A multi-level perspective on innovation ecosystems for path-breaking innovation

A MULTI-LEVEL PERSPECTIVE ON INNOVATION ECOSYSTEMS FOR PATH-BREAKING INNOVATION

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ABSTRACT

Path-breaking innovations are increasingly developed and commercialized by networks of co-creating actors, called innovation ecosystems. Previous work in this area demonstrates that the 'internal' alignment of actors is critical to value creation in the innovation ecosystem. However, the literature has largely overlooked that the success of an innovation ecosystem also depends on its 'external' viability, determined by the broader socio-technical environment. That is, path-breaking innovations inherently challenge the prevailing socio-technical regime in a domain (e.g., established rules, artifacts and habits) that tends to be resistant to change. Overcoming this resistance is a major challenge for ventures pioneering path-breaking innovations. The paper contributes to the literature on innovation ecosystems by explicitly considering the socio-technical viability of the innovation ecosystem around a path-breaking innovation. In particular, we theorize about the objects of manipulation in an innovation ecosystem and discuss the strategies that a focal venture, orchestrating the innovation ecosystem, can employ in manipulating these objects so as to increase the socio-technical viability of the ecosystem. We arrive at a multi-level perspective on innovation ecosystem development that integrates internal alignment and external viability and informs a research agenda for future studies in this field.

Keywords: innovation ecosystem, path-breaking innovation, ecosystem strategy, strategic niche management, multi-level perspective, objects of manipulation.

INTRODUCTION

Across industries, there is an ongoing transformation from separate products and services toward complex value propositions which are accomplished by integrating complementary products and services of different actors (Adner, 2006, 2012; Podoynitsyna *et al.*, 2013). Referring to such a network where actors collectively create, deliver and appropriate value as an *innovation ecosystem* (henceforth: ecosystem) (Adner, 2012; Nambisan and Sawhney, 2011), innovation research has emphasized the importance for firms to consider an explicit ecosystem strategy (Adner, 2012, 2016). Correspondingly, in addition to managing their own technological and commercial challenges, an innovating venture needs also to consider how to align the different and often diverse actors supplying the complementary offerings towards accomplishing an integrated value proposition (Adner, 2016; Adner *et al.*, 2013; Koenig, 2012; Williamson and De Meyer, 2012). Previous ecosystem research has identified several strategies that a focal venture can pursue in creating such an alignment, including defining the respective modularity in the ecosystem (Nambisan and Sawhney, 2011), coordinating value creation activities across actors (Williamson and De Meyer, 2012), establishing technological standards (Koenig, 2012), and creating mechanisms for fair value appropriation (Iansiti and Levien, 2004). We refer to these activities of the focal venture towards aligning the different actors as the *internal development* of the ecosystem.

However, consider Better Place, the technology venture that developed a network of smart charging stations and battery swapping facilities, enabling a unique switchable battery electric car service (Shankar, 2009). The venture took the lead in developing an ecosystem that integrated, among others, a battery manufacturer, a car producer, a network of switching stations and the software and hardware elements needed to enable that network. In the process, they successfully engaged a relevant set of highly diverse parties into an ecosystem wide value proposition of revolutionary electric mobility (Ofek and Wagonfeld, 2012). As such, the strategies and operations applied by Better Place have been used as state-of-the-art examples of effective ecosystem (internal) development (Adner, 2012; Johnson and Suskewicz, 2009). Yet, in 2013, the venture filed for bankruptcy, due to disappointing sales of just under 2,000 of the initially planned 100,000 cars (Kershner, 2013).

Indeed, many ecosystems seeking to introduce *path-breaking* value propositions fail in the market place, even when technological challenges are overcome and alignment of key actors is achieved (cf. Adner, 2012). A key reason why these systems nevertheless fail is that path-breaking value propositions often meet strong societal resistance, as they conflict with the prevailing *socio-technical regime*—the rules, artifacts and habits that structure economic viability and social life in a particular domain (e.g., city transportation, home heating) (Geels, 2004; Geels and Schot, 2007; Nelson and Winter, 1982). Typically, large incumbent actors combined with strong social networks sustain the socio-technical regime, by carrying the dominant elements that keep a domain on a certain developmental path (Geels, 2004; Kemp, Loorbach, and Rotmans, 2007). A path-breaking value proposition tends to challenge (at least some of) the elements underlying a socio-technical regime and can thus only become successful if relevant societal subsystems adapt or transform to accommodate it (Nelson and Winter, 1982; Raven, 2007).

The complexity and nature of the broader socio-technical setting therefore gives rise to specific challenges for those ventures pioneering a path-breaking value proposition. These pioneers need to adopt particular strategies that increase the likelihood of societal stakeholders accepting and adopting the ecosystem's value proposition. Yet, to date, the literature on innovation ecosystems has not explicitly considered the socio-technical viability of the ecosystem around a path-breaking innovation; and whether and how the venture orchestrating the ecosystem can influence such viability.

In this paper, we draw on a quasi-evolutionary perspective, and in particular on the literature on transition and strategic niche management (e.g., Kemp, Schot, and Hoogma, 1998; Schot and Geels, 2007), to develop a framework of ecosystem development for path-breaking innovations. We contribute to the innovation ecosystem literature by introducing the concept of *external development* of the ecosystem, alongside its internal development, which refers to deliberate efforts directed to enhance the viability of the ecosystem in its broader socio-technical environment.

To this end, we first identify the ecosystem-level objects, that is the 'ecosystem's value proposition' and 'ecosystem model', which a focal venture can 'manipulate' in developing their innovation ecosystem. Previous research argues that a focal venture can manipulate these objects to improve the internal alignment of the ecosystem—which then determines the extent to which the ecosystem is able to create and deliver its value proposition (Adner, 2016; Adner and Kapoor, 2010; Iansiti and Levien, 2004). We draw from research on socio-technical transitions to detail how manipulating the ecosystem's value proposition and/or the ecosystem model based on feedback from the socio-technical environment can also be used to improve the ecosystem's external viability. As such, by explicating the objects and the basis of manipulation, we link together the internal and external development of the ecosystem as performed by a focal actor. The resulting framework informs a research agenda for future work in the area of innovation ecosystems and ecosystem strategy.

INNOVATION ECOSYSTEMS

Conceptualizing innovation ecosystems

In view of resource constraints and the need for specialization, it is difficult for any single firm to develop and commercialize a (technology-based) offering from start to finish (Kapoor and Furr, 2015; Clarysse *et al.*, 2014). This is especially the case if the intended innovation disrupts the existing development path in a socio-technical domain. Thus, increasingly complex constellations of organizations have been emerging, in the form of *innovation ecosystems*, in which actors interact with each other to create, deliver and appropriate value.

In this study, we apply the ‘ecosystem as structure’ conceptualization of innovation ecosystems as suggested by Adner (2016), Adner (2012) and Gulati, Puranam, and Tushman (2012), rather than the broader ‘ecosystem as affiliation’ conceptualizations proposed elsewhere (e.g., Autio and Thomas, 2014; Iansiti and Levien, 2004; Moore, 1993; Rong and Shi, 2015). Accordingly, the defining element of an innovation ecosystem is a system goal in the form of an overarching common offering, which we refer to as the *ecosystem’s value proposition* (EVP). Similar to the value proposition at the individual firm level, the EVP can be viewed as a statement about the deed (to be) performed, or the performance that is achieved for the end users when the contributions of the actors in the ecosystem network are successfully combined (Ulaga and Reinartz, 2011). The EVP as defining element of an ecosystem has the following implications.

