Mapping, analyzing and designing innovation ecosystems

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Mapping, analyzing and designing innovation ecosystems: The Ecosystem Pie Model

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ABSTRACT

To achieve a complex value proposition, innovating firms often need to rely on other actors in their innovation ecosystem. This raises many new challenges for the managers of these firms. However, there is not yet a comprehensive approach that would support managers in the process of analysis and decision making on ecosystem strategy. In this paper, we develop a strategy tool to map, analyze and design (i.e., model) innovation ecosystems. From the scholarly literature, we distill the constructs and relationships that capture how actors in an ecosystem interact in creating and capturing value. We embed these elements in a visual strategy tool coined the Ecosystem Pie Model (EPM) that is accompanied by extensive application guidelines. We then illustrate how the EPM can be used, and conclude by exploring the multiple affordances of the EPM tool as a boundary object between research and practice.

Introduction

In a world of increasingly specialized organizations, a single firm typically does not possess the resources to develop and commercialize a complex value proposition from start to finish (Appleyard and Chesbrough, 2017; Kapoor and Furr, 2015). Therefore, firms often need to rely on other actors in their *innovation ecosystem*, to build an ecosystem-wide value proposition (Adner, 2012) that materializes when the individual contributions of different actors are combined (Hannah and Eisenhardt, 2017). On the one hand, the interdependency in ecosystem relationships confines firms; for instance, it delays the launch of new products/services until complementary elements from ecosystem actors become available (Dattée et al., 2018; Overholm, 2015). On the other hand, firms can leverage ecosystem relationships for higher value creation by exploiting the synergies and network effects arising from complementarities across actors (Adner and Feiler, 2017; Clarysse et al., 2014).

Academic research has kept pace with the trend toward ecosystem-based innovation, resulting in a substantial list of considerations that apply in this setting. For example, managers have been advised to consider the modularity within the ecosystem (Baldwin, 2008); the corresponding structure by which value is created in the ecosystem (Adner and Kapoor, 2010); the particular

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roles of actors within the value structure (Dedehayir et al., 2018); the (potential) network effects arising from the ecosystem composition (Williamson and De Meyer, 2012); the strategies for aligning the actors to the value proposition of the ecosystem (Walrave et al., 2018); the interfaces of collaboration between parties (Davis, 2016); the types of complementarity between the different actors (Jacobides et al., 2018); the influence of the properties of involved actors on their relative bargaining power and on the likelihood of these actors to contribute in a desirable way (Adner, 2006; Autio and Thomas, 2014); the risk and value trade-off of having more (or less) interdependent actors involved in the innovation process (Adner and Feiler, 2017); and the potentially asymmetric interdependence of the actors, and the implications of such interdependence for their behavior (Jacobides et al., 2018). The underlying assumption in these suggestions is that managers make decisions on ecosystem strategy based on a thorough understanding of not only what ecosystems are generally like, but also what the *specific ecosystem of their innovation* is (going to be) like (Adner, 2006, 2012; Williamson and De Meyer, 2012).

Although the idea that one can attempt to deliberately manipulate an innovation ecosystem is now well-established (Adner, 2012, 2017; Jacobides et al., 2018; Walrave et al., 2018), there is not yet a comprehensive approach that would empower managers in their efforts to analyze ecosystems across relevant categories and to develop an informed strategy. To address this gap, we develop a qualitative strategy tool (Jarzabkowski and Kaplan, 2015) for mapping, designing and analyzing (i.e., modeling) innovation ecosystems within the so-called *structuralist* tradition (Adner, 2017; Hannah and Eisenhardt, 2017). In doing so, we integrate the views and implications arising from recent scholarly work on ecosystems (e.g., Adner, 2017; Jacobides et al., 2018) and instrumentalize the innovation ecosystem concept for both practical and academic use.

The paper proceeds as follows. We first distill from the literature on innovation ecosystems the relevant ecosystem design *constructs* and their *relationships*. Embedding these in a graphical artifact, we propose a visual strategy tool coined the Ecosystem Pie Model (EPM). We then provide guidelines for modeling ecosystems with the EPM and illustrate how the tool could be used. We conclude by exploring the benefits of the EPM tool as a boundary object between research and practice.

