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## Transformative governance of innovation ecosystems

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### ABSTRACT

Transformative innovation policy has recently emerged at the intersection of innovation and socio-technical transition research. It has provided valuable heuristics to guide policy; but it has also led to the recognition of major challenges in the management of uncertainty and complexity. In this paper, we address these challenges by linking transformative innovation policy with research perspectives from (i) complex adaptive systems, (ii) ecosystems, and (iii) adaptive and participatory governance. Specifically, we develop a conceptual framework for transformative governance, which seeks to improve the adaptiveness and resilience of the ecosystem and orchestrates socio-technical transformation based on the balanced presence of diversity, connectivity, polycentricity, redundancy and directionality. We also present an illustrative example by applying the framework to a Finnish policy reform in which the lack of balanced attention to the ecosystem features catalysed major shortcomings in an emerging innovation mobility ecosystem. Finally, we explore the implications for the design of individual policies and policy mixes which arise from the recognition of complexity and the holistic policy impacts on the ecosystem and society at large.

### 1. Introduction

During the last decade, the emphasis of innovation studies has shifted from market and system failures towards transformative innovation policy (Diercks et al., 2019). These emerging research and policy efforts address the transitions of highly complex societal systems (Schot and Steinmueller, 2018; Weber and Rohracher, 2012). In such conditions, pinpointing core agents and elements (Isenberg and Onyemah, 2016) or predicting winners and losers (Moreno and Coad, 2015) is difficult if not impossible. Therefore, governance can be better off rather by observing and acting upon general features and dynamics in the complex system.

To further address complexity inherent in research on transformative innovation policy (Diercks et al., 2019), we connect this emerging field with research on (i) complex adaptive systems (see, e.g. Phillips and Ritala, 2019) (ii) *ecosystems*<sup>1</sup> and (iii) adaptive and participatory governance.<sup>2</sup> Specifically, we build a framework for transformative governance which enhances the adaptiveness and resilience of the complex ecosystem as well as orchestrates deliberate socio-technical transformation in society. Because such transformations are enabled by aligning the agendas of multiple ecosystem agents, the framework can be used both in policy and management of ecosystems.

To demonstrate the instrumental value of this conceptual

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<sup>1</sup> Introduced by Moore (1993) and developed further, e.g., by Adner and Kapoor (2010), Teece (2016) and Jacobides et al. (2018), the term ecosystem makes an analogy between biology and management. In ecology (e.g. Odum 1969), the biological ecosystem ‘community’ is considered to emerge with relatively few pioneering plants and animals, and to expand through increasing complexity until it becomes stable or self-perpetuating as a mature community. The ‘engine’ of succession, i.e. the cause of the ecosystem change, is the impact of established species upon their own environments. This implies that the ecosystem agents (e.g. companies) are organizing as complex nature-like systems (Shaw and Allen, 2018). While we build on the work on different types of complex systems and ecosystems. In this paper, in line with Pombo-Juárez et al. (2017), we use the terms interchangeably respecting the original use of the terms.

<sup>2</sup> In line with McGinnis (2011, p. 58), we refer to ‘governance’ as the ‘process by which the repertoire of rules, norms, and strategies that guide behaviour within a given realm of interactions are formed, applied, interpreted, and reformed’. The generic mechanisms of governance include the processes of interaction and decision-making among the agents involved in a collective problem. Such processes lead to creation, reinforcement, or reproduction of social rules and norms (institutions) (Hufty, 2011). Furthermore, governance as a human function is guided more or less explicitly by purpose and direction.

framework, we present an illustrative example which shows how the lack of balanced attention to ecosystem features in a Finnish policy reform led to major shortcomings in an emerging innovation mobility ecosystem. Finally, we derive implications for designing individual transformative innovation policy measures or even policy mixes with scrutiny on holistic impacts on the ecosystem and society at large.

The paper is structured as follows. In Section 2, we position our work in the broader discussion on the governance of complexity and present our main contribution by developing the conceptual framework for transformative governance. In Section 3, we demonstrate the relevance of this framework with an illustrative example. In Section 4 and 5, we discuss the implications of findings and finally conclude our contribution.

## 2. Framework for transformative governance

The emerging research stream on transformative innovation policy (Diercks et al., 2019), supported by cross-fertilization amongst researchers of innovation systems<sup>3</sup> and socio-technical transitions,<sup>4</sup> has helped identify core elements and their interconnections within innovation systems and provided heuristic policy guidance. All agents influence the evolution of the system, albeit to different degrees and in different temporal sequences. How this evolution occurs is a subject of research on socio-technical transitions (e.g. Geels, 2019) which is increasingly aligned with other innovation policy research (Diercks et al., 2019). The evolution of ecosystems can be understood in the light of research on technological change, most notably the S-curve of technological change (Adner and Kapoor, 2016), the emergence of dominant designs (Arthur, 1989; Kaplan and Tripsas, 2008), and the evolution and influence of the activities over analogous, successive stages of emergence, expansion and maturity (Dosi, 1982). These stages were noted also by Moore (1993) in connection with business ecosystems and later on Autio and Levie (2017) in the context of entrepreneurial ecosystems. The stages can be summarised as followed:

- Emergence: New activities emerge in the ecosystem with different premises, for instance, when existing markets, value chains or networks are digitalised or when new markets are created (Parker et al., 2016). Then, diverse competing efforts emerge in the system, but these tend to be fragmented and of lacking connectivity. Those who can pay high costs upfront may position themselves to exploit first-mover advantages (Kerin et al., 1992) and to monetize emerging asymmetries of information (Akerlof, 1970) which shape the later direction of the ecosystem.
- Expansion: Companies which enjoy increasing returns (Gawer, 2014; Nelson and Winter, 1977) are set to grow fast due to economies of scale (Hughes 1983) and scope (Panzar and Willig, 1981); learning by doing (Dosi et al., 2017; von Hippel and Tyre, 1995) and using (Arthur, 1989); direct and indirect network effects (Clements, 2004); and/or increasing expectations (Smith et al., 2005). While some agents can better connect with such networks, others remain excluded, reducing overall connectivity (Kim et al., 2017).
- Maturity: In the mature stage, incumbents are subject to lock-in mechanisms (Autio and Levie, 2017; Klitkou et al., 2015) that may lead to the 'winner takes it all' effect (Parker and Van Alstyne 2002;

Guan et al., 2015; Garcia-Swartz and Garcia-Vicente 2015; Eisenmann et al., 2011; Meyer 2012). For instance, major online intermediation services such as app stores and e-commerce platforms tend to evolve towards optimised closed ecosystems. The reasons for this include also quality control, issues of liability and security (Campbell-Kelly et al., 2015).

Following Filho and Heerdts (2018) as well as Russell and Smorodinskaya (2018), we posit that the research on the ecosystem stages and respective innovation policies need to be aligned with and responsive to contextual *uncertainty*<sup>5</sup> and *complexity*.<sup>6</sup> Pinpointing core agents and elements (Isenberg and Onyemah, 2016) or predicting winners and losers (Moreno and Coad, 2015) is difficult if not impossible in highly complex systems. In such conditions, governance can benefit from observing and acting upon general features and dynamics in the system.

Therefore, we relate transformative innovation policy studies also to complex adaptive systems approach on ecosystems (Phillips and Ritala, 2019; Richter et al., 2014). Furthermore, adaptive and participatory governance with works on the governance of commons (Dietz et al., 2008; Ostrom, 2004), socio-ecological ecosystems (Chaffin et al., 2014) and transport systems (Marchau et al., 2010), for instance, have developed invaluable approaches to complexity. Yet, apart from some exceptions like Rijke et al. (2013), these fields have paid limited attention to the long-term *direction* and *societal impact*; topics addressed by transformative innovation policy and socio-technical transition research (Foxon et al., 2008; Geels, 2005; Schot and Kanger, 2016; Walrave et al., 2018; Walrave and Raven, 2016).

Some innovation scholars have addressed this challenge of complexity governance through the concept of innovation *ecosystem* (Formica and Mitra, 1996; Russell et al., 2011; Russell and Smorodinskaya, 2018; Wessner, 2004), comprised of inter-organizational systems that catalyse and support innovation through information and talent flows in interconnected complex networks. This concept has parallels to research on entrepreneurial ecosystems (Ács et al., 2014; Autio and Levie, 2017; Isenberg and Onyemah, 2016; Mason and Brown, 2014) which focuses on complex socioeconomic structures that support or condition entrepreneurship.

In policy and management research, the ecosystem concept has further ramifications.<sup>7</sup> Even if the definitions and use of this concept vary, they commonly refer to (i) inter-organizational collaboration involving complex interdependencies of agents, (ii) at least partly decentralized organization of agents (Brandenburger and Nalebuff, 1996), (iii) articulation of joint (focal) value propositions between the agents (Adner, 2016), and (iv) alignment of collaborative arrangements of the agents for collective benefits (Adner, 2007).

Specifically, these representative lines of thinking characterize the ecosystem as (i) a complex system (Lopolito et al., 2013) and (ii) adaptive to the broader environmental conditions (Richter et al., 2014).

<sup>3</sup> The evolutionary and systemic view on innovation systems policy (Carlsson et al., 2002; Freeman, 1987) consists of complementary ways of framing innovation through national (Lundvall, 2007), regional (Cooke, 2011), sectoral (Malerba, 2002) or technological innovation systems (Carlsson and Jacobsson, 1994).

<sup>4</sup> Since early 2000s, socio-technical transitions and multi-level perspective have been studied among many scholars (Armitage et al., 2008; Diercks et al., 2019; Geels, 2019, 2005; Schot and Kanger, 2016; Walrave et al., 2018; Walrave and Raven, 2016).

<sup>5</sup> Oxford English Dictionary (2019) provides multiple definitions for uncertainty, among others "something not definitely known or knowable", which apply in this paper. Thunnissen (2003), for instance, offers a review of a wide variety of classifications of uncertainty in different fields. See also Vasconcelos de Vasconcelos Gomes et al., (2018) on how entrepreneurs manage collective uncertainties in innovation ecosystems.

<sup>6</sup> In line with Wang and Von Tunzelmann (2000), we consider 'complexity' to mean the 'depth' as well as 'breadth' of a phenomenon. The 'depth' refers to the analytical sophistication of a subject: complexity means the cognitive difficulty of pushing the particular matter to its logical extremes. On the other hand, complexity in 'breadth' refers to the range of areas that have to be investigated to develop a particular subject.

<sup>7</sup> Ecosystem models have been applied also to organize interorganizational collaboration, for instance on ecosystem management (Scaringella and Radziwon, 2018; Tsujimoto et al., 2018) and orchestrating extended enterprises and outspreading value appropriation regimes (Moore, 1993; Iansiti and Levien, 2004; Teece, 2018) or creating platform organizations (Thomas et al., 2014).

Perhaps due to its origin (Moore, 1993), the ecosystem discourse builds strongly on evolutionary theories (Shaw and Allen, 2018; Tsujimoto et al., 2018) and the facilitation of continuous change and adaptability (Brown and Eisenhardt, 1998), topics relevant also in transition research (Foxon et al., 2008; Geels, 2005; Schot and Kanger, 2016; Walrave et al., 2018; Walrave and Raven, 2016). Rijke et al. (2013) and adaptive governance (e.g. Dietz et al., 2008; Chaffin et al., 2014).

At this juncture, we elaborate five features of ecosystem governance. First, we note that business and innovation ecosystems are effectively governed through interactions amongst *diverse* agents which are *inter-connected*. Then, we draw attention to *polycentricity* and *redundancy* that enhance the adaptiveness and resilience of the ecosystem governance. Finally, we explore the fifth feature, *directionality*, to guide the deliberate transformation of ecosystems.

### 2.1. Diversity

Transformative innovation policy emphasizes diverse social and technological niches within which new alternatives for the regime level practices can emerge (Walrave et al., 2018). *Diversity can be understood as the condition or quality of being diverse, different, or varied* (Könnölä et al., 2007). In ecosystem research (Moore 1993; Moore 1996; Iansiti & Levien 2004; Teece 2016), diversity is manifested by the differences of suppliers, producers, competitors and other agents comprising the ecosystem. This diversity leads to a broader array of ideas, skills, and competencies (Koontz et al. 2015; Østergaard et al., 2011), resulting in variety (Bohórquez and Espinosa, 2015) that enhances the adaptive capacity of the system (Low et al., 1999). Thus, the emergent properties in such systems are crucially preconditioned on sufficient diversity<sup>8</sup> (Anderson, 1999; Smith and Stacey, 1997).

Consequently, the diversity of agents needs to be complemented by institutional diversity at the local, regional, and state levels which are connected by formal and informal networks (Dietz et al., 2003). Here, the experimentation (of new policies) is crucial for increasing learning and adaptability (Breznitz and Ornston, 2013; Sabel and Zeitlin, 2010; Sable, 2008). Experiments, usually occurring in the periphery of the ecosystems, may be pre-planned, but they may also occur spontaneously as 'errors', i.e. perturbations, see (Goldstein, 1999).

### 2.2. Connectivity

Innovation policy scholars have stressed connections and networking amongst innovation agents for purposes of overcoming market (e.g. Arrow, 1962) and system failures (e.g. Freeman, 1987) or, more recently, for addressing societal transitions (Schot and Steinmueller, 2018; Weber and Rohracher, 2012). In research on complexity and ecosystems, the interaction of diverse agents takes place in self-organising networks with nodes at which the pathways of agents intersect or branch (Koontz et al. 2015). Herein, studies of innovation ecosystems (Formica and Mitra, 1996; Russell et al., 2018; Wessner, 2004) have highlighted complex inter-linkages amongst various agents. Managerial research on ecosystems (Moore 1993; Moore 1996; Iansiti & Levien 2004; Teece 2016) underlines, especially, the coevolution of interconnected agents. Thus, we note that governance need not only to ensure the diversity of agents in the ecosystem but also to interconnect them in diverse ways. *With connectivity, we refer to the interconnectedness of agents, nodes and networks.*

Connectivity brings several beneficial qualities to the system. First, it exposes decision-makers to a greater diversity of possible solutions (Orsenigo et al., 2001). This is especially true for interactions that take

<sup>8</sup> Emergence refers to the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems (Goldstein, 1999). The interplay among agents creates new properties, e.g. a new technology or business.

place across the different levels of the ecosystem (Ostrom, 2005). Secondly, interconnections promote learning. The independent decisions made by agents provide a set of 'natural experiments' so that the decision-makers of one node can learn from the successes and failures from the others. Especially, in larger-scale systems the agents can capture feedback that might be lost at a smaller scale (Low et al., 1999). Thirdly, connectivity helps reduce conflicts arising from the competition of agents, because densely connected decision-makers can share their preferences and ideas, and also seek to discover common ground (Koontz et al., 2015).

The desired degree of connectivity between the agents depends on the diversity and redundancy in a system (Frenken, 2000).<sup>9</sup> The necessary diversity depends on the strength and number of ties between the agents. While few strong ties produce stability but too little variety for effective learning, many weak ties produce instability with too much variety for effective learning (Kaufmann, 1993).

In effect, approaches for ecosystem governance, characterized by informal self-organising social systems, have been developed to coordinate diverse interconnected agents around complex products or services in uncertain environments (Jones et al., 1997; Kash and Rycoft, 2000). An example is participant-driven network governance, in which participants are responsible for managing complex network relationships (Provan and Kenis, 2008).

### 2.3. Polycentricity

While some innovation scholars (Filho and Heerdt, 2018; Russell and Smorodinskaya, 2018) have studied the emergence of innovations amongst self-organising diverse and connected agents, scholars on adaptive governance (see, in particular, Ostrom, 2005) have gone further, noting that diversity and connectivity are not sufficient for self-organising sustainable networks or ecosystems. Also Österblom et al. (2010) emphasise multiple governance structures for enhancing the resilience of transition processes. Therefore, we consider structural aspects as well in exploring the governance of ecosystem activities demarcated by institutions such as rules and social norms (Koontz et al. 2015).

The adaptiveness and resilience of a complex system can be enhanced with polycentric<sup>10</sup> and nested governance constellations with multiple centres of power (Koontz et al., 2015) and redundant functions (see for instance Dietz et al. 2003; Dietz et al. 2008). *With polycentricity, we mean that the ecosystem has multiple nodes which have adaptable functions and overlapping spheres of influence at different scales.* Polycentricity accommodates adaptive constellations of multiple agents with open interfaces that help new functions and nodes emerge (for instance, consider how Facebook developed its bots and a wider ecosystem within the adaptable Android ecosystem). Thus, in line with Koontz et al. (2015), we consider adaptable boundaries a key aspect of polycentricity.

Anttiroiko et al. (2014) discuss governance in situations in which power is shared amongst interdependent agents faced with 'wicked' problems that cross organisational boundaries. Similarly, Wachhaus (2011) suggests that by developing platforms the government can become more flexible and responsive. The management literature has proceeded in a similar vein with entrepreneurial ecosystems calling for multi-stakeholder governance. Autio and Levie (2017) note that stakeholder misalignment is more likely when stakeholder interests are

<sup>9</sup> in the realm of geographic economy a good discussion on the relation of connectivity and diversity has emerged around the concept of related variety and its effects on economic development (Content and Frenken, 2016; Frenken et al., 2007).

<sup>10</sup> While polycentricity may also refer to multiple physical centres instead of single centre as addressed in urban planning and transport literature (Brezzi and Veneri, 2014; Khusnutdinova et al., 2017), we focus here on the multiple centres of power and functions in the ecosystem.

competing and diverging. If unattended, this may undermine their collective commitment and inhibit productive interactions in ecosystems. As pinpointed by [Autio and Levie \(2017\)](#), complex socio-economic processes are embedded in multipolar interactions that regulate the direction and quality of entrepreneurial innovation.

In the public sector, the polycentric network of government agencies with overlapping functions and spheres of influence mitigate the high risks of unanticipated consequences of system-wide policy interventions. [Bunge \(2000\)](#) suggested testing such policies locally through multiple agencies. [Brenzitz & Ornston \(2013\)](#), with similar suggestions, analyse the role of peripheral agencies in policy experimentation (see also above on diversity and connectivity).

#### 2.4. Redundancy

Innovation scholars with interests in societal resilience ([Österblom et al., 2010](#)) and adaptiveness ([Ponsiglione et al., 2018](#)) have considered the role of redundancy in the ecosystem. The overlapping functions in polycentricity are related to *redundancy which refers to similar, repetitive or varied means to perform the same or overlapping functions*. For instance, redundant command capacity helps distribute decision making, as agents can at each moment decide on the best ways to handle the occurring changes, thereby enhancing resilience and adaptiveness ([Bohórquez and Espinosa, 2015](#)).

The redundancy can be attained by duplicating or including additional components to fulfil the same functions or by executing the same tasks with different methods. The resulting redundancy improves reliability in that neighbouring and multilevel adjacent nodes and functions may provide services if a particular agent or node should fail ([Koontz et al., 2015](#)). In a polycentric system, redundancy builds on the existence of multiple and overlapping functions which combine and cooperate in new ways as needs arise.

Multiple redundant nodes and interacting functions can entail significant transaction costs ([Braun, 2008](#)), which need to be weighed against the benefits of improved resilience attained through redundancy. The fragmentation of authority can be a barrier to governance, especially in addressing large scale challenges ([Eisenack et al., 2014](#)). Therefore, redundancy needs to be matched with other features of the ecosystem, especially connectivity to ensure sufficient coordination and information sharing.

#### 2.5. Directionality

While the four features elaborated above enhance the adaptiveness of the ecosystem, they indicate little, however, on the direction of the ecosystem. The same is true with research on homeostatic<sup>11</sup> characteristics of complex adaptive systems and of the adaptive governance approach more generally ([Dietz et al., 2008](#); [Ostrom, 2004](#)). This may lead to anticipatory myopia ([Salmenkaita and Salo, 2002](#)) in the innovation ecosystem governance and thus constrain the learning, the evolution and, ultimately the *raison-d'etre* of the ecosystem ([Schneider and Somers, 2006](#)).

Research on transformative innovation policy, especially the transition research ([Armitage et al., 2008](#); [Diercks et al., 2019](#); [Geels, 2019, 2005](#); [Schot and Kanger, 2016](#); [Walrave et al., 2018](#); [Walrave and Raven, 2016](#)), in turn, has developed future-orientated approaches to proactively direct the system. In particular, directionality relates to

creating and shaping new trajectories (See also, [Hayek 1945](#); [Weber and Rohracher 2012](#); [Mazzucato 2016](#)) and harnessing the disruptive potential of ecosystems for societal transformation and seeking to direct such developments towards societally beneficial pathways ([Walrave et al., 2018](#)). In brief, *directionality refers to the purpose of the system and its normative direction*.

Also, several ecosystem scholars have recognised the importance of directionality. Moore's (1993) seminal work on ecosystems showed how one or several central agents can *orchestrate and provide direction* in the coevolution of stakeholders over the stages of ecosystem succession. Likewise, [Gawer \(2014\)](#) highlights the role of platform leaders to nurture their ecosystems and [Teece \(2016\)](#) addresses the role of a lead innovator who provides vision and coordinating mechanisms, including common standards for the ecosystem. Also, [Autio and Levie \(2017\)](#) explore how policymakers and other stakeholders lead renewal by acting as stewards of the entrepreneurial ecosystem and engaging a balanced set of stakeholders in finding ways to mutually coordinate their actions. [Autio and Levie \(2017\)](#) also suggest facilitating joint stakeholder actions to resolve ecosystem inertia.

Along similar lines, [Hayek \(1945\)](#) suggested that highly complex systems must be governed also with *shared visions*; the leadership steps in to consider the purpose of the ecosystem and to direct it ([Wang and Von Tunzelmann, 2000](#)) to escape from non-desirable path dependence towards desired transformative change. Directional leadership builds on the ability of the system to monitor, to anticipate and to involve agents in processes of self-governance ([Weber and Rohracher, 2012](#)).

Directionality goes beyond maximizing economic return and, for instance, helps identify major societal problems or challenges for which solutions are needed ([Mazzucato, 2016](#); [Weber and Rohracher, 2012](#)). Yet, forcing a transition with strong interventions affecting the entire system (e.g., a radical redesign of the legal and regulatory framework) may be a strategy with largely unknown outcomes ([Geels, 2005](#); [Hendriks and Grin, 2007](#)). Such transformations are arguably best governed by orchestrating diverse and connected agents within polycentric and even redundant institutional structures.

#### 2.6. Balanced presence of the features in the ecosystem

These five ecosystem features of transformative governance are summarized in [Table 1](#). They can be influenced by all *ecosystem agents*, ranging from individuals to profit, non-profit and (inter- and supra-) governmental organisations. Yet, while ecosystem agents take part in and are affected by governance, some agents, such as government agencies, can more effectively influence the ecosystem and the direction of its overall evolution.

The ecosystem dynamics in the three stages are prone to lock-in mechanisms (e.g. [Autio and Levie, 2017](#)) and the 'winner takes it all' effect (e.g. [Parker and Van Alstyne 2002](#)). These forces may undermine polycentricity, redundancy and diversity, in particular. Furthermore, while many agents tend to connect to emerging nodes, others may be excluded, thus reducing overall connectivity. Also, instead of societal benefits, the directionality of the ecosystem may be propelled by first-mover advantages, increasing returns to scale, and the monetization of information asymmetries.

**Table 1**  
The five ecosystem features in transformative governance.

Ecosystem features	Definition
<i>Diversity</i>	The condition or quality of being diverse, different, or varied
<i>Connectivity</i>	Interconnectedness of agents, nodes and networks
<i>Polycentricity</i>	Multiple nodes with adaptable functions and overlapping spheres of influence at different scales
<i>Redundancy</i>	Similar, repetitive or varied means to perform the same or overlapping functions
<i>Directionality</i>	The purpose of the system and its normative direction

<sup>11</sup> Homeostasis employs feedback mechanisms to maintain the dynamic equilibrium of a self-regulating system. [Schneider & Somers \(2006\)](#) discuss one form of homeostasis emerging from the system identity and self-similarity in complex adaptive systems. This means that a system remains invariant under a change of scale. Self-similarity is evidenced in the physical world in fractals such as fern leaves and broccoli, which are geometric spaces in which the parts exhibit the quality of the entity's whole ([Schneider and Somers, 2006](#)).

Consequently, *ecosystems do not tend to evolve towards the balanced presence of the described features*. Rather, they tend to evolve towards excessive concentration of power and techno-institutional lock-ins (Unruh, 2000), on the one hand, or the dissolution of the ecosystem to fragmented and chaotic markets, on the other (Hung and Tu, 2014). To address this challenge, we consider *transformative governance*,<sup>12</sup> which seeks to improve the adaptiveness and resilience of the ecosystem and orchestrates socio-technical transformation based on the balanced presence of diversity, connectivity, polycentricity, redundancy and directionality.

Transformative governance, in particular, calls for a substantiated understanding of ecosystem agents and their activities, stages of succession and possible future pathways. This complex governance challenge can be structured with the framework of the five features juxtaposed with the three succession stages of agents and their activities. The proposed framework for transformative governance is next applied to an illustrative example on a Finnish transport policy reform facilitating the emergence of ecosystems.

### 3. Illustrative application of the framework

Due to the novelty of our research topic, we illustrate the application of our framework with a real-life example.<sup>13</sup> The Finnish Transport Act, was selected as the example of a policy reform. In 2015, the Ministry of Transport and Communications of Finland started renewing the country's legislative framework related to the people, goods, and postal transport industries. The Transport Act initiative was one of the Government's key projects in facilitating digital platform businesses' development, improving legal provisions, and alleviating administrative inertia (The Government of Finland, 2015).

When the Transport Act planning began, the Finnish transport market was divided into sectors of which each was independently regulated and guided by separate public measures. The Government concluded that retaining this governance model would lead to economic inefficiencies, low growth opportunities, and sub-optimization between transport sectors and market agents. The objective of the Government and, more specifically, the Ministry of Transport and Communication was to unify all transport market regulation (except the development of the transport infrastructure) by aggregating them into a single act, referred by the ministry as the 'Transport Act' (The Government of Finland, 2015). The legislation transformation process was published in September 2015 and updated in April 2016. In September 2016, the Government of Finland submitted the legislative proposal to the Parliament.

The Transport Act aimed to facilitate the emergence of a new mobility ecosystem, focusing on user needs – seamless, multi-modal person logistic chains – and breaking down the transport mode silos. Customer-centric and multimodal mobility ecosystems entail many diverse actors: mobility service providers (like taxis, buses, trains), service platforms (which integrate service providers), technical infrastructure providers (e.g., ticketing systems), and support service providers (such as maps and routing). Seamless interplay of all these players is required. In Finland, this posed great difficulties in terms of competitive strategy as competitors must share data with each other,

<sup>12</sup> We identified some earlier sporadic uses of the notion 'transformative governance' in climate policy (Goodell, 2016; Nursey-Bray, 2013), citizen science (Conrad and Hilchey, 2011) and resilient water management (Rijke et al., 2013), of which the last one related to the theories of adaptive governance and transition management providing bases for building bridges over these streams of work. We contribute to this by establishing further connections with the work on ecosystems and complexity theory.

<sup>13</sup> A case study is suitable for generating theoretical and pragmatic insights from empirical observations even when little is known about a phenomenon under investigation. Case studies can also offer a more detailed picture of the phenomenon than top-down, aggregate quantitative analyses (Yin, 2009).

technologies as systems need interfaces to work together, and also culture as the mobility industry has been for a long time siloed around separate transport modes. Hence, the Transport Act specifically aimed to (i) facilitate data sharing in the market, (ii) lower the barriers to connect different services together, and (iii) empower the market members to co-create their own best practices in building interconnectivity.

We applied a qualitative single-case approach to analyse this illustrative policy reform in two phases. Although the analysis was conducted with systematic methods, the main objective is to demonstrate the applicability of the conceptual framework rather than deriving empirical insights for further theory building.

#### Phase 1: Primary analysis of intended impacts

The illustrative example was primarily analysed using data from the Transport Act proposal document (The Government of Finland, 2015). This document had been prepared through a collaborative process involving several government departments as well as extensive stakeholder consultations. As such, the document provided a concise view of an agreed joint agenda on how to develop the ecosystem from the governance perspective. The document consists of two parts: (i) the proposal of the Act, and (ii) an explanatory section describing the background, objectives, and content of the Act. Our analysis focused especially on the explanatory section of the document.

The analysis started with two rounds of qualitative coding of the Transport Act proposal document (The Government of Finland, 2015). First, we identified the initial codes to be selected for further analysis (Yin, 2009), focusing on how the transport system policed by the Transport Act is planned to function and be governed (objectives related to the desired functioning and governance of the desired transport system). The coding proceeded to the second level by further dividing first-level codes that contained two or more separate themes and combining codes that referred to the same theme. To examine the presence of ecosystem features in the transport act proposal, the second-level codes were categorized into the five features. Finally, the categorized codes were related to the different ecosystem succession stages: emergence, expansion, and maturity.

Furthermore, to triangulate and complement the findings from the primary data source, archival data<sup>14</sup> such as news bulletins, public talks and presentations related to the Transport Act and its preparation process, were examined to crosscheck the views and underlying assumptions of policymakers. All data sources used in the primary analysis are presented in detail in Appendix 1.

#### Phase 2: Ex-post analysis of occurred impacts and adaptation

The Transport Act came into force in July 2018. During 2018–2020, the Act's impact was analysed by the supervising authority, Finnish Transport and Communications Agency (Traficom). Based on the impact assessment, the Finnish government proposed changes to the original Transport Act in June 2020.

To analyse the first stages of the evolution of the Transport Act, we systematically reviewed the government's proposal document (The Government of Finland, 2020) and the results of Traficom's impact

<sup>14</sup> To be considered for the analysis the sources had to meet the following criteria: (i) they had to be official documents, authored by the public agencies, (ii) they had to present the agencies' views on the Transport Act, and (iii) they had to be available through the official communication channel of the Transport Act (LVM, 2017). The sources were analyzed with similar coding strategy as the primary source. Triangulation revealed no new themes beyond the primary source analysis but offered further insights into the already identified themes and their qualities.

analysis.<sup>15</sup> It is to be noted that Traficom’s impact assessment has a limited scope, as the policy maker’s primary focus has been so far in overseeing the Finnish taxi market developments. To verify the findings of our review, secondary empirical sources were analysed with a similar coding strategy as with the primary source. Data sources used in the ex-post analysis are presented in detail in Appendix 2.

In what follows, we employ our framework to elucidate the characteristics related to each of the ecosystem features, identified in the mobility ecosystem initially before the Act, as desired in the Act and as resulted in the ecosystem two years after its ratification. We also discuss the governance mechanisms in different succession phases in connection to each of the features. Furthermore, we identify follow-up measures initiated by the key ecosystem stakeholders to address the existing challenges, especially towards enhanced data sharing for multimodal mobility.

### 3.1. Diversity

Table 2 presents characteristics related to diversity, identified in the ecosystem initially before the Act, as desired in the Act and as resulted in the ecosystem two years after its ratification. Before the Act, the ecosystem was highly regulated and had high entry barriers for new service mobility providers. It largely missed innovative, data-intensive mobility services and alternative new ways to connect existing offerings leading to limited mobility choices for customers. Few in-

**Table 2**  
Initial, desired and resulted diversity characteristics of the mobility ecosystem.

Initial ecosystem characteristics	Desired ecosystem characteristics in the Act	Resulted ecosystem characteristics
<ul style="list-style-type: none"> <li>- High entry barriers for new service providers</li> <li>- Lack of innovative, data-intensive mobility services</li> <li>- Lack of alternative ways to connect existing offerings</li> <li>- Regulation prevents market member autonomy in terms of price and service terms setting</li> <li>- Customers have very limited choices</li> <li>- Lack of service availability in some areas</li> </ul>	<ul style="list-style-type: none"> <li>- Emergence of new ventures, business models, and service innovations</li> <li>- Meeting the diverse mobility needs of different users</li> <li>- Using data to combine and reconfigure existing and new mobility services for better coverage and quality</li> <li>- Strong role of mobility service intermediaries</li> </ul> <p><i>Examples:</i></p> <ul style="list-style-type: none"> <li>- <i>Large-scale mobility platforms that create open marketplaces for customized mobility solutions across all modalities; open platforms for service development/developer communities)</i></li> <li>- <i>Specialized solutions that connect e.g. taxi, bus and train services together as a customized solution</i></li> </ul>	<ul style="list-style-type: none"> <li>- The number of entrepreneurs in the taxi market and the number of valid taxi licenses grown (25% increase in licences; 25% increase in registered person logistics vehicles)</li> <li>- New ways of organizing work emerged (supporting flexible working hours, flexible use of cars and other resources)</li> <li>- New mobility types and levels of service for customers, especially in high-density areas</li> <li>- The increased diversity does not apply equally to all market agents (a lot of underserved parties, and certain market members have low level of autonomy)</li> </ul>

<sup>15</sup> Our ex-post analysis followed the same procedure as the primary analysis, with the following deviations: (i) the study of the primary document included only one round of coding; (ii) the coding was conducted with eight pre-defined categories (observed impact in general level, observed negative impact, observed positive effects, observed juridical issues, the objective of the development activities, proposed development action, proposed additional research action, and remaining uncertainties).

termediaries, for instance, Whim application struggled developing pilots for single mobility subscription services integrating public transportation, city bikes, e-scooters, ferry tickets, taxis and affordable rental cars all in one app (Whim Global, 2021).

The Act highlighted the importance of new ventures, business models, and innovations for the service ecosystem. For the stage of *emergence*, the Act set the activities to develop existing and new service concepts to better meet diverse customer needs. To answer the challenges of *expansion and maturity*, the Act defined roles for service intermediaries as a means of fostering diversity through reconfiguring existing solutions and enhancing data sharing amongst ecosystem agents.

After two years of implementation of the Act, the entry barriers to the taxi market have been lowered leading to the incremental diversification of service providers in the emerging mobility ecosystem. The number of valid taxi licenses has been increased leading to an increased number of entrepreneurs in the taxi market. Also, the global mobility platforms, such as Uber, have been permitted the access to the markets, which have brought in new ways of organizing work and mobility.

While the service providers have been encouraged to develop new types of services, they have mainly developed incremental additions to earlier services – radical and disruptive innovations have not yet materialized. Furthermore, the increased diversity does not apply to all market agents; some customer groups have fewer opportunities now than before the Act came into force (especially handicapped people).

For the way forward, the Ministry of Transport and Communications plans to use government procurement (subsidized services) to increase and diversify offerings to serve the underserved customer groups. To address shortcomings, also regulatory supervision of minimum work contract terms and customer service levels is now being strengthened. Education offerings for the service providers are developed further, and license supervision is now actively improved.

### 3.2. Connectivity

Table 3 presents characteristics related to connectivity, identified in the ecosystem initially before the Act, as desired in the Act and as resulted in the ecosystem two years after its ratification. Before the Act, the ecosystem suffered from the lack of data sharing and service integration leading to limited multimodal mobility and ticketing solutions.

Connectivity-related measures of the Act were mainly linked to the

**Table 3**  
Initial, desired and resulted connectivity characteristics of the ecosystem.

Initial ecosystem characteristics	Desired ecosystem characteristics in the Act	Resulted ecosystem characteristics
<ul style="list-style-type: none"> <li>- Low level of information system connectivity</li> <li>- Existing service integration does not meet future needs</li> <li>- Lack of data sharing, regulatory baseline not met</li> <li>- Lack of systematic use of transport system data in service innovation</li> <li>- Lack of data-intensive new innovations</li> <li>- Regulation prevents multi-modal transport solutions</li> <li>- Ticketing solutions are fragmented</li> </ul>	<ul style="list-style-type: none"> <li>- Seamless interconnectedness and interoperability of different services and related data</li> <li>- Open interfaces to services and data for all members of the service ecosystem</li> <li>- Many service intermediaries</li> </ul> <p><i>Examples:</i></p> <ul style="list-style-type: none"> <li>- <i>Minimum marketplace access requirements (inclusivity) for mobility marketplaces/platforms)</i></li> <li>- <i>Minimum data, API, and access requirements for all market agents</i></li> <li>- <i>Allocating resources specifically for solutions that can be linked/bundled with other solutions)</i></li> </ul>	<ul style="list-style-type: none"> <li>- Interface openness is kept at a legal minimum, and in many cases, also below the required level (2 major interventions from the Traficom were needed to open the interfaces of two major transport providers)</li> <li>- Data sharing between market players—and between market players and the policymakers—is perceived inefficient</li> <li>- Situational awareness about the market’s functioning is fragmented</li> </ul>

objectives of interoperability. Priority was given to seamlessly interconnected transport chains, interoperable services and related data to address the challenges of *all succession stages* of ecosystem agents and activities. In practice, the objectives were to be reached by establishing open interfaces to services and ensuring the availability of data for all members of the service ecosystem. To meet the demands related to the *emergence stage*, it was required that public funding was given specifically to those coordinating services that met the connectivity requirements. For challenges related to the *expansion and maturity stages*, in turn, the role of service intermediaries was emphasised to ensure technology- and sector-agnostic linkages in the service ecosystem. Concerning agents and activities in the *maturity stage*, the availability of open interfaces for all members of the service ecosystem was enforced. Attaining the connectivity objectives of the Act is facing significant challenges. The Act both enforced data sharing to move market agents to open their interfaces. However, interface openness is kept at a legal minimum, and in many cases, also below the required level, largely due to lack of understanding of the benefits to shared data, the fear of losing competitive power, and technical difficulties (lack of interfaces and standards). All this has resulted in the market conditions where situational awareness about the market's functioning is fragmented.

In conclusion, the very target of seamless interconnectedness and interoperability has not been attained in the mobility ecosystem. While some service intermediaries are connecting different multimodal ticketing services in the ecosystem, the number of such agents remains low and little efforts is made to interconnect such efforts. The Ministry of Transport and Communication is considering new regulation to make it more efficient to gather price and availability information from the market agents and force them to provide this information proactively.

### 3.3. Polycentricity

Table 4 presents characteristics related to polycentricity, identified in the ecosystem initially before the Act, as desired in the Act and as resulted in the ecosystem two years after its ratification. Before the Act, the strongly centralised governance model and regulation of the ecosystem were dictating the market structure dominated by “one car-firms” and few service intermediaries.

The polycentricity amongst the service providers and end-users was one of the central targets of the Act. The perspective of polycentricity was addressed in the Act especially via lowering barriers to entry, sharing data in the ecosystem and facilitating the emergence and

**Table 4**  
Initial, desired and resulted polycentricity characteristics of the ecosystem.

Initial ecosystem characteristics	Desired ecosystem characteristics in the Act	Resulted ecosystem characteristics
<ul style="list-style-type: none"> <li>- Regulation dictates market structure: dominance of “one car-firms” and few service intermediaries</li> <li>- Platform-based (aggregation) services focusing only densely populated areas</li> <li>- amongst service providers, perception of unfair treatment from the policymakers</li> <li>- Lack of autonomy to develop own offerings to match market needs</li> </ul>	<ul style="list-style-type: none"> <li>- Data openness and fluidity for all parties of the service ecosystem,</li> <li>- Many key service intermediaries</li> <li>- The fairness of competition between incumbents and new entrants</li> <li>- To simplify regulation, give more freedom to market agents</li> </ul> <p><i>Examples:</i></p> <ul style="list-style-type: none"> <li>- Coordinating resources also to less attractive / more risky sectors</li> <li>- Allocating resources specifically for new and innovative services and platforms</li> </ul>	<ul style="list-style-type: none"> <li>- The entry of foreign platform operators like Uber</li> <li>- Radically innovative new service intermediaries have not emerged, and the conventional large service providers still dominate the market</li> </ul>

expansion of new intermediaries. Data, as produced and disseminated in the ecosystem, was seen to help decentralise power, especially in answering challenges related to the *emergence* of agents and activities. Thus, information flows were to be fostered with regulation. To tackle challenges in the *expansion* stage, the objective was to decentralize power by facilitating the emergence of many strong service intermediaries (or service platforms) which link agents and resources across different industry sectors. To avoid consolidation of agents and activities in the *maturity stage*, the Act limited the power of incumbents by lowering the market entry barriers for growth-orientated ventures and individual entrepreneurs. Yet based on our analysis, it appears that the emphases placed on data gathering for the optimization of the transport system were conditioned by the prevailing centralised governance mechanisms in the transport sector, with little indication of the development of polycentric structures amongst government entities.

While lowered entry barriers to the taxi market have brought in new businesses, including the entry of foreign operators like Uber, radically innovative new service intermediaries have not emerged, and the conventional large service providers still dominate the market structure. Instead of introducing polycentric local governance structures and practices, Kela, the Social Insurance Institution of Finland, has introduced subsidies to alleviate the implications of the Act (low availability of taxis in less populated areas). Thus, despite its' objectives the Act appears not to have enhanced polycentricity, quite the opposite.

### 3.4. Redundancy

Table 5 presents characteristics related to redundancy, identified in the ecosystem initially before the Act, as desired in the Act and as resulted in the ecosystem two years after its ratification. Before the Act, while the ecosystem suffered from occasional redundancy of taxi service operators in densely populated areas, in the rural areas satisfactory service levels were ensured by regulation and subsidies. A limited number of intermediary services contributed to the problem. Amongst the five features, redundancy had the smallest role in the Act. Still, to some extent, redundancy was promoted in *all the stages* of agents and activities through the usage of different and overlapping data sources in innovation and decision making (as opposed to relying on a rigid pre-determined set of measurements). Also, in the Act the challenges related specifically to the *maturity stage* were to be addressed by emphasizing the importance of overlapping business models and innovations. Answering diverse customer needs (even if quite similar to

**Table 5**  
Initial, desired and resulted redundancy characteristics of the ecosystem.

Initial ecosystem characteristics	Desired ecosystem characteristics in the Act	Resulted ecosystem characteristics
<ul style="list-style-type: none"> <li>- Low usage rate in Taxi market – but service coverage is good (except peak hours in densely populated areas)</li> <li>- Few intermediary services and lack of customer choice especially in rural areas</li> </ul>	<ul style="list-style-type: none"> <li>- Mutuality and overlap between company-provided and peer-to-peer services</li> <li>- Using many different business data sources in decision making and service innovation</li> <li>- Multiple intermediaries for more choice and better prices</li> </ul> <p><i>Examples:</i></p> <ul style="list-style-type: none"> <li>- Gathering market information from a diverse set of stakeholders</li> <li>- Supporting different types of organizing ranging from peer to peer to intermediaries and big service providers</li> </ul>	<ul style="list-style-type: none"> <li>- The availability of taxi services has improved in some areas</li> <li>- General satisfaction with service quality has decreased (satisfaction 84% decreased to 75%)</li> <li>- The Transport Act has also decreased the policymakers' possibilities to ensure service availability with compensations and subsidies, as those measures sometimes violate the competition law.</li> <li>- Only few intermediary platforms have not emerged reducing customer choice</li> </ul>



each other) and reconfiguring existing service offerings (even if leading to similar configurations) were considered important for the operative and innovative transport markets.

The ex-post impact assessment of the Act shows also that the market has not strived autonomously for higher redundancy in the ecosystem. The Transport Act has also decreased the possibilities of the Ministry of Transport and Communications and the Finnish Transport and Communications Agency to ensure service availability with compensations and subsidies, as those measures sometimes violate the competition law. Thus, while the reform managed to dismantle features of the mature system, new alternative practices have not emerged sufficiently to compensate service gaps. From the customer's perspective, the availability of taxi services has improved in some areas. General satisfaction with service quality has decreased.

Overall, redundancy was featured only in a minor role in the Transport Act, which remains to be the case in the new market situation. The Ministry of Transport and Communications and the Finnish Transport and Communications Agency are addressing these concerns only partially with market subsidization and increased regulation (and supervision).

### 3.5. Directionality

Table 6 presents characteristics related to directionality, identified in the ecosystem initially before the Act, as desired in the Act and as resulted in the ecosystem two years after its ratification. Before the Act, the centralised governance and direction-setting in the ecosystem limited the possibilities for market agents to develop the mobility sector. Also, the lack of shared visions of the future provided little incentives to develop the overall multimodal mobility ecosystem.

Along with polycentricity and connectivity, themes related to directionality were addressed extensively in the Act, albeit more prominently at the level of objectives, not as concrete measures *per se*. The Act did not go into much detail on governance structures and decision-making procedures which would programmatically shape the ecosystem. The idea of the Act seemed to be that market agents could jointly identify common opportunities and problems of the transport

**Table 6**  
Initial, desired and resulted directionality characteristics of the ecosystem.

Initial ecosystem characteristics	Desired ecosystem characteristics in the Act	Resulted ecosystem characteristics
<ul style="list-style-type: none"> <li>- Regulation-centric market situation</li> <li>- Lack of autonomy for market agents</li> <li>- Regulation is slow and resource-consuming also for the regulator</li> <li>- Inefficient taxi license caps and minimum service level policies</li> <li>- Subsidised services are charged with the allowed maximum amount</li> <li>- Lack of incentives for all market members to develop the industry</li> <li>- Lack of shared visions of the future mobility ecosystem</li> </ul>	<ul style="list-style-type: none"> <li>- Co-created situational awareness of the service ecosystem, available for all stakeholders</li> <li>- The strong role of self-governed contracts between different agents</li> <li>- Co-created interoperability technology</li> <li>- Resilience of the service ecosystem</li> </ul> <p><i>Examples:</i></p> <ul style="list-style-type: none"> <li>- <i>Creating a data-sharing infrastructure/framework for the transport market</i></li> <li>- <i>Setting sustainable development as one of the primary objectives why data is shared</i></li> <li>- <i>Using shared data to analyse the market in real-time</i></li> </ul>	<ul style="list-style-type: none"> <li>- The market has expanded, and digitalization has progressed, especially, in the customer-facing interfaces (better taxi apps)</li> <li>- Uncertainty in the market has increased as the collaboration between market agents has remained very limited.</li> <li>- The market has been largely left to self-organize itself, which, is producing firm-focused operating models.</li> <li>- Interoperability technology goals have not progressed</li> <li>- Combining different offerings remains one of the most considerable challenges for the market agents</li> <li>- Lack of data sharing between market agents</li> </ul>

market and coordinate their actions to address issues. Transparent markets and customer choices were seen as the primary means of governance, whilst ministries and agencies were left with the role of controlling a few aspects critical for market fairness.

To meet challenges in the *emergent stage*, the Act emphasised the co-creation of formal and informal contracts amongst market agents over hierarchical top-down regulation. In the *later stages*, the Act promoted self-regulation to improve service ecosystem resilience; this is visible on many fronts in the Act, such as in defining technological solutions for interoperability and gathering data for collective performance optimization of the transport system.

Thus, while the Act was connected to the broader governmental agenda for lowering emissions and reducing the costs of publicly subsidized transport services, the Act specified few concrete actions for embedding the directionality agenda in market structures. Instead, the Act facilitated the emergence of market-driven mechanisms also as a means for defining and enforcing long-term goals.

The market has been largely left to self-organize itself, which, however, is now producing suboptimal firm-focused operating models. The objectives of the Act for co-created interoperability technology have not progressed, and combining different offerings remains one of the most considerable challenges for the market agents. The largest single inhibiting factor for shared directionality is the lack of data sharing between market agents. After two years of the ratification of the Act, on the one hand, the market has expanded, and digitalization has progressed, especially, in the customer-facing interfaces. But on the other hand, uncertainty in the market has increased as the collaboration between market agents has remained very limited.

Due to the political shift in the Government since the Transport Act's preparation stages, the government is now increasing the control and is taking a more critical stance on agents to organise autonomously the markets.

### 3.6. Unbalanced presence of ecosystem features

The overarching objective of transformative governance is to ensure the balanced presence of the five ecosystem features. Based on our analysis, the Act did exhibit these features, but these did not receive equal attention, nor were they addressed at the same level of detail. Specifically, our coding resulted in only 3 codes related to redundancy, in striking contrast to the four other features: polycentricity (53 codes), connectivity (39 codes), diversity (38 codes) and directionality (26 codes). Moreover, the Act has very specific objectives for some features (e.g., related to connectivity) while those for others are addressed in very general terms (e.g., those related to the diversity).

Furthermore, our contextual analysis of the ecosystem before and after the Act appears to support the finding that the unbalanced presence of the five features in the Act provided inadequate means for the development of the long-term adaptiveness and resilience of the ecosystem. This is evident, especially on data sharing, which is critical for the functional multimodal mobility ecosystem. Moreover, while the Act was connected to the broader governmental agenda, the stipulated measures in support of directionality paid limited attention to building adequate participatory governance structures for the directional transformation towards a shared understanding of the long-term goals for the ecosystem.

Our ex-post analysis further demonstrates the unbalanced attention to the features and the importance of the follow-up and adaptation of policy measures to ecosystem changes. While more recent policy measures have been developed to enhance diversity, other features have not received balanced attention in the implementation of the Act. Notably, the connectivity-related improvements addressed widely in the Act have not been implemented, possibly because of a lack of shared awareness for directionality in the ecosystem. As a consequence, agents have differing views on data sharing and, in general, on the future mobility ecosystem. This has also hampered efforts to develop polycentric market

structures, with the exception of the market entry of few foreign mobility platforms, namely Uber. Furthermore, the lack of attention to redundancy as well as to polycentric and directional governance structures in the Act and the subsequent missing follow-up measures, all together, explain further the limited advances in the development of the mobility ecosystem aimed at in the Act.

#### 4. Discussion

Our analysis of the Finnish policy reform illustrates how the framework for transformative governance can support policy formation and assessment. Specifically, the policy objectives can be assessed from the perspective of the five features in the different succession stages of the ecosystem, providing insights to policymakers in different levels of government, to overcome difficulties in ensuring the connectivity of market agents and setting desired directions for ecosystem development, for instance. The analysis of the reform also points to needs for enhancing redundancy and developing polycentric governance structures.

Apart from showing the instrumental value of the framework, the illustrative example gives indications as to *how the presence of the five ecosystem features can be ensured and how governance measures within the succession stages can be prioritised*. Towards this end, selected measures identified in our analysis, concerning the features and the succession stages, are stylised in Table 7 and discussed subsequently in more detail.

Table 7

Stylised guidelines for transformative governance measures concerning the ecosystem features and the succession stages of agents and activities.

SUCCESSION STAGES OF AGENTS AND THEIR ACTIVITIES			
ECOSYSTEM FEATURES	<i>Emergence</i>	<i>Expansion</i>	<i>Maturity</i>
<b>DIVERSITY AND CONNECTIVITY</b>	Subsidize innovative businesses and the development of open interfaces (e.g. APIs) to enhance interoperability Carry out pilots for regulatory and governance experimentation	Enhance the interoperability through standardisation and data sharing and access to infrastructure Support and/or invest in the promising alternatives to incumbents	Avoid lock-ins through innovative regulatory initiatives addressing information asymmetry to ensure renewal Ensure access of niche agents in data and avoid privatisation of public data
<b>POLYCENTRICITY AND REDUNDANCY</b>	Develop nested structures of multiple agencies Allocate overlapping functions and open peripheries for innovation	Support the scaling up of initiatives Implement infrastructure redundancy to ensure resilience	Reduce switching costs between platforms Maintain and encourage overlapping functions of agencies in monitoring the ecosystem to enrich learning and boost renewal
<b>DIRECTIONALITY</b>	Launch foresight processes for shared visions, action plans and networked governance	Support and/or invest in the promising nodes that can challenge the incumbents	Measure the broad societal impact of the ecosystem and develop foresight and other measures offering alternative pathways

#### 4.1. Diversity and connectivity

The governance of ecosystems stewards interconnected networks of diverse agents. In line with network governance approaches (Jones et al., 1997; Kash and Rycraft, 2000), the policy reform stresses the key role of open service intermediaries. Beyond the emergence of such self-organizing networks, direct measures of public agencies are important for enhancing both the diversity (e.g. supporting business creation) and connectivity (e.g. ensuring open interfaces) of the ecosystem.

However, while the Transport Act reflected both the diversity and connectivity in the ecosystem, the balance of these two features was not addressed sufficiently. This tension was identified especially in our ex-post analysis, and it may pose further problems in ecosystem governance, given that this balance is often crucial for ecosystem strength (Frenken 2000).

Besides, because ecosystems consist of diverse agents in different stages of succession, it is hard to prioritise and schedule measures given trade-offs between the five features. For instance, the promotion of partial connectivity in the Act has led to co-optation that reduces diversity. The challenges resemble those encountered in standardisation in which right timing is crucial for offering first-mover advantages while avoiding picking winning technologies prematurely (Teece, 2018; Wiegmann et al., 2017).

Herein, our framework calls for the balance between diversity and connectivity over the different stages of the ecosystem. Thus, in the emergence stage, while the policy may subsidize business creation, it also needs to enhance open interfaces. In the expansion stage, the policy can carry out pilots for experimentation, but also enhance interoperability with standardization and data sharing, for instance. In the maturity stage, incumbent firms tend to control data leading to information asymmetries (Bauer, 2014) polarising the ecosystem between highly connected networks around incumbent firms and fragmented efforts by the agents locked out from the networks. Therefore, the policy should avoid such lock-ins (Unruh, 2000) around dominant platforms by way of supporting network diversity. This can be done by enhancing the access of niche agents in data and by avoiding the privatization of public data, for instance.

#### 4.2. Polycentricity and redundancy

Polycentricity and redundancy foster the development of adaptive and resilient constellations. However, the analysis of Transport Act indicates how difficult it is for markets alone to create radically new service intermediaries. Intentional governance actions need to be tailored to enhance polycentricity.

Bunge (2000), as well as Breznitz & Ornston (2013), suggest to experiment and test new polycentric policies first locally through multiple agencies, before any system-wide implementation. Our analysis of the Transport Act did not detect such approaches, which is an indication of the centralised governance mechanisms in the transport sector. Nor did we find any evidence on encouraging overlapping functions of agencies in the monitoring of the ecosystem or its enrichment through ecosystem-wide learning. By contrast, the Act pinpoints the data gathering for the optimization of the transport system. Against this backdrop, future research on good practices for experimentation and nested structures for monitoring may be needed to enhance polycentricity.

Moreover, in the Act, the lack of attention to redundancy was particularly striking, which may be a symptom of a broader policy trend associated with the paradigm of lean government (Janssen and Estevez, 2013). Yet reducing redundancy can be a high-risk strategy especially in the context of critical infrastructures such as transport (Schade, 2016; Taleb, 2012). Furthermore, the expansion of the activities of platform intermediaries may require that the government has a strong role in ensuring that the service infrastructure has sufficient redundancies, allowing multiple platforms to scale up in parallel (Leceta et al., 2017).

This is particularly important in avoiding winner-takes-it-all problems (Parker et al., 2016).

In summary, our framework draws attention to the polycentric institutional structures and the role of redundancy in enhancing resilience and alternative ecosystem pathways (see also, Marchau et al., 2010). In the emergence stage, the policy develops nested structures of multiple agencies and infrastructure to be scaled up in the expansion stage. In the maturity stage, the policy reduces switching costs between platforms to maintain and encourage overlapping functions of agencies in monitoring the ecosystem and to enrich learning and encourage renewal.

#### 4.3. Directionality

Transformative governance influences also the direction of the ecosystem by orchestrating deliberate transformation in society. In this regard, our analysis on the Transport Act indicated clear efforts to mitigate the ‘winner-takes-it-all’ effect (Parker et al., 2016) by downplaying the mature path-dependant mechanisms of increasing returns and by stimulating the emergence of alternative pathways (Walrave and Raven, 2016).

Furthermore, by addressing different measures to engage agents in the ecosystem, the Act emphasises the self-organisation of agents and homeostatic self-similarities (Schneider and Somers 2006). However, the Act relates only partly to societal goals that would provide further normative direction (Hayek 1945; Weber and Rohrer 2012; Mazzucato 2016). Here, ecosystem-wide distributed learning and participatory direction-setting mechanisms like foresight and transition management, amongst others (Weber and Rohrer, 2012) could be helpful. These topics merit further research in ecosystem governance.

With the directionality, our framework elucidates the shifting roles of policymakers in guiding the direction of the ecosystem. In the emergence stage, it is easier to influence the direction of the ecosystem succession. Therefore, the policy should launch foresight processes for shared visions, action plans and networked governance. In the expansion stage, the policy can anticipate how agents and activities will shift from expansion to maturity so that targeted measures can be introduced for curbing the negative effects of power concentration and for ensuring the renewal of the ecosystem in time (Geels, 2019).

In the maturity stage, the policy ought to measure the broader societal impacts of the ecosystem and develop foresight and other measures offering alternative pathways. Takeovers are typical at the maturity stage amongst incumbents to avoid competition and/or to integrate new services to maintain market dominance; consider for instance Facebook buying WhatsApp, Instagram and Oculus VR to benefit from enveloping for economies of scope (Panzar and Willig, 1981). The direction of the ecosystem may be driven by the survival strategies of incumbents, rather than the considerations of societal benefits focal in transformative governance.

To the extent that changes in infrastructure, applications and services involve switching costs, incumbent platforms may exhibit problems of path dependency (Hollingsworth, 2009). In principle, any government-imposed change should yield benefits that exceed the aggregated switching costs. However, not only may the benefits and costs be difficult to assess, but often they are asymmetrically distributed. Consequently, the stakeholders who benefit from the status quo but stand to lose under alternative rules will most likely resist changes (Weber and Rohrer, 2012). It is worth developing further advanced practices for measuring this and for justifying policy actions for renewal.

## 5. Conclusions

Traditional policy responses to control markets have become a

source of inertia and a point of vulnerability addressing challenges associated with digital platforms (Janosec et al., 2017), financial crises (Taleb 2008; Taleb 2012) and potentially the covid-19 pandemic as well. We align with transformative innovation policy (Diercks et al., 2019) and contribute to this stream by addressing uncertainty and complexity. In this paper, we elaborated the notion of transformative governance, which seeks to improve the adaptiveness and resilience of the ecosystem and orchestrates socio-technical transformation based on the balanced presence of diversity, connectivity, polycentricity, redundancy and directionality. The significance of each feature depends on the boundary conditions set by the succession stages of the ecosystem. Such a conceptual framework can help define, implement and evaluate needed coordinated actions both in business and policy.

Our illustrative example of applying the framework to the transport policy reform in Finland suggests that it can yield actionable insights. More generally, the framework seems relevant also in other policy and management contexts which are characterised by complexity and uncertainty, both within vertical policies (e.g. research, energy, mobility or health) as much as within more horizontal policies (e.g. entrepreneurship or innovation). In effect, it can help design and assess policy measures which exhibit the desired five features in the three succession stages, thereby fostering more balanced ecosystem development.

Apart from designing of specific policy measures, the framework can be harnessed for shaping the general conditions of transformative innovation policy (Diercks et al., 2019) and associated governance structures, for instance by overcoming bottlenecks related to both innovation and entrepreneurial ecosystems (Ács et al., 2014; Mason and Brown 2013). Furthermore, it could be used for assessing and designing policy mixes (Rogge and Reichardt, 2016) to support the development of innovation ecosystems into desired directions.

As it is, the illustrative example of applying the framework to the transport policy reform has offered evidence-based and actional insights which we believe would be far less apparent and compelling without the use of this framework. For future work, this framework could be further elaborated by operationalizing more concretely how the presence of the five features in different stages of ecosystem development can be best assessed and communicated. An empirical multi-case analysis, possibly in another context, would provide evidence on the broader relevance of the framework and suggest avenues for its continued development. Moreover, related further research in transformative innovation policy can be enriched, for example, through policy experimentation and exploration of mechanisms for enhancing learning and direction-setting in innovation ecosystems.

#### CRediT authorship contribution statement

**Totti Könnölä:** Writing – original draft, Conceptualization, Methodology, Resources. **Ville Eloranta:** Writing – original draft, Methodology, Resources, Investigation, Formal analysis. **Taija Turunen:** Resources, Writing – review & editing. **Ahti Salo:** Supervision, Writing – review & editing.

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## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.techfore.2021.121106](https://doi.org/10.1016/j.techfore.2021.121106).

## Appendix 1: Empirical data sources used in primary analysis of the illustrative example

Document title		Release date	Document address	Nr. of pages	Nr. of codes identified	Accessed
<i>Main empirical source:</i>						
The accepted proposal of the Transport Act.	Government of Finland	22.9.2016	<a href="https://www.eduskunta.fi/FI/vaski/HallituksenEsitys/Documents/HE_161+2016.pdf">https://www.eduskunta.fi/FI/vaski/HallituksenEsitys/Documents/HE_161+2016.pdf</a>	75	172	Sep 24th, 2016
<i>Sources used for triangulation:</i>						
Proposal of the Transport Act by the Parliament: Säädöshankepäätös.	Ministry of Transport and Communications	6.11.2015	Not online since 2019. Available from the authors.	6	50	Dec 3rd, 2017
Implementing the Governmental Program with the Transport Act.	Ministry of Transport and Communications	14.12.2015	Not online since 2019. Available from the authors.	9	21	Dec 11th, 2017
Blog post: Transport Act preparation is progressing.	Minister of Transport and Communications	17.12.2015	Not online since 2019. Available from the authors.	3	11	Dec 11th, 2017
The level of quality in transport services – a national perspective.	Ministry of Transport and Communications	17.12.2015	Not online since 2019. Available from the authors.	8	6	Dec 3rd, 2017
Services in the Transport Act.	Ministry of Transport and Communications	14.12.2015	Not online since 2019. Available from the authors.	6	2	Dec 9th, 2017
Digitalization of the transport industry, and transport services. Author: Minister of Transport and Communications	Minister of Transport and Communications	6.11.2015	Not online since 2019. Available from the authors.	20	61	Dec 9th, 2017
The media event of the Transport Act. Author: Ministry of Transport and Communications	Ministry of Transport and Communications	7.6.2016	Not online since 2019. Available from the authors.	8	8	Dec 3rd, 2017
Press release on Transport Act	Ministry of Transport and Communications	24.5.2017	<a href="https://www.lvm.fi/-/liikennepalvelulaki-mahdollistaa-hyvvat-ja-joustavat-liikenteen-palvelut-932759">https://www.lvm.fi/-/liikennepalvelulaki-mahdollistaa-hyvvat-ja-joustavat-liikenteen-palvelut-932759</a>	3	19	Dec 11th, 2017
Responsibilities of the Ministry of Transport and Communications, according to the Transport Act	Ministry of Transport and Communications	4.10.2017	Not online since 2019. Available from the authors.	9	10	Dec 11th, 2017
Act on transport services – Trafi's new tasks and how to prepare for them	Finnish Transport Safety Agency	11.10.2017	Not online since 2019. Available from the authors.	8	17	Dec 9th, 2017
Key changes in personnel logistics	Finnish Transport Safety Agency	20.10.2017	Not online since 2019. Available from the authors.	20	12	Dec 9th, 2017
Interoperability requirements in the Transport Act (17.10.2017)	Ministry of Transport and Communications	17.10.2017	Not online since 2019. Available from the authors.	20	19	Dec 9th, 2017
TOTAL				251	408	

## Appendix 2: Empirical data sources used in the ex-post analysis of the illustrative example

Document title		Release date	Document address	Nr. of pages	Nr. of codes identified	Accessed
<i>Main empirical source:</i>						
The proposal to change Traffic Act	Government of Finland	11.6.2020	<a href="https://www.lausuntopalvelu.fi/FI/Proposal/Participation?proposallid=5abdd40e-14b5-4f00-bd4d-d73fb7ee764d">https://www.lausuntopalvelu.fi/FI/Proposal/Participation?proposallid=5abdd40e-14b5-4f00-bd4d-d73fb7ee764d</a>	109	99	Nov 29th, 2020
<i>Sources used for triangulation:</i>						
Renewal of the traffic market needs openness and data disclosure for market participants – Traficom's supervision has already produced results	Traficom	1.7.2019	<a href="https://www.traficom.fi/fi/ajankohtaista/liikennemarkkinoiden-uudistuminen-ja-kasvuvaativat-avoimuutta-ja-tiedon">https://www.traficom.fi/fi/ajankohtaista/liikennemarkkinoiden-uudistuminen-ja-kasvuvaativat-avoimuutta-ja-tiedon</a>	4	3	Nov 29th, 2020
Mobility services increase customer choices: VR and HRT have opened their interfaces	Traficom	30.6.2020	<a href="https://www.traficom.fi/fi/ajankohtaista/liikemispalvelut-lisaavat-valinnanvapautta-ja-helpottavat-asiointia-vr-ja-hsl-ovat">https://www.traficom.fi/fi/ajankohtaista/liikemispalvelut-lisaavat-valinnanvapautta-ja-helpottavat-asiointia-vr-ja-hsl-ovat</a>	6	3	Nov 29th, 2020
The impact of Traffic Act is being monitored	Traficom	21.3.2019	<a href="https://www.traficom.fi/fi/ajankohtaista/liikennepalvelulain-vaiikutuksia-seurataan">https://www.traficom.fi/fi/ajankohtaista/liikennepalvelulain-vaiikutuksia-seurataan</a>	20	8	Nov 29th, 2020
The traffic market is digitalizing and servitizing as the market participants open their interfaces to each other	Traficom	29.3.2019	<a href="https://www.traficom.fi/fi/ajankohtaista/liikenne-digitalisoituu-ja-muuttuu-palveluksiyrytysten-avatus-rajapinnat">https://www.traficom.fi/fi/ajankohtaista/liikenne-digitalisoituu-ja-muuttuu-palveluksiyrytysten-avatus-rajapinnat</a>	2	2	Nov 29th, 2020
Taxi policy renewal has increased the number of taxis in Uusimaa, Lapland, and Varsinais-Suomi	Traficom	1.2.2019	<a href="https://www.traficom.fi/fi/ajankohtaista/taksiuudistus-lisannyt-taksien-maaraa-eniten-lisaysta-uudellamaalla-lapissa-ja">https://www.traficom.fi/fi/ajankohtaista/taksiuudistus-lisannyt-taksien-maaraa-eniten-lisaysta-uudellamaalla-lapissa-ja</a>	8	11	Nov 29th, 2020
Helsinki taxi market is not yet fully complying with the new regulations	Traficom	2.2.2019	<a href="https://www.traficom.fi/fi/ajankohtaista/helsingin-taksiliikenteessa-uusien-saannosten-noudattamisessa-viela-parannettavaa">https://www.traficom.fi/fi/ajankohtaista/helsingin-taksiliikenteessa-uusien-saannosten-noudattamisessa-viela-parannettavaa</a>	6	4	Nov 29th, 2020

(continued on next page)

(continued)

Document title	Release date	Document address	Nr. of pages	Nr. of codes identified	Accessed
Taxi market supervision revealed issues in Uusimaa area	Traficom 30.3.2019	<a href="https://www.traficom.fi/fi/ajankohtaista/taksiliikenteen-valvonta-paljasti-puutteita-asiakkaalle-ilmoitettavissa-tiedoissa-ja">https://www.traficom.fi/fi/ajankohtaista/taksiliikenteen-valvonta-paljasti-puutteita-asiakkaalle-ilmoitettavissa-tiedoissa-ja</a>	4	4	Nov 29th, 2020
TOTAL			159	134	

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