The notion of a system goal suggests that meaningful boundaries for the ecosystem arise from those elements of the system that in interaction (are likely to) accomplish the EVP (Adner, 2016). These elements can only be identified from the viewpoint of an *end user* (Clarysse *et al.*, 2014). For example, a carmaker can integrate the entire vertical value chain in producing an electric vehicle. However, the perspective of the end user serves to reveal that, no matter how advanced the car is, a sustainable mobility experience (as EVP) is only achieved when the users can also conveniently charge it, for instance, via the infrastructure provided by local grid companies. In creating and delivering the EVP, the grid company is therefore a critical actor, even though it may have no direct transactional links with the value chain that produces the car. Such interdependencies can only be identified through considering the viewpoint of the end user, for whom the electric car and the ability to charge it are necessary *complementarities* (Nambisan and Sawhney, 2011).

The boundaries of the ecosystem are thus determined by the EVP to include such elements that are required to achieve the intended EVP. Consequently, any change in the EVP is likely to give rise to changes in the elements and/or the interactions of the elements of the ecosystem, and vice versa. In this respect, ecosystems can be understood as networks in which actors are co-evolving (Li, 2009; Moore, 1993). As such, the typically specialized actors in an ecosystem are *interdependent* in their efforts to accomplish the EVP (Adner, 2016; Adner *et al.*, 2013; Gulati *et al.*, 2012). However, interdependence also means that failure of any key actor to successfully contribute to the EVP negatively impacts the success chance of the whole ecosystem and thus every actor partaking in it (Brusoni and Prencipe, 2013). Furthermore, the embeddedness of actors in an ecosystem network implies that the ability of any particular actor to appropriate value for itself is influenced by the other actors (Nambisan and Sawhney, 2011). A defining element of ecosystems is thus also the distribution of appropriated value among its actors (Autio and Thomas, 2014).

We therefore define an *innovation ecosystem* as a network of interdependent actors who combine specialized yet complementary resources and/or capabilities in seeking to (a) co-create and deliver an overarching value proposition to end users, and (b) appropriate the gains received in the process.

Objects of manipulation

A common understanding, or alignment, among ecosystem actors about how to accomplish an intended EVP is a key condition for success of the ecosystem (Adner, 2012; Williamson and De Meyer, 2012). Yet, and especially for path-breaking value propositions, reaching alignment provides a serious challenge due to, for instance, differences in industrial contexts (Autio and Thomas, 2014; Moore, 1993), conflicting cultural backgrounds of the parties involved (Lavie, Haunschild, and Khanna, 2012), and initial misalignment in terms of the goals and intentions of key actors (Casadesus-Masanell and Yoffie, 2007; Kapoor and Lee, 2013; Sharapov, Thomas, and Autio, 2013). As such, despite the possibility that an ecosystem can be self-organized (Autio and Thomas, 2014; Williamson and De Meyer, 2012), most path-breaking innovation ecosystems need an entity that *orchestrates* the process of integrating the ecosystem and realizing its EVP (Iansiti and Levien, 2004; Nambisan and Sawhney, 2011). Such an orchestrating position is often assumed by a central innovator in the ecosystem—the so-called *focal* actor (Adner, 2012; Clarysse *et al.*, 2014). Accordingly, we focus in this paper on innovation ecosystems operating around a given focal venture that orchestrates (a) the EVP and (b) the alignment of the various actors in the ecosystem that surrounds such an EVP (Adner, 2006; Iansiti and Levien, 2004; Moore, 1993; Teece, 2007). This focal venture 'lens' resonates with recent (empirical) research on innovation ecosystems (e.g., Adner and Kapoor, 2010; Clarysse *et al.*, 2014; Kapoor and Lee, 2013; Williamson and De Meyer, 2012).

As the orchestrator of the ecosystem, and likely main proponent of the EVP, the focal venture can influence how the ecosystem as a whole operates (Nambisan and Sawhney, 2011). In this respect, the *ecosystem model* (EM) refers to the structure of how the ecosystem as a network creates and delivers value, and how value is appropriated by the actors in it (Adner, 2012; Thomas, Autio, and Gann, 2014; Williamson and De Meyer, 2012)—corresponding to the two main aspects emphasized in our definition of an innovation ecosystem. In particular, the EM encompasses the activities necessary for accomplishing the EVP, the actors performing these activities, the positioning of these actors in the ecosystem and the links specifying the transfers between these actors (Adner, 2016). As such, the EM is a network-oriented extension of the *business model* concept that specifies the value logic for an individual firm (Adner, 2016; Osterwalder and Pigneur, 2010; Zott, Amit, and Massa, 2011).

Given a specific EVP, a focal venture can influence the associated EM, both in terms of innovation as well as network design aspects (Nambisan and Sawhney, 2011; Thomas *et al.*, 2014). For example, it can develop an awareness of what a functional ecosystem might look like for accomplishing a specific EVP (Autio and Thomas, 2014; Overholm, 2015; Williamson and De Meyer, 2012). The focal venture can also affect the EM by defining the respective modularity in the ecosystem (Nambisan and Sawhney, 2011), choosing technological standards (Gawer and Cusumano, 2002), gaining insights into who/what could be the appropriate complementary actors/technologies to include in the ecosystem (Adner, 2012; Fjeldstad *et al.*, 2012; Koenig, 2012), and orchestrating these technological complementarities (Thomas, *et al.*, 2014). Moreover, the focal venture can coordinate alignment with regard to the activities contributed by the actors involved (Adner *et al.*, 2013; Koenig, 2012; Williamson and De Meyer, 2012), comprehend the flows of resources in the ecosystem (Adner, 2012; Nambisan and Sawhney, 2011), establish the resources and rules to be shared among the actors (Fjeldstad *et al.*, 2012; Koenig, 2012), design an incentive system for the ecosystem to attract new actors (Ritala *et al.*, 2013; Williamson and De Meyer, 2012), assure fair mechanisms for value appropriation (Dhanaraj and Parkhe, 2006; Iansiti and Levien, 2004; Thomas *et al.*, 2014), and establish mechanisms that lead to continuous self-renewal of the ecosystem (Iansiti and Levien, 2004; Moore, 1993, 1998). Previous research therefore suggests that ecosystems can be deliberately developed toward achieving an EVP and in doing so, the main object of manipulation is the EM, which can be manipulated by (a selection of) the strategies illustrated above.

However, developing an ecosystem is challenging for the focal venture, especially in view of the considerable effort required to adequately assess the vast number of options for building a complex system (Massa and Tucci, 2014). In this respect, many focal ventures initially struggle in choosing a strategy for the dimensions of the EM, given the uncertainty about which critical components and activities a functional EM might require (Autio and Thomas, 2014; Overholm, 2015; Williamson and De Meyer, 2012). In the early stages of the ecosystem, it may also be highly uncertain how effective the cooperation with other (potential) ecosystem actors will be and what kind of dynamics and interdependencies will emerge (Brown and Eisenhardt, 1997; Gulati *et al.*, 2012).

For example, Overholm (2015) describes how ventures offering solar panels as a service considered different kinds of partners, and engaged in a series of 'experiments' to determine how the relationships between actors in the ecosystem could be arranged to allow for the intended EVP to be realized. Notably, the question of who (and how) to include as an initial financing party in the service offering led these focal ventures to test multiple partner options. These ventures thus assumed the EVP to be fixed, but manipulated the (emerging) EM in an *iterative* manner, in order to converge to an increasingly better alignment between the EVP and the EM.

Conversely, Adner (2006, 2012) and Williamson and De Meyer (2012) argue the focal venture might first aim to achieve alignment between the EM and a less complex EVP, and then subsequently develop *both* elements toward greater complexity by attempting to incorporate new technological complementarities, activity structures and actor-network configurations in creating and delivering value. In addition to the EM, the EVP as an *intended* system goal can thus also be the object of manipulation.

More specifically, considering the uncertainties associated with path-breaking value propositions, developing the ecosystem constitutes a dialectic process (Van de Ven and Poole, 1995) in which the focal venture attempts to manipulate the EVP and EM, challenged by the complexity of the situation and the other actors involved (Adner, 2012). The synthesis of these antagonistic forces informs subsequent attempts to align the ecosystem, giving rise to new experiments around a different EVP and/or EM (Gavetti, Levinthal, and Rivkin, 2008). Here, a key strategy for the orchestrating venture is to adopt *feedback-driven learning*, in which one perceives the current EVP and EM as experimental propositions to be tried out (Adner, 2012; Gavetti *et al.*, 2008; Schön, 1984). Ideally, the EM fully enables the creation and delivery of the EVP. We characterize this ideal state by a high level of internal alignment of the ecosystem (Adner, 2016; Adner et al., 2013; Nambisan and Sawhney, 2011). Correspondingly, the *internal development* of the ecosystem refers to the focal venture's efforts to increase internal alignment by manipulating the EVP, the EM, or both.

External viability of the ecosystem

Achieving internal alignment is, however, just one side of the coin. Especially for those ventures that are developing an ecosystem around a path-breaking innovation (Smith and Raven, 2012) another major challenge is to achieve viability of the ecosystem in its broader socio-technical environment (Nambisan and Sawhney, 2011). More specifically, an evolutionary perspective implies technology development in society involves a process of variation, selection and retention (Basalla, 1988; Nelson and Winter, 1982). Path-breaking innovations represent a dramatic departure from the current development trajectory in a particular domain (Birkinshaw, Bessant, and Delbridge, 2007; Smith and Raven, 2012). Such innovations are, therefore, subject to the selection environment that is dominated by a *socio-technical regime*: the currently prevailing collection of artifacts, habits and the action-guiding rules about the domain which are upheld by a wide actor network surrounding a vested solution (Geels, 2004, 2005; Raven, 2007). The established actors backing these solutions have usually invested substantially in the existing regime—for example in terms of infrastructure (Nelson and Winter, 1982; Raven, 2007)—and thus prefer incremental improvements that build on existing artifacts, rules and habits in use. As a result, the dominant socio-technical regime creates a high level of retention, as most resources and attention get channeled to improving the existing and proven solutions (Adner and Snow, 2010; MacKenzie, 1992). Consequently, path-breaking innovations are at a structural disadvantage in the selection environment because they are simply too demanding in terms of their socio-technical implications to the regime (Smith and Raven, 2012).

The lock-in in the selection environment goes beyond the user and market dimensions, to include public policies and institutions, infrastructure, cultural discourse, and maintenance networks (Lie and Sørensen, 1996). Moreover, there may be no established markets and user preferences to start with, so an initial interface with potential adopters may be absent. Finally, the adoption process itself is not straightforward either, as users have to integrate the innovative solution into their infrastructure, practices, organizations and routines—all of which involves adjustments and time (Geels, 2002) and may be subject to retention of the dominant regime. In this respect, so-called *transitions* of the socio-technical regime are quite rare, take a long time, and follow a rather unpredictable path (Geels, 2004).

For example, in the context of mobility, the current socio-technical regime entails vehicles based on internal combustion engines; and the behavioral patterns and infrastructure enabled and supported by this regime accommodate and prioritize this particular approach to mobility. This, in turn, inhibits any development that is not in line with the regime. For ventures developing a path-breaking EVP (e.g., Better Place), the socio-technical regime's inertial forces thus present a formidable challenge (Geels, 2004). In developing the ecosystem for a path-breaking innovation, internal alignment is therefore not sufficient; a successful ecosystem also arises from its socio-technical fitness or *external viability*. Consequently, the *external development* of the ecosystem pertains to the interaction of the focal venture and other key actors with their socio-technical selection environment in order to increase the external viability of the ecosystem.

DEVELOPING A PATH-BREAKING INNOVATION ECOSYSTEM

In the remainder of the paper, we seek to develop a systemic framework that considers the internal as well as the external development of the ecosystem. We do so by drawing from the strategic niche management (SNM) discourse. The literature on SNM involves (public) policy-oriented studies that, based on evolutionary theory (Basalla, 1988; Levinthal, 1998; Nelson and Winter, 1982) and a dynamic multi-level perspective (Geels, 2002), investigate the mechanisms that facilitate the development and commercialization of path-breaking innovations (Huijben and Verbong, 2013; Markard, Raven, and Truffer, 2012; Smith and Raven, 2012). As such, SNM proposes a set of policy strategies for overcoming the potentially hostile influence of the socio-technical regime on a path-breaking innovation. These strategies have been successfully applied in domains such as biogas (Raven *et al.*, 2008), social entrepreneurship (Witkamp, Raven, and Royakkers, 2011), long-term care (Loorbach and Rotmans, 2010), and eco-housing and organic food (Smith, 2007). The set of SNM strategies provides a foundation for the framework of innovation ecosystem development proposed in this section—however, contrary to the public policy-orientation prevailing in the SNM literature, we operationalize the strategies of the focal venture as propositions at the venture/firm level, directed toward the external development of a given ecosystem.

The core argument of SNM is that actors operating in a particular upcoming technology domain (need to) collectively maintain a so-called (*socio-)technical niche*—the unit of analysis in SNM. This particular type of niche constitutes a community of actors who are interested in influencing the development (trajectory) of the particular domain (Geels, 2002). It is thus a cross-functional group, consisting not only of different innovation ecosystems (applying related technologies), but also of, for example, universities, scientists, NGOs, associations and policy makers (Geels, 2004). In the dynamic multi-level perspective (Geels, 2002), the niche constitutes a system level that is located *between* the single actors/ecosystems and the broader environment dominated by a prevailing socio-technical regime. Positioned as such, activities on the niche level can significantly counteract the retention and inertia of the socio-technical regime (Schot and Geels, 2008; Smith and Raven, 2012) and thus mediate the influence of mainstream selection forces on the path-breaking innovation. The positioning of the different levels is presented in Figure 1.

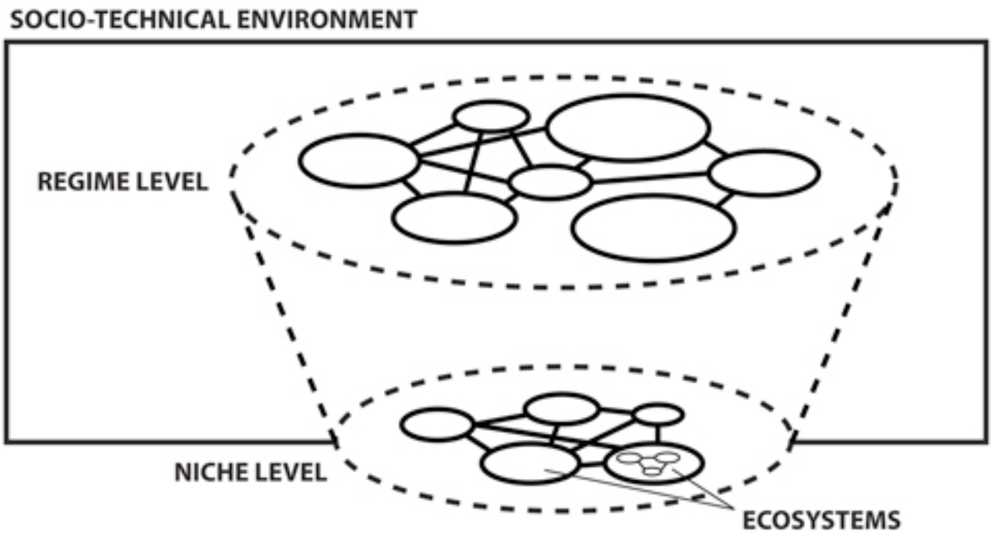

Fig. 1. A multilevel perspective on innovation ecosystems.

The socio-technical niche somewhat resembles the 'fuzzy front end' of an emerging industry (Suarez, Grodal, and Gotsopoulos, 2015), characterized by great uncertainty about the technology and market, which results in a wide diversity of technological and market approaches adopted by the actors within the niche (Geels, 2004). However, a niche emerges, by definition, in the face of an existing socio-technical regime, the latter hindering progression of path-breaking innovations promoted in the niche. Therefore, the relational dynamics within the niche are likely to differ substantially from the competition-oriented behavior observed in some early-stage industries (e.g., Santos and Eisenhardt, 2009). In this respect, a socio-technical niche invokes more cooperation between actors, as a means to survive and challenge the dominant regime (Raven, van den Bosch, and Weterings, 2010). An example is the international network of stakeholders collectively pioneering the use of building-integrated photovoltaics: these various kinds of enterprises, non-profit organizations and other actors actively seek a common agenda and action framework, to increase the societal prominence and commercial application of the proposed technology.

The SNM literature suggests four strategic principles to develop and commercialize path-breaking innovations in the face of an unfavorable selection environment. That is, niche actors should: (1) engage in socio-technical experimentation; (2) maintain a collective knowledge base; (3) converge their efforts in getting the technology widely adopted; and (4) achieve and take advantage of protection measures that help sustain the niche and its participants (Raven *et al.*, 2010). The principles together serve to inform the external development of the ecosystem. In this respect, while previous research suggests that the EVP and EM can be manipulated to achieve internal alignment, we argue that the principles, as developed by SNM scholars, inform the basis for manipulating the EVP and EM to achieve external viability of the innovation ecosystem. In particular, we posit that driving the innovation ecosystem towards overall success is dependent *both* on 'internal' (as elaborated earlier) as well as 'external' feedback-driven action.

External viability and socio-technical experimentation

In a situation where markets and user preferences are underdeveloped, niche actors can seek to enhance the reciprocity (i.e., co-evolution) between their niche and the socio-technical environment (Geels, 2005). The central driver of this reciprocity is *socio-technical experimentation*, involving attempts to engage the (potential) stakeholders in the environment to interact with the niche actors and their offerings (Raven *et al.*, 2010). To be effective in enhancing reciprocity, this experimentation strategy calls for repeated interaction and continual learning from feedback arising from the interactions. In the context of path-breaking innovation ecosystems, this implies that any EVP and EM are treated as no more than current 'best estimates' that are iteratively exposed to the socio-technical environment to trigger responses that inform subsequent experiments (Gavetti *et al.*, 2008; Lynn, Morone, and Paulson, 1996; Voss, 1984). In doing so, external viability is enhanced via two mechanisms.

First, the focal venture can gain feedback concerning the viability of the current EVP-EM combination by means of pilot cases, living labs, user tests, and other forms of socio-technical experimentation (Hoogma, 2002). These experimentation modes also serve to create a better understanding of the characteristics of the selection environment and the level of discrepancy between the two (Geels and Raven, 2006). More specifically, by introducing versions of the EVP-EM to prospective users, policy makers and support organizations, the focal venture can measure their responses in terms of potential enablers as well as barriers to adopting/supporting it. Such data provides valuable cues about the actual strength of the regime lock-in as well as the changes needed to overcome it. For instance, in case of a strong lock-in arising from the dominant regime, the focal venture and its partners may steer toward versions of the EVP and EM that challenge the regime less (Raven, 2007). Experimentation can thus serve to grow the level of acceptance regarding the EVP in the selection environment, by leading the ecosystem to *adapt* its EVP and/or EM to the existing rules, habits and artifacts in the environment.

An example of such a deliberate learning strategy is the innovation ecosystem orchestrated by the Dutch venture Qurrent. Qurrent's ecosystem aimed to offer a range of devices and services enabling the creation of small local energy networks. This ecosystem experimented with several EVPs and EMs, engaging a combination of municipalities, housing corporations, an office real estate developer, private residence owners, a utility company and a manufacturer of heat pumps (Ceschin, 2013). In each case, Qurrent measured the opportunities for technical integration as well as the societal response. The overall purpose of Qurrent's experimentation strategy was to understand which EVP might gain the highest adoption rate, which user segments it would need to target, which EM it would correspond to, and who would be viable actors to include in the ecosystem (Ceschin, 2013).

Second, socio-technical experimentation is also instrumental in asserting influence to the selection environment, especially by gradually building support for the new EVP as a potential alternative to the technologies/solutions established and enabled by the dominant regime (Raven *et al.*, 2008). First, via socio-technical experimentation, the ecosystem can grow awareness of the potential need in terms of its EVP. Second, the novel offering is exposed to various stakeholders, increasing the chances that at least some of them may choose to experiment with and subsequently adopt the novel rules, artifacts and habits involved. Third, experimentation invites institutional stakeholders, such as governmental agencies, public media or NGOs, to pay attention to what the ecosystem is offering (Schot and Geels, 2007), which can be critical in sculpting (a positive) public opinion about the EVP. Socio-technical experimentation can thus serve to increase the acceptance and legitimacy of the EVP, by gradually leading the environment to *alter itself*.

For example Tesla Motors, the electric vehicle manufacturer, at the time steered its ecosystem to develop and launch their first full-electric car models in the high-price segment. Introducing the EVP of a sustainable but also fast and luxury vehicle that is little bound by range limitations has been instrumental in growing the societal awareness of ecological mobility. In this respect, Tesla's offering has challenged conventional beliefs regarding the shortcomings of electric mobility, and in doing so, also raised a significant amount of public attention, as well as motivated an increasingly growing number of customers to buy Tesla's vehicles (Hurst, 2014). In sum, we formulate the proposition, defined from a focal venture perspective:

> ***P1.*** *Developing the EVP and EM iteratively, informed by feedback from socio-technical experimentation, serves to increase the external viability of the ecosystem*[1].

Empirical work informed by this proposition can draw on longitudinal studies of ecosystems to identify whether and how ecosystem actors have installed deliberate learning mechanisms (Almeida, Dokko, and Rosenkopf, 2003), what the critical (events in) interactions with actors *outside* the ecosystem are, and whether and how these learnings and interactions inform the development of the EVP and EM.

To measure the external viability of the ecosystem, one could draw on (a) formal analysis of the total value appropriated by the actors in the ecosystem (e.g., Garcia-Castro and Aguilera, 2015); (b) financial analysis of the individual performance of these actors; (c) content analysis of data collected from public and social media, to assess the public sentiment regarding the EVP (e.g., Riffe, Lacy, and Fico, 2013); and (d) analysis of survey data (e.g., Berger and Schwartz, 2011). Finally, incumbent regime actors might be probed for information on the particular technological niches and innovation ecosystem (actors) challenging the regime, for instance by means of interviews.

External viability and inter-local learning

While engaging in socio-technical experimentation can improve the external viability of the ecosystem, it may take (too) many iterations that are likely to drain the constrained resources available within the ecosystem, hampering the ability to experiment further. In addition to

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[1] We emphasize that previous research highlights the importance of experimentation for the *internal* development of the innovation ecosystem (e.g., Adner, 2016). Here, we specifically stress the importance of socio-technical experimentation as a source for feedback in *external* development of the ecosystem.

resource constraints, the focal venture and other ecosystem actors also have a tendency towards satisficing (Geels, 2010; Simon, 1956) and due to the limited number of options considered in their own local search, sub-optimal versions of the EVP and EM are likely to be chosen.

In light of these issues, SNM theory implies that, to be more effective at increasing the external viability of the niche offering, actors in the niche should converge to a common knowledge base (Raven *et al.*, 2010). Here, the core driver is so-called *inter-local learning*, that is, learning from the lessons of others in other local contexts (Raven *et al.*, 2008). For the focal venture, complementing its own experimentation by means of sharing knowledge across different ecosystems and different institutional settings accelerates the learning curve and reduces the risk of sub-optimality. External viability is thus created by learning from others to more effectively develop those EVP-EM combinations (and subsequent experiments) that are receiving a level of success (i.e., have not been 'eliminated') in interacting with the selection environment.

This kind of learning can be reciprocal in nature, when actors across ecosystems jointly discover and blend knowledge and skills in repeated interactions (Lubatkin, Florin, and Lane, 2001). The local learning of each actor is then extended toward more distant learning that benefits all parties (Rosenkopf and Almeida, 2003). Reciprocal learning is more likely to happen with help of a third-party facilitator, such as an industry association or a governmental agency (Rotmans and Loorbach, 2006).

Alternatively, a focal venture can employ associative reasoning and carry over information (Schön, 1984) by imitating the behavior of organizations and ecosystems that they perceive as analogous. Strategy scholars have long advocated this approach to learn from the practices of the best performing organizations in the field, or to avoid mistakes made by others (Casadesus-Masanell and Zhu, 2013; Csaszar and Siggelkow, 2010; Gavetti, Levinthal, and Rivkin, 2005). In contrast to reciprocal learning, imitation does not require the consent of the model/benchmark organization. For example, Overholm (2015) observed that new entrants to the emerging solar service industry in the US followed the logic (cf. EM) of previous entrants in building their ecosystems, even using the same bank as the incumbents had chosen to work with. While imitation without consent may reduce the quality of (knowledge about) the benchmark (Amit and Zott, 2012), even irrelevant analogies tend to provide better results than making decisions solely based on one's local optimum (Gavetti *et al*., 2008).

Ryanair, the Irish company that built the first low-fare airline operation in Europe, provides an example of inter-local learning. In the late 1980s, Ryanair already adopted a price advantage strategy. However, after the general collapse of the airline industry during the Gulf War, the firm set out to introduce in Europe the value proposition that Southwest Airlines had developed successfully in North America (Regani and Dutta, 2003). In 1991, the deputy CEO visited Southwest in Dallas to obtain detailed information about the operating logic of the American benchmark (Maier, 2006). Rather than merely introducing single elements, Ryanair was able to carry over much of the EM that Southwest had pioneered. This included 1) standardizing the fleet; like Southwest, Ryanair chose to exclusively partner with Boeing; 2) flying to secondary airports where the costs per passenger were much lower than at major ones; 3) fast turnaround times and point-to-point flights; and 4) mediating extra services from a network of partners such as hotels, transfer services, car rental offices and insurance providers (O'Higgins, 1999; Regani and Dutta, 2003). In conclusion, this suggests the following proposition, again defined from a focal venture perspective:

> ***P2.*** *Developing the EVP and EM by learning from the experiences of other organizations that have pioneered (somewhat or highly) similar path-breaking innovations, serves to increase the external viability of the ecosystem.*

Future empirical work informed by this proposition can operationalize the learning variable in terms of knowledge transfer across ecosystem boundaries (Maurer, Bartsch, and Ebers, 2011), drawing on survey data (Li, 2005) and social network analysis (Sammarra and Biggiero, 2008). Additionally, learning from others in the niche can in some contexts be considered a 'knowledge spillover', which can be measured, for instance, by means of patent analysis (Jaffe, Trajfenberg, and Henderson, 1993).

External viability and niche trajectory

In SNM theory, the niche is seen as a source of disturbance for the progress of the dominant socio-technical regime. That is, a niche provides an alternative (potential) trajectory to societal and industrial development in a domain (e.g., transportation, health care) (Geels, 2002). However, this alternative trajectory cannot be explored and sustained by learning from peers only (i.e., P2). Another driving force arises from sequences of experiments in different local contexts, which gradually add up to a niche trajectory (Geels and Raven, 2006). As a result, the initially divergent and dispersed processes and routines become more articulated, specific and stable over time (Raven *et al.*, 2010). Together with these changes, any approach to commercializing the new technology that follows these (increasingly articulated and stable) processes and routines is more likely to survive and thrive (Schot and Geels, 2008).

In this respect, convergence toward a particular (set of) EVP(s) and EM(s) will substantially affect which propositions and models are externally viable in the long run, and which are not (Suarez *et al.*, 2015). For example, in the case of a substantial and unexpected surge in market demand arising from a new EVP, other actors/ecosystems in the same niche are likely to imitate it (Argyres, Bigelow, and Nickerson, 2015), which in turn brings in resources and institutional support that further enhance the emerging path (Raven, 2007). This 'bandwagon' effect amplifies the external viability of the particular EVPs and EMs in at least two ways. First, the increasing number of actors supporting the development trajectory for the niche empowers the lobby for specific protection measures that would support it (Kemp *et al.*, 2007). For instance, as a result of lobbying efforts for sustainable energy, (local) governments have adopted policies that enable specific solutions in this area. Examples of this would be the German 1,000 Roof and 100,000 Roof programs that provided financial support to owners of residential photovoltaic solar panels, building the foundation for the German *residential* solar market to grow exponentially for more than two decades (Bergek and Jacobsson, 2003).

Second, niche actors are also likely to collectively influence the market, user practices, routines, policies, cultural discourse, infrastructure, and maintenance networks more than any single actor (Lie and Sørensen, 1996). Here, the convergence in their interactions with the socio-technical environment and increasing public exposure enhances the cognitive as well as socio-political legitimacy of the niche trajectory (cf. Aldrich and Fiol, 1994). For instance, Smith (2007) studied such a process for organic food in the UK. The initially small niche of organic producers converged explicitly on matters such as supply chain composition, organic labeling and joint marketing. As a result, since the 1990s, the organic food movement has been gaining substantial societal support, and was adopted as part of the processed and packaged food regime in the UK.

If the focal venture timely spots an emerging trajectory in terms of a distinctive EVP and EM becoming more prevalent in the niche, aligning to that trajectory is likely to make the venture's ecosystem more externally viable. Timely spotting any convergence in the niche is largely a question of the (cognitive) abilities of people in the focal venture and other actors in its ecosystem. Cues may arise in the form of, for example, innovation shocks (Argyres *et al.*, 2015), emergence of dominant categories (Suarez *et al.*, 2015), or protection measures that selectively support certain offerings (Kemp *et al.*, 2007). Furthermore, once a potential trajectory is identified, the ease with which the ecosystem can be repositioned toward an emerging path is determined by the available resources of the focal venture and its ecosystem partners (Argyres *et al.*, 2015). In other words, repositioning is less risky and takes less effort when the focal venture and its key partners possess information and capabilities relevant to the approach adopted—providing further support for P1 and P2. In sum, we propose:

> ***P3.*** *Aligning the EVP and EM with the development trajectory that is emerging in the socio-technical niche serves to increase the external viability of the ecosystem.*

Empirical work informed by P3 can draw on the notion of innovation shocks, dominant categories, and specific protection schemes as proxies for the emergence and convergence of a niche development trajectory. These trajectories can be inferred from qualitative data, in terms of dominant EVPs and EMs, using content analysis of keywords that refer to specific propositions and models (e.g., Pontikes, 2012). The work on 'dominant designs' (Abernathy and Utterback, 1978), and how to measure such designs (e.g., through market share analyses and/or expert interviews), might also be utilized as inspiration on how to measure emerging development trajectories (Anderson and Tushman, 1990; Srinivasan, Lilien, and Rangaswamy, 2006).

Sustaining ecosystem development

SNM theory postulates that any niche emerging in the context of a dominant socio-technical regime needs protection in its early stages, as the niche actors are not likely to survive the full selection pressure if exposed to it too early (Smith and Raven, 2012). Protection can come in financial and non-financial forms. The former can take shape as subsidies, tax breaks, grants, or market stimulation mechanisms. An example would be the support scheme that the Dutch government has developed for supporting large scale renewable energy generation. Namely, considering the financial disadvantage of renewable energy generation compared to fossil alternatives, producers of renewable energy are compensated for that difference with a feed-in tariff the size of which is determined by the price dynamics of fossil-based energy (Chatelin, 2016). Non-financial forms of protection include for example policy support, legal requirements, education and public appraisal (of the niche's EVPs at the expense of alternative EVPs). Examples of non-financial forms of support would be the entrepreneurial education programs run by European Institute of Innovation & Technology Knowledge Innovation Communities. Such programs provide entrepreneurial education to individuals with an engineering background on strategically important areas, such as climate change, sustainable energy and raw materials (EIT, 2016). The various forms of protection are provided by either governmental agencies or other stakeholders interested in developing the niche (Huijben and Verbong, 2013; Smith and Raven, 2012), possibly as a result of lobbying efforts by niche actors.

For any ecosystem, the usage of niche protection measures provides the space and time to develop the internal alignment and external viability of its (emerging) EVP-EM, and thus make the ecosystem increasingly fit to face the socio-technical selection environment. In other words, while protection creates neither internal alignment, nor external viability *per se*, it 'buys time' for the focal venture and its ecosystem to develop, learn and grow in terms of the mechanisms outlined in P1 to P3. We therefore propose that:

> ***P4a.*** *The use of niche protection schemes enables the focal venture and other ecosystem actors to exploit the mechanisms defined in P1, P2 and P3, and thus serves to indirectly increase the external viability of their ecosystem.*

The level of available resources, other than those originating from protection schemes, is also likely to enable the ecosystem to develop, learn and grow. That is, ecosystems without any slack in resources, such as financial assets and human resources, have to be much more selective in engaging in the activities outlined in P1 to P3, compared to ecosystems with substantial resource slack (cf. George, 2005). In this respect, a high level of resource slack provides a buffer that allows for more time and discretion in responding to the challenges arising from, for example, the interaction with potential customers, other focal ventures and their ecosystems, and the emerging niche trajectory (Bradley, Shepherd, and Wiklund, 2011; Dolmans *et al.*, 2014). This suggests the following proposition:

> ***P4b.*** *Resource slack enables the focal venture and other ecosystem actors to exploit the mechanisms defined in P1, P2 and P3, and thus serves to indirectly increase the external viability of their ecosystem.*

Future empirical work informed by proposition 4a-b might draw on data such as the number and size of (governmental or other) grants, subsidies or tax breaks the niche and specific ecosystems within the niche have received or indirectly benefited from, in addition to firm-specific measures such as a federal loan (e.g., Tesla's loans from the US federal government) investment capital obtained from external investors, and so forth. Resource slack, for proposition 4b, is typically operationalized on the basis of current assets and liabilities (e.g., current ratio). Future work, however, needs to consider that resource slack entails a perception at the decision-making level, which would likely demand a more fine-grained (qualitative) measure (see Dolmans *et al*., 2014).

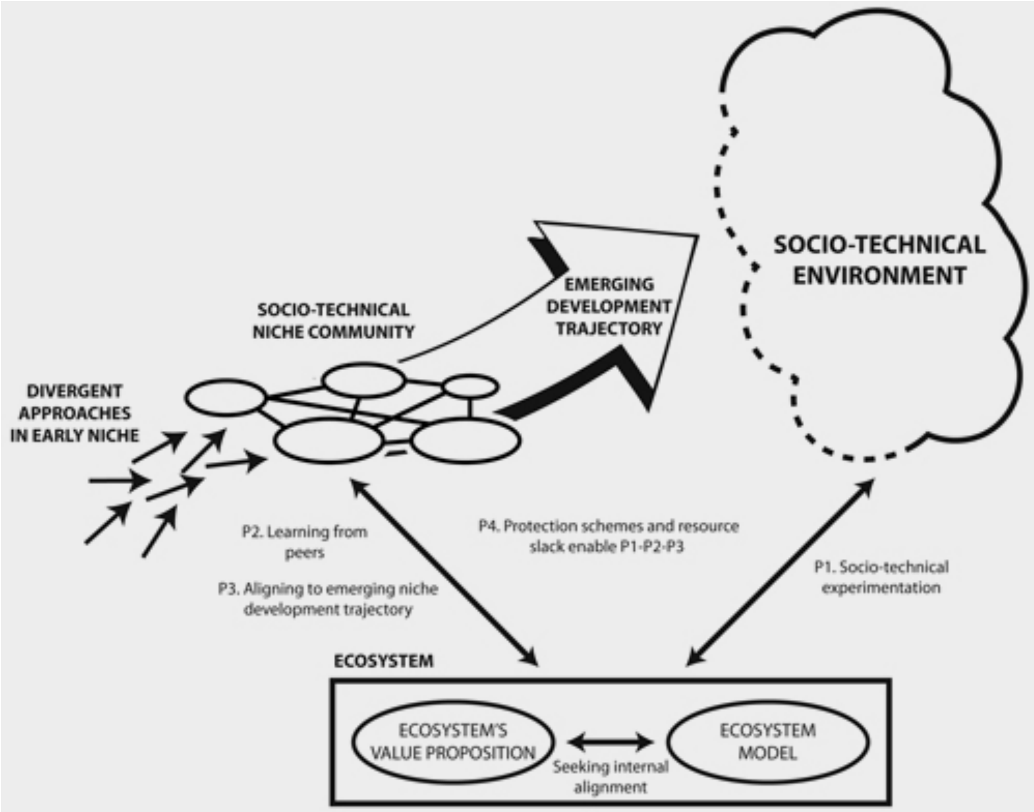

Fig. 2. Ecosystem development for path-breaking innovations.

DISCUSSION

Figure 2 outlines a multi-level perspective on how a focal venture should enhance both the internal alignment and the external viability of its innovation ecosystem. Previous research suggests that the focal venture may manipulate the EVP and/or EM to improve the internal alignment in the ecosystem (Adner, 2016). In this research, we have argued that internal alignment is not sufficient for the success an ecosystem that is trying to develop a path-breaking innovation. Here, a focal venture and associated ecosystem also need to carefully consider and learn from the selection environment surrounding them, in order to develop external viability; that is, by manipulating the EVM and/or EM using feedback obtained from the socio-technical environment.

More specifically, in the first feedback interface, the ecosystem actors interact directly with the socio-technical environment via experimentation activities (see P1). Socio-technical experimentation further informs changes in the EVP and EM, as well as asserts influence to the environment. Furthermore, the focal venture can draw in its ecosystem development activities from peers by means of inter-local learning (P2, the second feedback interface) as well as from the collective agency on the socio-technical niche level, which may lead to convergence of certain EVPs and/or EMs (P3, the third feedback interface). Acquiring feedback for ecosystem development from these three levels is enabled by resource slack and protection mechanisms, typically assigned first to the niche as a whole, and then exploited by the focal venture and other ecosystem actors for sustaining the development of their ecosystem (P4).

A case featuring such niche protection as well as the use of all three feedback interfaces in ecosystem development can be found from the US residential solar industry. First, the market for residential solar was largely enabled by a protection measure in the form of the US Energy Policy Act (2005) that allowed residential solar installers to receive a 30% investment tax credit (P4) (Hannah and Eisenhardt, 2016). Second, focal ventures such as Solarcity, and Sunedison developed their ecosystems consistently through socio-technical experimentation with each next installation, often with different partners in different geographical regions, providing feedback to their EM (P1) (Overholm, 2015). Third, taking analogy from peers was a commonly used strategy in ecosystem development, especially considering EM design questions such as which elements of the EVP to outsource versus which to internalize, which parties to collaborate with, and how to support the partner networks (P2) (Hannah and Eisenhardt, 2016; Overholm, 2015). Fourth, as the EVPs in the industry were developing over time, the niche featured several points of convergence where a certain EM composition allowed focal ventures to achieve continued growth. In particular, Hannah and Eisenhardt (2016) illustrate how the success of these ventures highly depended on their ability to steer their ecosystem strategy according to the convergence in the development trajectory of the niche with regard to the means of targeting cost savings (P3).

With the framework, our paper contributes to the literature on innovation ecosystems by explicitly considering the socio-technical viability of the ecosystem around a path-breaking innovation. To guide future (empirical) work on this framework, we provided potential measures for the concepts featured in the different propositions above. In the remainder of this section, we present an additional research agenda informed by the framework.

The role of experimentation. A key implication of our framework is that both the EVP and the EM can be the target of innovation efforts, similar to how the firm-centric value proposition and its corresponding business model have become the objects of innovation (e.g., McGrath, 2010; Zott *et al.*, 2011). The focal venture can orchestrate the development of an ecosystem iteratively via experimenting with different EVPs and EMs, changing the way the ecosystem as a whole creates, delivers and appropriates value. For the focal venture, deliberately experimenting with these elements therefore constitutes an important element of its ecosystem strategy, which thus far has received little attention (cf. Adner, 2006; Adner and Kapoor, 2010; Kapoor and Furr, 2015; Kapoor and Lee, 2013). Our framework also raises several research questions for future work in the area. For example, research might explore the extent to which testing and experimentation activities provide diminishing returns, and when the focal venture should settle on a specific ecosystem configuration (Sommer and Loch, 2004); how the focal venture balances its resource constraints with the perceived need to continue experimenting; and how the focal venture's experimentation activity affects the behavior of other actors in the ecosystem. The latter question is particularly relevant, considering that external feedback is (a) likely to disturb the ecosystem's internal alignment and (b) a precondition for long-term value appropriation opportunities for ecosystem actors, which seems to imply that the external development of the ecosystem should take prominence over its internal development. How to alleviate the resulting tensions between actors is left for future research.

Prioritizing feedback. Related to the previous, to what extent should a focal venture and its ecosystem partners use their (limited) resources on each of the strategies of external development of the ecosystem? While this is predominantly a question for future research, there appears to be a trade off in the resource use (P4) and the contextual accuracy of the sources of feedback (P1 to P3). Own experimentation implies placing the EVP into its intended context. The mechanisms presented in the argumentation for Proposition 1 are thus fully operational, either towards building support for the EVP or towards providing feedback for further developing the ecosystem in that context. At the same time, such experimentation likely entails a high resource commitment. Meanwhile, inter-local learning (P2) or aligning to the emerging development trajectory of the niche (P3) is lighter in terms of resource necessity, but can render feedback that is perhaps not directly applicable in the ecosystem's context, due to its more holistic nature. How to balance the ecosystem external development activities over the three feedback interfaces is an important strategic consideration for the focal venture; one that is likely dependent on factors such as the existence of appropriate peers, the maturity of the niche, level of context-specific elements in the domain (such as legislative control), as well as uniqueness and replicability of key EM elements (Overholm, 2015). As such, future research could, besides extending this list of factors, study what specific form of feedback interface is most effective for ecosystem external development, at what moment in time.

Strategies for manipulation. In this study, we focused on creating an understanding about how a focal firm can use feedback-driven learning from the socio-technical environment to develop its ecosystem's external validity. We have, however, implicitly assumed that the focal venture can manipulate the EVP and/or EM if achieving such external viability (or internal alignment for that matter) would require so. In reality, however, attempting to manipulate the ecosystem is likely subject to misaligned agendas (Casadesus-Masanell and Yoffie, 2007), power struggles, and interplay between independent, interdependent and dependent elements of the ecosystem structure (Adner, 2016). Sculpting an ecosystem strategy would thus be much more than a question of knowing which direction to steer it. Although research provides some cues (as also outlined in this paper), future studies on innovation ecosystems should investigate (a) how agents incentivize others to align to their (path-breaking) EVP; (b) how to sculpt a value distribution logic for a future ecosystem constellation (Dhanaraj and Parkhe, 2006) before it is fully clear how much value will there be available for appropriation; (c) how to assert influence on the actors with whom the ecosystem has an asymmetric dependence: for instance, actors that perform activities that are necessary for the EVP to be realized, but who themselves are largely indifferent to being part of the ecosystem constellation (Adner, 2016); and (d) how to increase the resilience of the ecosystem in dealing with the failures of some actors to (re)align to the EVP.

Ecosystem management as dynamic capability. Our framework also implies that ecosystem management by the focal venture can be studied from a dynamic capability perspective (Eisenhardt and Martin, 2000; Teece, Pisano, and Shuen, 1997), that is, 'the capacity of an organization to purposefully create, extend, or modify its resource base' (Helfat *et al.*, 2007: 4). As argued earlier, ecosystem actors provide critical resources such as knowledge, complementary products and market distribution channels for the EVP and EM orchestrated by the focal venture (Mahmood, Zhu, and Zajac, 2011). In this respect, the primary resource base for accomplishing the EVP is located at the ecosystem level, as opposed to the venture or firm level. As changes at the ecosystem, niche and/or regime levels unfold, the focal venture thus needs to possess a dynamic capability to keep the EVP viable by sensing and seizing these changes and managing the experimentation-driven transformation of the EVP and EM implied by them. In this respect, a promising avenue for future research might arise from developing the micro-foundations of ecosystem management as dynamic capability (cf. Helfat *et al.*, 2007), for instance in understanding how particular individuals as agents of ecosystem actors make sense of the shifts at the ecosystem, niche and/or regime level and sculpt strategies for (re-)steering the EVP and/or EM.

The faster the better? The speed and phasing of socio-technical transitions constitute critical challenges for technology ventures. While punctuated equilibrium theory suggests that, at times, the socio-technical environment accommodates path-breaking innovations quite rapidly (Anderson and Tushman, 1990; Mokyr, 1990), it is more realistic for path-breaking innovators to adopt a longer time horizon in trying to accomplish their EVP (Geels, 2005), in line with Adner's (2012) notion of 'staged expansion'. In this respect, technological development trajectories are often characterized by several episodes of S-shaped growth (Christensen, 1992a, 1992b) and socio-technical transition processes evolve through a series of thresholds (Gold, 1983), where the speed of change is difficult to predict. Indeed, part of the failure of Better Place's ecosystem (see Introduction) can be attributed to underestimating the resistance arising from the prevailing mobility regime. In particular, Better Place's CEO assumed and expected a high rate of change of the dominant socio-technical regime would be achieved (Ofek and Wagonfeld, 2012), an assumption that turned out to be false. The non-linear and unpredictable nature of transitions from one regime to the next also raises the question how a focal venture can assess the status of an unfolding transition of the prevailing regime and the strength of the regime-level actors to fight back. We have provided some ideas in our argument supporting proposition 3, but this key question warrants more attention.

Survival in niches. While we have developed a framework for ecosystem external development that builds on the literature on SNM, it is necessary to emphasize a critical difference that adopting the focal venture viewpoint to ecosystem development adds to the argumentation in SNM (e.g., Raven, 2007), as well as in parallel transition-oriented research streams such as studies on technology innovation system (TIS) (e.g., Wieczorek and Hekkert, 2012). Namely, in concentrating on the support of a path-breaking technology, it is implied in these literatures that individual initiatives (i.e., manifestations of these technologies in specific value proposition by specific actors) can increase the common knowledge base for benefit of other proponents of the same technology even if they are not successful. In fact, it has been argued that failed projects often provide more fruitful contributions to the shared knowledge base of the niche, allowing for subsequent initiatives to be stronger as a result (Raven and Verbong, 2004). Contrastingly, by taking the viewpoint of a focal venture and its ecosystem actors, the focus logically shifts to achieving success of these actors and the EVP they represent. As such, our research contributes to transition studies (e.g., SNM and TIS) by providing an actor- and ecosystem-based viewpoint to navigating transitions; and serves as an example of the potential insights that can be gained from bridging transition studies and innovation/strategy research. Future research might explore other insights that such cross-overs can deliver.

The value of the niche concept. Finally, a key notion in our framework is the (socio-technical) niche (Geels, 2002; Schot and Geels, 2007), an additional layer of networks and activities that single actors and ecosystems in emerging fields can leverage in order to enhance their external viability. While the niche concept has been widely used in innovation policy research, our argument suggests it is also highly relevant to strategy research, especially in the area of disruptive innovation. Future research in this area might, for example, explore how focal ventures and other actors in their ecosystems identify the broader niche community (if any) they are part of, and how and when they connect and collaborate with other actors in this niche.

Boundaries and limitations

Any model or framework is inevitably limited in its assumptions. For one, we assumed a path-breaking innovation originates from *outside* the dominant socio-technical regime. However, incumbents of the socio-technical regime can sometimes also develop path-breaking innovations (Van der Vleuten and Högselius, 2012). These instances are likely to face significantly different selection pressures than those pioneering an innovation outside the dominant regime though. The case of Kodak that invented digital photography but then decided not to commercialize it (Tripsas and Gavetti, 2000) suggests incumbents of the prevailing regime may face more severe corporate 'selection environments' (Walrave, Van Oorschot, and Romme, 2011), even when their external environment is less selective. This raises interesting questions with regard to path-breaking innovation by focal firms that are incumbents to the prevailing regime versus those that are not.

In this paper, we focus on the formative stages of an innovation ecosystem and its socio-technical niche. In the early stages, the cooperation-competition dynamics in the niche tend to be different than when the innovation has already gained substantial foothold (Brandenburger and Nalebuff, 1996). More specifically, our framework suggests that focal ventures emphasizing niche level collaboration in these formative stages, which facilitates knowledge sharing and subsequent niche building and protection, are more likely to generate viable ecosystems. Yet, the stronger the niche and its actors become, the more the actors are likely to compete with each other. Our framework does not explicitly consider this shift in competitive dynamics.

In order to keep the framework parsimonious, we assumed an innovation ecosystem is linked to merely one socio-technical niche. In practice, however, the ecosystem can be embedded in multiple (emerging) niches existing and evolving simultaneously (Levinthal, 1998; Raven, 2007). This raises questions about how and when the focal venture chooses the most promising niche trajectory, under which conditions the focal venture is better off by connecting to multiple niches simultaneously, and whether and how this venture and its ecosystem can potentially switch from one niche to another. Real options theory may inform future work in this area (Damaraju, Barney, and Makhija, 2015).

CONCLUSION

This paper presents a theoretical framework of how a focal venture develops an innovation ecosystem for path-breaking innovation. We argued that ecosystem success arises from achieving internal alignment as well as external viability of the ecosystem, which are both dependent on the configurations of the EVP and the EM. Considering the EVP and EM as objects that the focal venture in the ecosystem can manipulate, we developed a multi-level perspective on innovation ecosystem development. This framework considers the internal alignment as well as the external viability of the ecosystem, through iterative development of the EVP and/or EM, according to cues from inside the ecosystem, from the socio-technical niche level, as well as from the external environment. Based on the framework, we developed a substantial research agenda to guide future studies on innovation ecosystems.

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