Modeling ecosystems: the Ecosystem Pie Model tool

Fig. 1 presents the blank version of the Ecosystem Pie Model tool, including (a short description of) all relevant elements. Each element, or construct, is further explained in Table 1. Notably, in developing a strategy tool for ecosystem modeling, we first identified the relevant constructs and relationships that would provide an exhaustive and internally consistent base (cf. March and Smith, 1995) for representing how a real-world or prospective ecosystem functions in terms of value creation and capture. Building

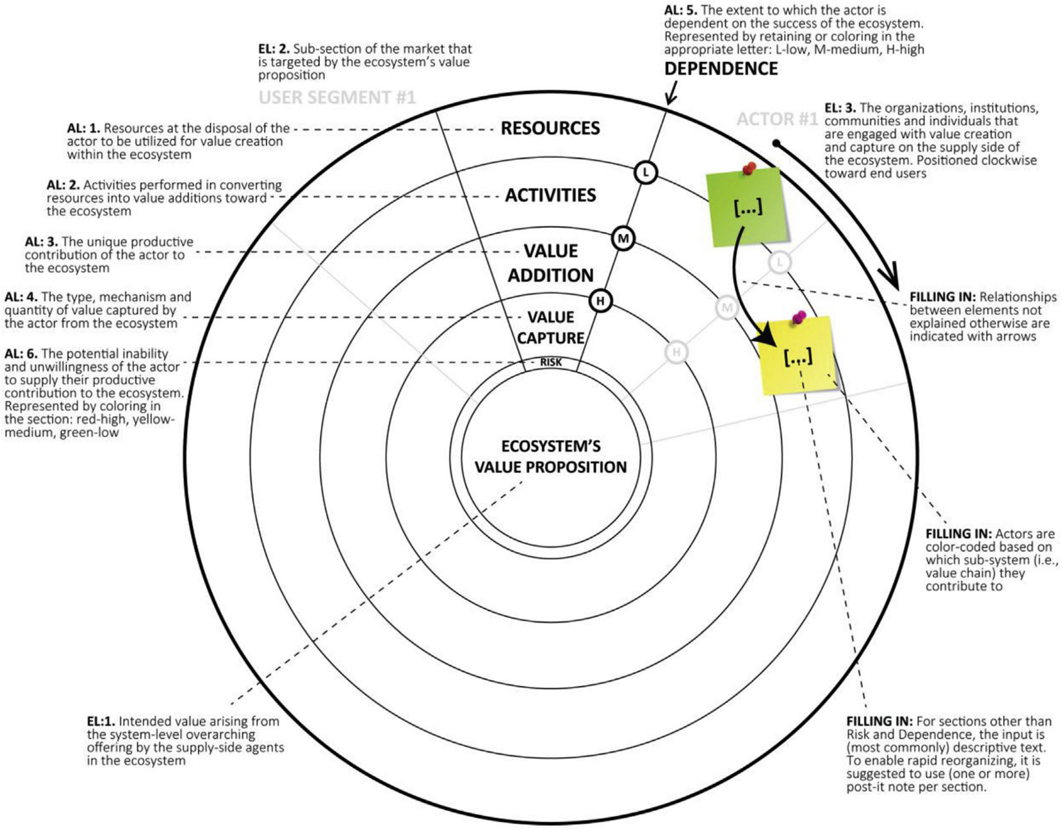

Fig. 1. The Ecosystem Pie Model tool.

Table 1
Ecosystem Pie Model (EPM) constructs.

Construct	Description
Ecosystem level constructs	
EL: 1. Ecosystem's value proposition	Within the structuralist approach (Adner, 2017), an ecosystem is characterized by a system-level goal in the form of a coherent customer-oriented solution (Appleyard and Chesbrough, 2017; Clarysse et al., 2014). We refer to the intended value arising from this solution as the ecosystem's value proposition (EVP), which represents an overarching offering by the supply-side agents in the ecosystem (Slater, 1997), corresponding to an (assumed) need and/or a desire of the end user (Keeney, 1999; Lepak et al., 2007).
EL: 2. User segments	Corresponding to the EVP, user segments specify the target market for the value created in the ecosystem. The need for clear and defined user segments applies to both the firm and the ecosystem level (Williamson and De Meyer, 2012; Winter 1984) and as competition in the market place is increasingly taking place between ecosystems rather than individual firms (Teece, 2014), the ability to serve specific groups of users within the boundaries of the EVP can serve as a competitive advantage for the ecosystem as a whole (Clarysse et al., 2014). Specifying the target audience for the EVP in terms of user segmentation is thus an ecosystem-level construct. At the same time, users also constitute separate actor(s) in the ecosystem because: (1) In some ecosystems, users have substantial discretion regarding which specific complementary contributions offered by supply-side actors they will make use of (Parker and Van Alstyne, 2005). For any particular instance of consumption, the overarching solution of the ecosystem is then re-combined, which in turn assumes some level of resilience on behalf of the supply-side arrangements in the ecosystem (Jacobides et al., 2018); (2) Value in ecosystems is often co-created at the interface of supply-side actors and demand side actors, and in extreme cases, a particular entity can take turns in being on either side, or act in both (Parker et al., 2017); (3) Users can generate transactable value, such as usage data, that other ecosystem actors can use in providing further value elsewhere in (or outside) the ecosystem. In an ecosystem, value transfer can thus be bi-directional, moving both toward and away from the user segments (Appleyard and Chesbrough, 2017).
EL: 3. Actors	The organizations, institutions, communities, and individuals are the main agents engaging with value creation and capture in any given ecosystem (Adner and Feiler, 2017; Autio and Thomas, 2014; Gulati et al., 2012). We conceive ‘actors’ as a construct representing the legally independent, but economically interdependent entities involved in performing distinct productive activities within the modular architecture of the ecosystem (Baldwin, 2008; Jacobides et al., 2018). Meanwhile, the productive contributions made by actors are not equally critical. In ecosystem analysis, focus should be placed on actors providing such complements that are non-generic from the point of view of the EVP (Jacobides et al., 2018). This means that of interest in ecosystem modeling are entities whose productive contributions need to be at least partly tailored to the purpose of the particular innovation ecosystem, assuming investment on behalf of the contributing actor (Helfat and Lieberman, 2002). Generic complements, as for example parcel services would be for most ecosystems, can be assumed as interchangeable at market conditions and deserve thus little or no explicit attention in ecosystem analysis.
Actor level constructs	
AL: 1. Resources	Resources are the basis of firm-specific value creation (Penrose, 1959) and in order to understand the origin of the value addition by a specific actor in an ecosystem, one needs to understand the resources of that actor (Davis, 2016). This does not imply an actor necessarily owns the resources it uses for generating value. Instead, some of the resources can be obtained from other actors in the ecosystem (Lubik and Garnsey, 2016), for instance via setting up a joint venture or using shared facilities in a technology park. The ecosystem literature also emphasizes the importance of resource complementarity for driving value creation at the ecosystem level (Kapoor and Furr, 2015; Koenig, 2012): the total value creation potential of an ecosystem increases as the result of a more heterogeneous and complementary ecosystem resource base (Iansiti and Levien, 2004; Teece, 1992), especially if these resources are non-generic (Jacobides et al., 2018).
AL: 2. Activities	Activities are the mechanisms by which an actor generates its productive contribution to the ecosystem. More specifically, the basis for creating value as a firm is the activity system of the firm, which encompasses how it converts resources into value addition through a process of coordinating within and/or across resource interactions between actors (Möller et al., 2005; Zott and Amit, 2010). Activity is an actor-level construct, but its boundary-spanning nature implies that different activities across the ecosystem are related by means of value delivery toward users. Based on the sequence of necessary activities to accomplish the EVP, actors in the ecosystem are structurally positioned with regard to each other, and with regard to the user segments (Adner, 2017).
AL: 3. Value addition	As an outcome of its activities, each actor contributes to the ecosystem in the form of a productive component (for which they likely possess a comparative advantage relative to the other actors) (Autio and Thomas, 2014; Rothaermel, 2001). We refer to this individual contribution as an actor's ‘value addition’, which constitutes a module within the supply-side system accomplishing the EVP (Clarysse et al., 2014; Nambisan and Sawhney, 2011). Furthermore, following the core-periphery approach developed by Borgatti and Everett (2000), some value additions can in a strict sense be uniquely complementary (i.e., necessary) to the composition of the EVP (Jacobides et al., 2018), while others are value enhancing but not a necessary condition for the EVP to be accomplished (Gawer and Cusumano, 2002).
AL: 4. Value capture	While the ecosystem creates and delivers end-user value through network interactions, in appropriating value, each actor embedded in the ecosystem seeks benefits for itself (Teece, 1986). In ecosystem modeling, the ‘value capture’ construct represents *how*, *what kind*, and *how much* value created by the ecosystem is captured by a particular actor. The opportunity to capture value is a key motivation to join an ecosystem (Lepak et al., 2007; West and Wood, 2013) and for the actors to commit to the ecosystem, they should perceive their ‘share’ as fair (Iansiti and Levien, 2004; Williamson and De Meyer, 2012). In addition to direct financial gains, actors may capture value by leveraging the ecosystem for growth, reputation, higher efficiency or additional resources (e.g., knowledge) (Lepak et al., 2007; Thomas et al., 2015); as such, a firm capturing non-monetary value, which for instance can be monetized outside the particular ecosystem, may still be highly motivated to contribute to that ecosystem.
AL: 5. Dependence	Ecosystems are networks that can include actors of diverse profiles (Adner and Kapoor, 2016). For some of these actors, accomplishing the EVP may be of utmost importance, while for others contributing to a particular EVP is just a small

(*continued on next page*)

Table 1 (*continued*)

Construct	Description
	share of their total activities (Adner, 2017). The extent to which the success of the actor is related to that of the ecosystem represents the 'dependence' of that actor on the ecosystem.
AL: 6. Risk	The notion of actor-specific risk is directly related to the constructs of dependence and value capture, and indirectly to all other constructs. For the EVP to materialize, the actors need to achieve a sufficient level of agreement, alignment and commitment about their individual contributions (Koenig, 2012; Walrave et al., 2018; Williamson and De Meyer, 2012). A potential source of risk here is the ***unwillingness*** of certain actor(s) to contribute; for example, due to inadequate incentives such as a low ratio of value capture to the costs borne by an actor (Iansiti and Levien, 2004); or an actor's low dependence on, and consequently low effort toward, the success of the ecosystem (Adner, 2017). Potential unwillingness can also arise from the extent to which participation in the ecosystem requires actors to invest in resources, activities and/or products/service configurations that are specific to this particular ecosystem and could not be redeployed elsewhere (i.e., the ***fungibility*** of the resources or activities) (Cennamo et al., 2018). Furthermore, an actor may be unwilling to contribute to, or even desire to undermine the ecosystem for strategic reasons; for instance, due to a different vision of leadership in the ecosystem, or because the EVP at hand could shift the power balance in the industry (Iansiti and Levien, 2004). In addition to unwillingness, actor-specific risk can arise also from the ***inability*** of actor(s) to provide the value addition needed, for example due to staffing, technological or legal difficulties (Adner, 2006). The overall likelihood that the EVP is achieved can be determined by multiplying the individual likelihoods of each critical actor to be both willing and able to contribute to the EVP (cf. Adner and Feiler, 2017). Thus, although risk is an actor-level construct representing the likelihood of a particular actor to fail to contribute its specialized value addition to the realization of the EVP, the unwillingness or the inability of any actor to contribute would undermine the prospective performance of the whole ecosystem and thus warrant action from other actors (Adner, 2006; Gulati et al., 2012).

on the insight that the operating logic of any given innovation ecosystem is dependent on the properties of the individual actors *as well as* the properties of the ecosystem network (Adner, 2006; Dattée et al., 2018), we distinguished constructs and their relationships at the ecosystem level (EL) and the actor level (AL).

In its visual form pictured in Fig. 1, the EPM employs elements of actor-based sectors and embedded circles representing specific characteristics of each actor. This circular shape has two benefits. It enables the simultaneous detailed representation of ecosystem- and actor-level properties, and it enables users to capture relationships that transcend the immediate vicinity of any actor in a value chain. A similar visual structure has also been used to represent other classes of multi-actor value systems (e.g., Bocken et al., 2013; Bourne and Walker, 2005; Lüftenegger, 2014).

Relationships of constructs

The constructs included in Fig. 1 and detailed in Table 1 interact, both within and between actors (Adner, 2012, 2017; Nambisan and Sawhney, 2011). In Fig. 2, we summarize the *intra*-actor relationships between the constructs. This allows a modeler to develop the characterization of actors across relevant constructs, and to test for the consistency of the overall description of the actor as part of the ecosystem.

Relationships between constructs on the *inter*-actor level include the following. First, given the modular nature of the ecosystem, the actors can combine their value additions to the EVP in different ways. They can integrate their value additions in the hands of end users, for example when the latter draw on the electricity grid to charge their electric vehicles; alternatively, the exchange between ecosystem actors can serve to integrate their value additions, such as when a battery is incorporated in an electric vehicle, constituting a value chain where some actors are sequenced closer to the end user while others are positioned further from the end user. As such, an ecosystem can span *one* or *several* value chains (Adner and Kapoor, 2010). Second, resources such as intellectual property from different actors can be shared or (re-)combined to enhance the ability of any particular actor(s) to create value (Leten et al.,

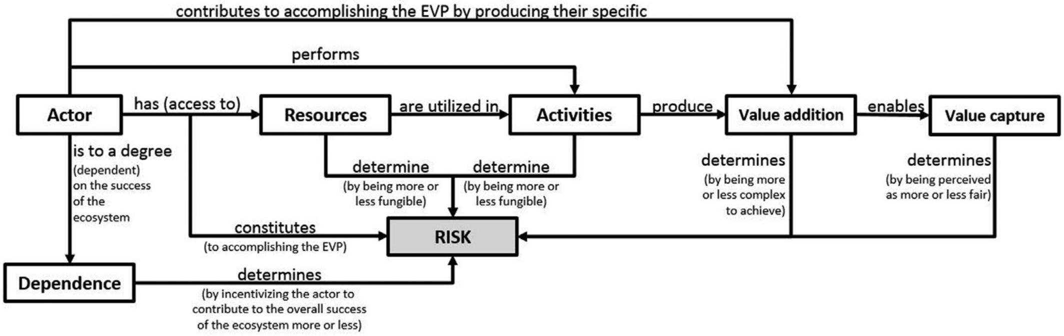

Fig. 2. Intra-actor relationships of constructs.

2013). Third, the activities of an actor can be boundary-spanning, that is, deliberately combining with the activities of other actors. For example, the activity of a firm developing a higher capacity battery needs to be incorporated in the effort by the electric vehicle manufacturer to develop the technical specifications of the whole vehicle. Fourth, the value capture of an actor is determined by the value capture of the other actors. For instance, considering a target price per cup, the pricing strategy for a coffee machine and the pricing strategy of coffee capsules (as coming from another producer) are interdependent. Finally, while the risk level of actor(s) is influenced by all actor-specific characteristics (see Fig. 2), the risk of an actor, in turn, influences the activities of other actors and, consequently, each other actor's value additions and value capture levels. For example, if one or more producers of critical components (are expected to) fail to deliver a specific level of performance within their module in the ecosystem, the other actors have a choice regarding whether to allow the performance of the entire system to suffer, develop the critical component themselves, or invite additional parties to join the ecosystem to deliver it.

Illustration of how the EPM is used

The EPM tool, presented in this paper, has been prototyped and improved in a substantial number of iterations, where it has been used to model more than 260 different innovation ecosystems with a wide array of modeler profiles and contexts. Extensive guidelines for modeling ecosystems with the EPM are available as an online appendix (Talmar, 2018). Here, we briefly illustrate the modeling process in an example that involves a novel process for storing (renewable) power in liquid form, developed at a Dutch university. The generic nature of this technology made it possible to commercialize the invention in a number of different application areas. However, it was also clear that in all of these possible applications, wide-scale adoption of the technology could only be achieved with a substantial shift in the activities of incumbent actors. The team developing the technology considered this to be a major barrier (cf. Adner, 2017; Geels, 2004). Nevertheless, a spin-off from the university was created to (try to) bring the technology to the market in such a way as to increase the chances of its adoption. It was at this point that the team engaged in ecosystem modeling by using the EPM with a focus on considering multiple ecosystem alternatives for the commercialization pathway of the technology. Three of these alternatives were positioned within the domain of mobility (i.e., using the technology in city public transport, in trucks, or in boats) and another one in power storage for use in buildings. Fig. 3 presents the first steps in modeling one of these examples, including how the team used the logic from Fig. 2 to map its own potentially valuable characteristics, as well as a prospective EVP and a corresponding user segment.

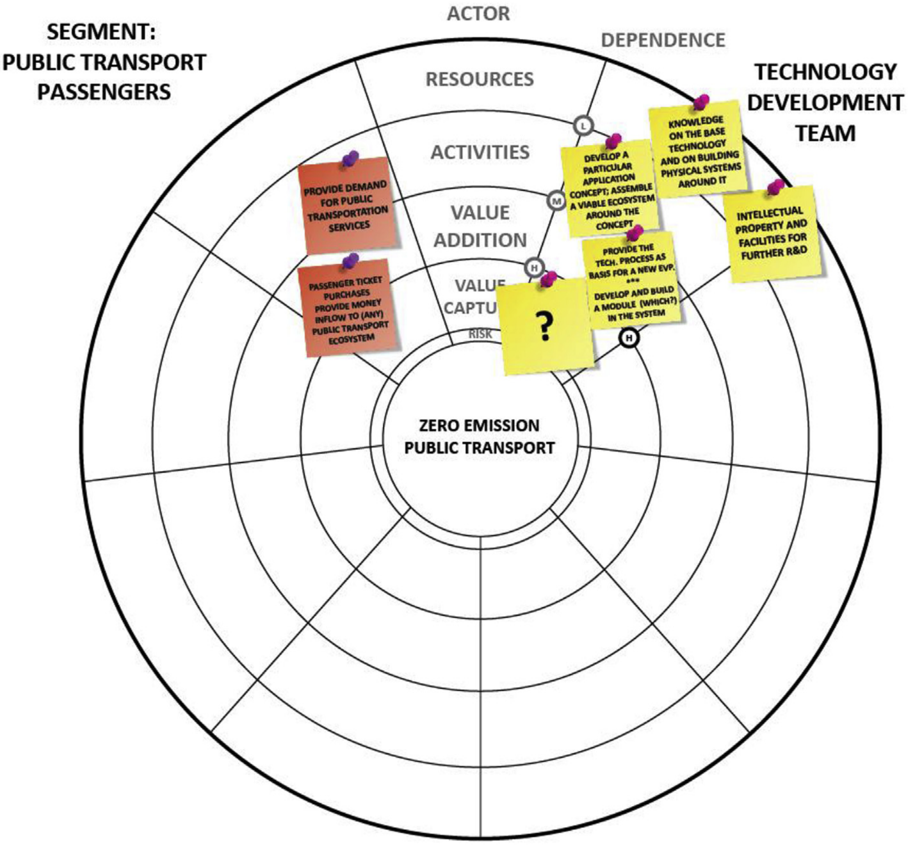

Fig. 3. First step in modeling a potential ecosystem in public transport.

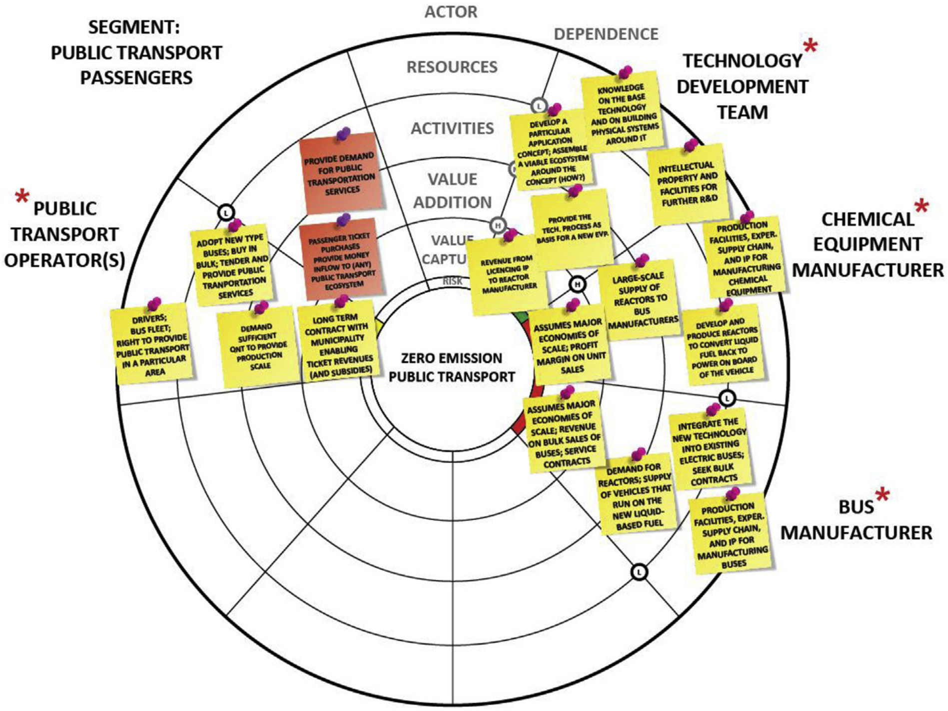

Fig. 4. Model after considering the direct chain of adopters to reach end users.

As Fig. 3 illustrates the basis of EPM modeling is qualitative information concerning each of the constructs. Nonetheless, in some contexts, one can add useful detail in terms of additional specifications that are quantitative (e.g., as part of the value capture, provide the profit function of each actor) or visual in nature (e.g., representing the value additions of each actor by a scheme of its product). Furthermore, to represent 'dependence', the EVP tool uses the grades L (low), M (medium) and H (high) as represented by the letter and the position of the respective circle on the downstream separation line for each actor. In our example, the technology development team assumed that, due to limited resources, it would initially enter only into one application area, thus being highly dependent on achieving that EVP.

Subsequently, the direct chain of adopters between the technology team and the end users was considered, as visualized in Fig. 4. Here, a minimum of three parties were deemed necessary: a) a chemical equipment manufacturer to produce the necessary reactors for converting chemical fuel back into electricity; b) a bus manufacturer with prior experience with electric buses; and c) local public transport operators who would tender buses from the manufacturers and ultimately provide the transportation service. In line with the notion that an EVP can emerge from the combination of complementary subsystems in the ecosystem (Adner, 2017), modelers would assign all actors within a direct adoption chain with the same (background) color of yellow. Additionally, to represent the level of risk arising from the willingness and ability of each actor to contribute, the estimated risk level is translated into generic color codes (red = high risk; yellow = medium risk; green = low risk) (cf. Adner, 2012). As a result, the technology development team was confident about its own module in the system, but the broader adoption chain appeared risky with regard to two actors (see Fig. 4). As indicated by the red asterisks next to the titles of these actors, both actors would also contribute value additions that are critical from the point of view of the EVP, thus constituting a major concern for the team.

In the next step, the team modeled the subsystems that complement the main adoption chain. As featured in Fig. 5, these included the value chain around fuel supply as well as a distinct role for municipalities. These actors were expected to influence the dynamics surrounding the ecosystem and therefore the team adjusted some of the previous characterizations in Figs. 3 and 4, while checking continuously for the internal consistency of each actor's characterization (Fig. 2).

The team conducted similar exercises regarding each of the other three potential applications and subsequently compared and assessed the four alternatives. Based on the comparison, they decided to target the public transport segment. In this respect, the other three ecosystems modeled (for trucks, boats, and buildings) were assessed as less viable and riskier, especially in terms of the potential for upscaling the distribution and use of the technology. Meanwhile, in the public transport segment, municipalities are setting increasingly stricter requirements for greenhouse gas emissions in tender calls for public transport services, which triggers a chain of demand for compliant vehicles from the public transport operators to bus manufacturers. While that demand does not immediately translate into a demand for the team's value proposition per se, it does have the power to eliminate, or at least reduce the competitiveness of some economically more attractive technological options from competitors; and thus, to increase the likelihood of adoption of the proposed value proposition.

As the last step toward completing the EPM, its users would mark particular relationships between actors (e.g., the combination of

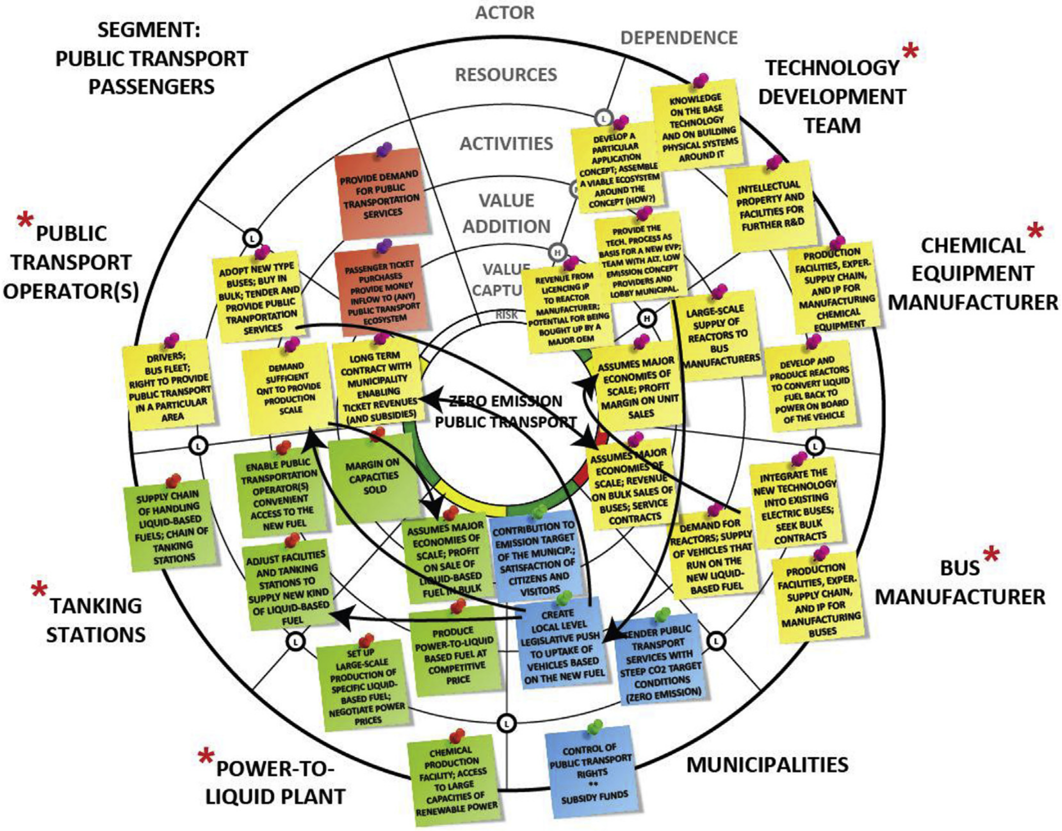

Fig. 5. Completed EPM for public transportation application for the technology under consideration.

resources, or the zero-sum nature of value capturing opportunities) on the EPM, employing arrows that indicate the direction of the relationships. There is a large potential number of important relationships, but 'hiding messy reality is exactly what a good representation is supposed to do' (Baldwin and Woodard, 2009, p. 34). As such, we recommend limiting the number of explicitly represented relationships in the EPM to the most relevant and/or the potentially least comprehensible from the point of view of the general EPM principles outlined earlier. Following these guidelines, Fig. 5 includes relationship arrows that predominantly reflect how certain critical assumptions (e.g., for a certain scale of demand) made by some actors are potentially reinforced by other actors in the ecosystem.

In sum, the development team in this example analyzed the commercialization pathways for its new technology by modeling four ecosystem options. This allowed the team to address the following aspects of their innovation strategy for each alternative: (1) What kind of changes in the activity systems of external actors would adopting the technology assume? (2) How are these actors likely to react to the EVP concept? (3) How to alleviate the risks associated both with the adoption chain actors and the complementary service providers? (4) Which modules of an ecosystem could the team internalize and which would better be left to others to develop and maintain? (5) What would be a suitable mechanism for the technology development team to capture value (e.g., licensing, becoming an OEM) so as to encourage external parties to adopt the technology and accomplish the respective EVP? (6) What are the implications of that choice to the resource requirements of the development team? And ultimately: (7) which of the alternative ecosystems will the development team pursue in real life. As a result of the analysis, the team proceeded with pursuing the public transportation alternative by undertaking lobbying activities to municipalities and addressing the obstacles and challenges identified in the ecosystem for the public transport segment. The team members have continued reflecting upon their progress with the use of the EPM.

Discussion and conclusion

In carrying scientific knowledge to management practice, and in return practical wisdom to science, boundary objects are needed at the interface of scholarship and practice (Eppler and Platts, 2009; Romme, 2016; Spee and Jarzabkowski, 2009). In this research, we have proposed such a boundary object in the form of a strategy tool for modeling ecosystems as conceptualized in the structuralist approach (Adner, 2017). The tool serves to consider and integrate relevant ecosystem properties such as interdependency (Gulati et al., 2012), complementarities (Jacobides et al., 2018) and alignment risks (Adner, 2017).

As such, the EPM tool empowers managers to make informed decisions about their innovation strategy, by helping them make sense of ecosystems as complex entities along relevant ