAs are typically not tied to public governance processes, so they have had little resource allocation or regulation associated with them. However, the broader policy mix creates the enabling or hindering conditions for transitions and hence are analysed in the process of conducting TAs. For applicability to the PRI, TAs could be designed to be politically neutral but supported by resources from the public governance, for instance, by appointing an independent coordinator to the process.

4.2 Entrepreneurial Discovery Process within Smart Specialisation

Smart Specialisation (S3) is a place-based research and innovation strategic approach with an ambition to contribute to regional economic transformation. S3 should foster "discovery of new domains of opportunity and the local concentration and agglomeration of resources and competences" leading to new regional specialisations (Foray, 2015). S3 was conceptualised in the 2000s as new generation of regional development strategies. Since 2014, more than 180 Smart Specialisation strategies have been developed in Europe and beyond.

The Entrepreneurial Discovery Process (EDP) is one of the core methodological elements at the heart of the S3 approach. EDP is a bottom-up, interactive and inclusive process in which stakeholders collectively deliberate new and potential innovation activities and areas expected to foster economic transformation. Together with available evidence on regional economic and innovation potential, the EDP underpins identification and selection of S3 priority areas. The process should be inclusive engaging stakeholders from business, research and the public sector. It is a continuous process of learning and adaptation that contributes to the economic transformation process by helping territories onto most promising development paths. The inspiration of the concept comes from the new industrial policy literature rooted in evolutionary economics (Hausmann and Rodrik, 2003; Rodrik, 2004; 2008).

First element: system-level scope. S3 has an ambition to foster structural economic change by promoting economic diversification and technological upgrading in innovation areas expected to grow and strengthen region's competitive position and economic performance. The consideration of the wider systemic change on the level of socio-technical or social-ecological systems is not an explicit part of the S3 approach. Similarly, the EDP has a focus on identifying existing and emerging technology areas or sectors with the growth potential rather than with the potential to foster sustainability transitions.

Second element: transformative ambition. While the ambition to foster structural transformation lies at the core of Smart Specialisation, many scholars have pointed out its limited transformative potential (Marques and Morgan, 2018; Hassink and Gong, 2019; Benner, 2020). EDP itself has been criticised for not providing sufficient theoretical and conceptual basis to address structural transformation (Hassink and Gong, 2019). In addition to lacking clarity on the process of structural transformation, S3, and the EDP as its core element, does not embed any clear guiding principles on how S3 should contribute to wider systemic change. Even if the S3 guide lists "sustainable growth" as one of key priorities guiding the development of S3, the approach offers neither a steer to prioritise sustainability goals nor a conceptual guidance on how to ensure that sustainability objectives are not overridden by the dominant goals of economic growth and competitiveness.

Third element: pathways. Foray et al. (2012) propose pathways of structural economic change. The pathways reveal directionality embedded in the S3 concept; they all point into the direction expected to improve economic competitiveness and growth. The pathways are focused on economic development, and do not

venture into exploring dependences between economic, social and environmental transformations. The approach does not offer clarity on how alternative pathways may emerge in different places and what are roles of actors in shaping the direction of change. Hassink and Gong (2019) criticise the conceptualisation of change in S3 as not fit for overcoming developmental lock-ins and lock-outs and overly dependent on the incremental structural change based on existing structures. They argue that the pathways embedded in S3 do not give due attention to the evidence on the importance of unrelated variety and unrelated knowledge in driving change in peripheral and core regions. They also argue that the current implementation of the EDP is prone to be captured by actors with interests vested in the existing economic structures and technologies. The design of the EDP does not equip it with guidance on how to use the process to focus on sustainability challenges and collectively deliberate alternative transition pathways.

Fourth element: Agency. EDP is by design a participatory and inclusive process encouraging broad and continuous stakeholder participation in the S3 design. The S3 guidelines endorse broad participation in the process, including firms and entrepreneurs, research and academia, public sector as well as innovation users or groups representing consumers and NGOs (Foray et al., 2012). Such an inclusive approach was expected to prevent capture by specific interest groups or major regional stakeholders which proved highly challenging in practice (Hassink and Gong, 2019). The initial design encouraged engaging 'boundary spanners' to foster collaboration and manage potential conflicts (Foray et al., 2012). This approach is to become the foundation for 'collaborative leadership' and shared ownership of the S3 process. Although inclusive by design, the EDP focused mainly on bringing together business and business representatives, research and public sector. EDP is crucial for developing shared understanding on the role of research and innovation in economic development and putting forward concrete ideas for the consideration of policy makers. The EDP rarely focused on developing shared vision; S3 strategies would either "inherit" from other strategic policy documents or develop using other consultation mechanisms. Arguably, the current design of EDP does not endow it with tools to manage implications of embedding strong directionality in S3. The challenge-led EDP will be more open to political debates, potentially diverging stakeholder view, interests and normative choices between different innovation projects, transition pathways and sustainability dimensions (Skjølsvold and Coenen 2021).

Fifth element: Multi-scalar scope. EDP as a process focused mainly on the regional and, in some instances, national level, reflecting the level at which the S3 strategy is formulated. The EDP as a process has not had any formal role in ensuring horizontal and vertical coherence. However, it may contribute to improving coherence of instruments thanks to the engagement of policy makers representing different ministries and public bodies. The emphasis on the vertical coherence has been particularly strong in countries implementing S3 on national and regional level (e.g. Poland). The rationale behind improving coherence was mainly to improve regional or national competitiveness by aligning specialisation areas to benefit from economies of scale and avoid duplication of investments between regions. Policy coherence driven by sustainability concerns requires fostering localised approaches that may be strikingly different in different territories. For example, to improve resilience to climate change countries need to develop localised approaches recognising territorial differences in exposure, vulnerabilities and capacities to mobilise research and innovation to address the challenge.

Sixth element: Reflexive learning. EDP provides a space for continuous reflection and learning with many heated debates about future challenges. Due to the conceptual boundaries of Smart Specialisation focused mainly on innovation and economic development, EDP as well as S3 monitoring and evaluation processes do not focus on system-level change.

Seventh element: Embeddedness to the broader policy mix. Typical outputs from the EDP are proposals of the most promising innovation areas or flagship projects to be funded from the EU Operational Programmes or, less often, other R&I programmes. The predominant focus is on supply-side instruments. The EDP discussions rarely explicitly discuss changes in the wider policy mix, especially that the regional level, where most EDPs take place, do not have competences to adjust, for example, fiscal or regulatory frameworks.

With its participatory and inclusive approach, EDP has a significant potential to become a tool well suited to contribute to transformative change. Many European countries and regions are already using EDP to address sustainability challenges (Miedzinski et al, 2022). However, just as S3 was not designed to foster system-level change towards sustainability, neither is EDP fully equipped to become a transformative tool on its own. Miedzinski et al. (2021, 2022) put forward some suggestions on how to adapt EDP to align it with sustainability transitions. More generally, S3 needs to extend its boundaries from structural transformation to wider societal transformations. EDP could then incorporate an explicit challenge-led or mission-oriented approach to give a direction to bottom-up deliberations, partnerships and experimentations. The discovery process can become a co-creation space situating bottom-up approaches with top-down strategic

frameworks, such as the European Green Deal and the SDGs. The EDP needs to extend its outreach to include new actors who may bring in alternative perspectives on transitions or are likely to impacted by them. EDP will be then better equipped to translate sustainability challenges into concrete local (or wider trans-local) actions while considering the voices of those directly affected or at risk of being impacted by systemic shifts (Miedzinski et al., 2021). Lastly, embedding directionality in the EDP comes with its own challenges. Policy makers and public authorities will need to develop new capacities to anticipate and manage these new tasks.

4.3 The EU's Missions

Solving complex, systemic, interconnected, and urgent problems (such as climate change, health or poverty) requires grand challenge thinking that sparks innovation across multiple sectors and actors. Missions or mission-oriented policies/innovation, stemming from military R&D programmes, are half-century old policy tools, lately gaining a new framing and much of attention. A mission has been, for instance, defined as "an urgent strategic goal that requires transformative systems change directed towards overcoming a wicked societal problem" (Hekkert et al. 2020). In academic scholarship, focus on mission-oriented innovation policy (MOIP) has expanded (Janssen et al. 2021; Robinson and Mazzucato 2019; Wanzenböck et al. 2020) and to some degree also shaped EU and OECD policy discussions. The OECD has defined mission-oriented innovation policy as "a co-ordinated package of policy and regulatory measures specifically tailored to mobilise innovation to address well-defined societal objectives in a defined timeframe" (OECD, 2023). A recent macro level application of mission-oriented policy is EU missions, a new element of Horizon Europe programme for 2021-2027, that will support "Europe's transformation into a greener, healthier, more inclusive and resilient continent". The five missions are aiming to be inspirational and relevant to society, measurable, time-bound with realistic goals and impact-driven. EU missions will mobilise resources at EU, national and local levels linking activities across different disciplined and different types of research and innovation (European Commission, 2022a).

First element: system-level scope. Mission-oriented innovation intends to provide a policy framework for tackling the grand challenges for society at a system level (OECD, 2021). It has been argued that missions should be broad enough to engage the public and attract cross-sectoral investment and remain focused enough to involve industry and achieve measurable success (Mazzucato, 2018). The aim behind mission-oriented innovation policy is to address system failures (Robinson and Mazzucato 2019). For instance, the Swedish innovation agency, Vinnova, notes that missions address entire systems that include cultural and technical elements following the logic of systems thinking and the practice of design (Vinnova, 2022). However, some practical regional examples of applications of missions show that the system-level scope cannot be taken for granted. The mission-oriented approach of the Scottish Innovation Bank has been argued as 'fuzzy' policymaking failing to align with the Scottish innovation system (Brown 2021). In another case of Western Norway ferry electrification, the mission was largely successful because of low complexity and low uncertainty regarding the technological options, hence, higher systemic orientation was not required (Bugge, Andersen, and Steen 2022). In turn, EU missions had to be developed in a comparatively short period with turning a vague and abstract idea into an operational concept, ready for implementation. However, the mission approach is still malleable with major uncertainties. Most missions require complementary actions by demand-side sectoral policies, member states and stakeholders (Janssen et al., 2023).

Second element: transformative ambition. Only such missions that aim at behavioural and structural change contribute to comprehensive system transformations (Linder et al., 2021). In the EU practice, missions are applied by seeking transformation at all levels with combining resources and aligning broad scope of potential contributors. However, it is not yet clear how such a mission approach will mobilise directionality below the macro level and whether transformativeness towards the SDGs will be prioritised. Interim evaluation revealed that the prominence of societal challenges in the Horizon2020 programme has proven insufficient to re-orient significant parts of research and innovation activities towards clear and ambitious societal goals (Wanzenböck et al., 2020). Generally, the few studies published so far on concrete applications of the mission approach have not been specific about the different phases of transformation.

Third element: pathways. The general argument is that the missions approach is broad and does not impose specific technology pathways but rather the pathways emerge as outcomes (Hekkert et al. 2020). In practice, there is not yet much recent evidence for the effectiveness of the missions approach, especially due to relatively recent revival of mission oriented policies and the time it takes such policy cycle to be implemented. However, a recent evaluation of mission-driven innovation shows that self-forming different pathways, additional or alternative approaches are possible within the "formal" boundaries of a mission (Essen et al., 2022). Further, it would be that policies embedded in the missions-approach provide 'subtle' selection of predetermined pathways (Kirchherr, Hartley, and Tukker 2023) Appearance of alternative approaches in form

of competition for resources could be fatal for the success of the mission. The lack of pathways may also complicate the design of a more specific policy mix (Roth et al. 2022).

Fourth element: Agency. While missions are formulated based on a diverse inclusion of stakeholders and shared vision formation, the implementation is based on carefully planned and centrally controlled actions without additional layer of agency. The presence of core agent of change is rather choice of mission delivery design than the typical feature. A case of mission in Western Norway ferry electrification emphasises as success factors the institutional and strategic agency by policy actors in multiple levels (regional, national), distributed agency coupled with a sequence of and feedbacks between decision-making and actor collaboration on different spatial scales – resulting in limited contestation (Bugge, Andersen, and Steen 2022). Another case, however, of Vision Zero for traffic safety, shows perhaps a more traditional approach with a strong coordinated role for a public organisation while supported widely by other actors (Craens et al., 2022). While missions are linked to an increased number of public participants, the study by Wiarda et al. (2022) on public participation in mission-oriented innovation projects did not find that this is accompanied with an increased diversity of public participants.

Fifth element: Multi-scalar scope. As discussed in previous elements, missions are multi-scalar, with aim of linking above national, national, regional and local levels. A case in point is the above referred to ferry electrification mission in Western Norway (Bugge, Andersen, and Steen 2022). While missions are seeking transformation at all levels, the focus of the mission implementation and actors can be from national to local. Recent example is the EU Cities Mission, involving citizens, businesses, investors and regional or national authorities for a demand-led approach to meet the actual needs of the cities. Effectively, Horizon Europe missions cannot be achieved by means of European policy alone but require structures, policies and R&I actions at lower policy levels; therefore, the success of the missions will largely depend on these still unfolding local and national actions (Janssen et al., 2023). A recent example from Sweden of biogas introduction to number of regions showed that the success of the mission depended on local preconditions. Existing direction of the national mission in this case was insufficient to justify local actions. Local missions became more multifaceted and dynamic than the national mission and worked best where global problems were re-framed as local opportunities (Brett et al. 2023).

Sixth element: Deep learning. Missions, with bottom-up experimentation and learning, should encourage institutional and organisational capacity building, which can be supported with available (policy) instruments. MOIP is based on the idea of reflection and experimental learning (Linder et al., 2021) in a continuous manner which evaluates how contestation, complexity and uncertainty are present resulting in redefinition of targets (Wanzenböck et al. 2020). In practice, such reflection should be performed not only by understanding the mission design and undesirable developments, but also how policy instruments ensure appropriateness of actions. Through trial, error, international exchanges and policy learning, MOIP initiatives gradually change their position, unfold and move forward through experimentation, negotiation and learning in an evolutionary way, building on existing policy settings and instruments (Larrue, 2021). Also, scientific debates about the concept and feasibility of EU missions were important as the foundation of debates internal to the European Commission, with member states and stakeholders (Janssen et al., 2023). The risk with lack of proper understanding might come with simply up-scaling the ideas and experiences of champions or bringing local cases that promotes a "naïve uniformity that strips bottom-up perspectives of (mission) uniqueness and enables more of the same top-down thinking". Aim to understand missions should identify lessons and applications beyond incidental successes in narrow policy domains (Kirchher et al., 2023).

Seventh element: Embeddedness to the broader policy mix. Policy instruments consists of measures, stimulating change of behaviour and institutions, together with more supply-side oriented STI policy measures and other instruments, such as stimulation of demand and supporting regulatory framework (Linder et al., 2021). For instance, the lack of specifically defined pathways in missions may complicate policy design and its alignment with the broader policy mix, as noted above (Roth et al., 2022). For example, the new mission orientation approach in preparing German High-tech Strategy 2025 was broader from previous generations in the width of goals, the variety of involved stakeholders, the spectrum of disciplines and sectors involved, as well as the broader policy mix. Examining the previous missions, one of the questions was the inclusion of other types of instruments such as regulation and discursive means as part of a coherent policy mix. Notably, such course of action, carrying substantial potential for achieving the desired transformative and behavioural change, has not been part of the High-tech strategy approach previously (Roth et al. 2021).

4.4 The EU's just transition initiatives

The concept of a "just transition" has emerged in international policy discussions around the transition of energy systems, in the UN (Lee, 2022), the ILO (2022) and the European Commission (EC, 2022b). Its growing prevalence reflects a recognition that the sustainability transition will likely have major distributional impacts, which if not anticipated and acted upon, may reproduce or even amplify existing inequalities. The concept is defined and understood differently in various parts of literature. According to Wang and Lo (2021), just transition is seen variously as: (1) a labour-focused concept (2) an integrated framework for justice, linked to many forms of existing or potential injustice (environmental justice, energy justice, climate justice) (3) an element of broader theories of socio-technical transition, (4) a governance process and strategy, and (5) a public perception.

The European Commission created the Just Transition Mechanism (JTM) to aid regions and sectors most negatively affected by sustainability transitions due to their high dependencies on fossil fuels or carbon-intensive processes, by means of re-skilling programmes, re-employment in new sectors and advancing energy efficient housing (Filipović et al. 2022). One of its pillars is the Just Transition Fund (JTF) that aims for economic diversification and reconversion of territories by reskilling, SME investments, research and innovation, environmental rehabilitation, clean energy, job-search assistance, and transforming carbon-intensive installations[3]. Member states need to create Territorial Just Transition Plans (TJTPs) to apply for funding from the JTF. No overall evaluation of the JTF or the TJTPs was available at the time of writing, so the illustration that follows relies on programmatic announcements by the European Commission, policy reports (Cameron et al., 2020; Rösch. and Epifanio, 2022; Akgüç et al., 2022; Stapper, 2023) and a limited number of published articles that take stock of experience so far (e.g. Moodie et al., 2021; Filipović et al., 2022; Moesker and Pesch, 2022; Sarkki et al., 2022).

First element: System-level scope: The process of drafting of just transition plans seems to have varied across territories, but there was no method for mapping out the scope of the affected socio-technical system. Rather the scope of intervention was technically established as part of the JTM, and seems to have covered the energy and transport sectors (including support for consumption such as district heating), loans to public authorities and support for associated infrastructure (including public transport). The JTF has been focused especially on carbon-intensive industries and their phase-out (coal regions) or switching to different modes of production (steel regions). [4]The consideration of system elements has been limited to technology and practices (education, skills) mostly while affected by market and policy changes. Moreover, Moodie at al. (2021) also noted that TJTPs were driven by technical considerations instead of spatial or socio-economic issues. Limited funding, especially when compared against the challenge posed by the sustainability transition (Cameron et al., 2020), has led to pragmatic decisions about what can be funded, which in practice narrowed the scope (Moesker and Pesch, 2022). Akgüç et al. (2022), writing from the perspective of the needs of workers, argue that on account of its limited resources and focus on select regions, the JTF reaches only a small fraction of the people affected by decarbonisation.

Second element: Transformative ambition: The context of just transition initiatives (JTM, JTF, TJTPs) is transformative, being based on the EU Green Deal. However, the initiatives themselves are aimed supporting transformation by creating legitimacy to the broader policy mix by compensating the negative effects of transitions. For instance, the JTTPs do have some transformative ambition, especially around the energy and transport sectors. However, as their scope is smaller than the affected socio-technical system, and the plans revolve around a single fund (rather than seeking to align efforts across budgets and funds), they do not seek to harness all opportunities for transformation. The JTF, in turn, can contribute by funding alternative industries to coal mining and production and the shifts of, for example, carbon-intensive steel production to alternative modes.[5] The JTF cases examined by Moesker and Pesch (2022: 6) also had a low level of ambition. According to Stapper (2023: p.21), the JTTPs focus on job preservation and transforming existing industries may reproduce existing economic structures and offers limited possibilities for sectoral diversification. Stapper (2023) argues that a transformative ambition might have been better served by a stronger focus on improving social conditions, and the resulting business opportunities that could emerge from such a change in focus.

Third element: Pathway neutral or pathway reinforcing: In principle, they do not favour any one renewable energy source or sustainable transport technology, so they can be neutral at least with regard to technology

[3]Accessed 27.3.2023: https://commission.europa.eu/funding-tenders/find-funding/eu-funding-programmes/just-transition-fund_en

[4] Personal communication 08.03.2023

[5] Personal communication 08.03.2023

pathways. However, alleged lack of citizen engagement in the drafting of the JTTPs (Moodie et al., 2021), may have limited opportunities for behavioural changes in consumption, suggesting a pathway reinforcing tendency. The concrete projects funded by the JTF are still oriented to particular industries, such as the JTF-supported magnet factory in Narva, Estonia. Moesker and Pesch (2022) also find evidence of existing path reinforcement, including cases which make doubtful contributions to sustainability (such as replacing district heating with fossil-based gas).

Fourth element: Distributed and inclusive (as opposed to concentrated agency): National and regional governments are involved in drafting the just transition plans. No formal mechanisms for engaging with citizens in the affected areas exist and there are some indications that drafting could have been more participatory, and that governance coordination challenges may hamper their implementation (Moodie et al., 2021). The focus tends to be on regional justice and other aspects of inclusivity, such as more vulnerable groups, indigenous communities or the youth are not specifically considered. An examination of cases from Germany and Czechia found that distributional justice can be expected to be harmed by insufficient and, in the Czech case, volatile funding and by often arbitrary eligibility criteria (Moesker and Pesch, 2022)

Fifth element: Multi-scalar scope: The JTF is coordinated on the EU level, cohesion policy funding directed at the national/regional level, and considered the disadvantaged regions, hence, it is multi-scalar in scope. The distinction between the overall pan-European frame of the JTF and the specific JTTPs was meant to allow for context specificity and the incorporation of multi-level governance aspects and may have allowed for flexibility (Sarkki et al., 2022: p. 777). The JTTPs in Sweden took into consideration both national and regional initiatives (Moodie et al., 2021) and in this respect can be considered multi-scalar, though it is unclear if their governance mechanisms enable continuing coordination during implementation.

Sixth element: Reflexive learning: As JTTPs were seen as one-off initiatives, there are no provisions for iterative learning and policy improvement.

Seventh element: Embeddedness in the broader policy mix: The broader framework is connected to the EU Green Deal, so is a planned part of the EU transformative policy mix. However, cohesion policy has limited potential to influence EU member state decision making and tends to be resource-driven besides enabling conditions that are binding. The provisions for embedding JTTPs in ERDF planning (Cameron et al., 2020) provide an opportunity to embed them in the policy mix, but existing studies do not shed light on the extent to which sufficient links with other funds and planning frameworks were established. What is clear from the available studies however is that the JTTPs are entirely resource-driven, with no provisions for regulatory reform or experimentation. Moodie et al. (2021), in fact, identify a need for regulatory simplification in the Swedish case, which, alongside other governance dimensions, including provisions for coordination structures was not taken into account in the corresponding JTTPs.

4.5 Policy integration/coherence

The importance of policy integration and coherence have been rather little discussed in connection to sustainability transitions. Policy integration and coherence refer to the type of interactions that occur between policy domains and levels, and the degree to which policy making is streamlined (Cejudo and Michel 2017; Tosun and Lang 2017). They also imply that governments can systematically and intentionally pursue policy coherence and integration (Jones 2002). Policy coherence aims to reduce conflicts and promote synergies within and between policy areas (Nilsson et al. 2012), whereas policy integration is focused on integrating specific policy goals, such as decarbonisation, to other policy sectors. More concretely policy coherence and integration can be pursued by administrative coordination; strategies, objectives, and shared visions; targeted committees and working groups; or even new agencies set up to do this (May et al. 2006; Tosun and Lang 2017; Runhaar et al. 2018; Mickwitz et al. 2009).

Some previous studies have looked at policy mixes for sustainability transitions from the perspective of horizontal coherence between policy domains and how this effects the transition process (e.g., Huttunen et al. 2014; Kivimaa and Sivonen 2021). The OECD (2020) have noted a regionalisation trend of innovation policy which should be matched with attempts to strengthen coherence between regional and national policy levels, as much of innovation policy is still led from the national-level. For instance, some innovation-affected policy areas are handled locally (e.g., incentives to collaborate or training) and other areas nationally (e.g. IPR, education policies) (OECD, 2020). Interestingly, transitions expand the relevant areas for innovation to environmental, climate and social policies, for instance, making the policy coordination even more of a complex task.

First element: The system level scope is generally missing from policy integration and coherence approaches, while they do focus on systems implicitly by analysing policy interactions across domains and levels of governance (Huttunen et al. 2014).

Second element: Transformative ambition: Policy coherence is not focused on transformation and may be counter-intuitive by placing attention of alignment which may benefit status quote. However, policy integration can be used to benefit transformation by emphasising the principled priority of environmental protection (Lafferty and Hovden 2003) or sustainability transitions.

Third element: pathway neutral or selective. Policy coherence and integration are not typically oriented to identifying or pursuing sustainability pathways. However, this kind examination could be used to identify omissions in the policy mix or counter-forces or barriers to particular pathways. For instance, Kivimaa and Sivonen (2021) observed in an analysis of coherence between energy transition and security policies, that security policies did not pay attention to the security implications of new energy pathways.

Fourth element: Distribute and inclusive. Policy coherence and integration literature has not paid attention to the agency, i.e. who should improve the state of policy and the inclusivity of processes.

Fifth element: Multi-scalar. The vertical aspect of policy integration and coherence puts specific attention to how different levels of governance are coordinated with each other (Howlett et al. 2017; Mickwitz et al. 2009). Therefore, the vertical coherence and integration aspect could be used to complement the other policy initiatives by looking at the alignment between levels of governance for transition initiatives.

Sixth element: Reflexive learning. Learning is one of the core assumptions of (environmental) policy integration processes (Nilsson and Persson 2003), where it is not merely instrumental or mechanistic but requires learning on behalf of, for example, civil servants to consider what the integration of environment means for STI policy processes and instruments.

Seventh element: Policy mix support. The (environmental) policy integration literature emphasises that sufficient human and financial resources are a precondition for integration to occur (Kivimaa and Mickwitz 2006). Moreover, at the core of policy coherence analyses is looking at the alignment of the whole policy mix.

In that sense, policy integration and coherence can be seen more as a complementary policy tool for advancing transitions instead of a specific one targeting transitions.

5 Discussion and conclusions

5.1 Summary of policy approach illustrations and applicability to PRI

Table 2 summarises how the directionality-elements we proposed are visible in the conceptualisations and practical experiences so far of the selected policy approaches: transition arenas, missions, just transition initiatives, the EDP and policy coherence. In sum, transition-oriented policies are by nature systemic and transformative in ambition, but their implementation affects how systematic or transformative they are in practice. Therefore, the EU's PRI and its implementation in the regions of EU member states should explicitly consider how they will advance directionality – considering the different system elements, transformative ambition, selection of transition pathways, distributed and inclusive agency, multi-scalarity, reflective learning, and alignment with the broader policy mix. The policy approaches illustrated here can be useful for regional transition-oriented STI policies, but they need context-specific and place-based development in terms of how they approach different innovation pathways that contribute to the transition, i.e., to what degree and at what point in the process should selections regarding resource allocation be made without closing certain pathways out too early.

The more generic policy approaches need to be further developed to be more beneficial for directionality, by adopting a systemic approach going beyond technology (in the case of the EDP) or policy (in the case of policy coherence). They need explicit focus and high ambition regarding how to integrate environmental and social sustainability goals. The latest IPCC reports show that less than ambitious policies will not be enough to mitigate and adapt sufficiently to climate change.

All the policy approaches we analysed need to be developed to be more inclusive of different kinds of stakeholders beyond the typical (triple helix) and established players, and especially bring in more civil society actors and marginal views. This is especially important given the broadening perspectives of what just transitions, and climate policy justice, mean in practice (in essence, comprising not only distributive but also recognitive, restorative, procedural, intergenerational and global justice).

Table 2: Summary of selected policy approaches regarding the seven elements of directionality.

Element of directionality	**Transition arenas**	**Missions**	**JT initiatives**	**Policy integration / coherence**	**EDP**
System-level scope	Yes (usually)	Yes (but not always)	Partial, needs expanding beyond energy, transport and digitalisation	Implicit, needs more attention.	Partial, needs expanding beyond structural economic change.
Transformative ambition	Yes	Yes (but not necessarily gaining priority over other goals)	Partial, limited by sectoral scope and single-fund perspective	Not usually but could be added to policy integration.	No, does not go beyond economic growth. Needs more attention.
Pathway neutral or selective	Neutral at first, then selective	Broad missions with pathways as outcomes (except for narrow technologically-oriented missions that implement a pathway)	Neutral but aspects may be selective and have occasionally supported activities with limited contribution to sustainability.	Not explicit, needs more attention	Conceptual focus on economic transformation pathways. No consideration for sustainability transition.
Distributive and inclusive	Needs more attention	Aim to target whole society, but processes somewhat exclusive. Variation in empirical	Inclusive of public authorities and sectoral interests, no formal mechanism to engage citizens	No, needs more attention.	Inclusive but in practice often limited to triple helix, needs more attention.

		examples of missions between distributive and concentrated.			
Multi-scalar	Needs more attention	Yes	Yes	Yes.	Mostly regional with several country-level exercises including national and regional level.
Deep and policy learning based	Yes	Yes	No	Yes.	Partial, but not oriented to transitions.
Policy mix support	Needs more attention	Yes	Partial, focused on investment support and incentives	Yes	Partial, focused mainly on supply side instruments

5.2 Concluding discussion

Direction is a key element of sustainability transitions and transformation; one needs to know what the different pursuits are aimed at. Yet, it is not the only relevant aspect. For instance, who is included in or excluded from transition processes and its justice (Kaljonen et al. 2021; Martiskainen et al. 2021) as well as broader connections to climate change adaptation (Jerneck and Olsson 2008; Carter et al. 2021) alongside the speed and disruptiveness of change are important (Kivimaa et al. 2021; Lindberg et al. 2019). Moreover, directionality for sustainability transition pursuits is created in an increasingly turbulent world, which is simultaneously tacking the repercussions of the Covid-19 pandemic, the Russian war in Ukraine and increasing inflation (Kivimaa and Schwaag-Serger 2023). This means that the directionality for sustainability transitions is competing with the new EU goals related to technology sovereignty and strategic autonomy.

The interconnectedness of directionality with other transition and non-transition activities will create increasingly complex and potentially incoherent policy mixes (Kern et al. 2017). Therefore, the EU PRI efforts need to consider that some kind of minimum criteria for implementing directionality is set, perhaps using the dimensions above (see Tables 1 and 2). This can go beyond individual policy instruments or approaches and be assessed regarding the overall policy mix. The policy mix level is better in a sense that omissions in a given policy instrument or tool (as illustrated in Table 2) can be complemented with other policies in the mix. For instance, a lack of transformative ambition in a territorial just transition plan could perhaps be derived from overall national or EU regulation. However, it would still make the plan less efficient from the perspective of transitions than if such an element of directionality would be embedded in it. In essence, many of the elements of directionality – we induced from transition and innovation studies – appear essential for advancing sustainability transitions.

In addition, the broader policy mix may also water-down and dilute the directionality provided by novel policy approaches, if not aligned with it. Therefore, singular policy instruments or approaches advancing directionality are not enough for the nature of transformation required. Instead, genuinely transformative policy mixes integrate a transition-oriented approach across different policy domains and policy levels. This means that it may be difficult to pursue sustainability transitions in given cities or regions, if the national policy mix is not equally transition-oriented, resulting in vertical incoherence in the policy mix. Similarly, innovation policy is more influential for transitions when attempts on directionality in innovation policy are coupled with sectoral policies transformation-efforts (e.g. Kivimaa and Rogge 2022).

So, what does directionality mean for regions and cities with different capacities and capabilities? The prevailing conditions and future opportunities can differ greatly between leading and laggard regions, the latter with little innovation activity and difficulty to attract private sector R&D activities. Some regions may struggle with basic policy issues and setting up more transformative policy experiments may be difficult. This links to cohesion policy and structural funds that can support innovation in more poorly performing regions, and thus also create conditions for more transformative policy experiments (Kivimaa, 2023). Therefore, coherence between PRI and cohesion policy is also important.

While regional conditions differ, PRI could help by identifying certain socio-technical pathways which can support sustainability transitions. It could also indicate ways to align different values, but also emphasise the importance of environmental and social sustainability over short-term economic gains. The outcome of decisions regarding what pathways and values are pursued in regions should be based on inclusive and transformative vision building processes that account for appraisal diversity.

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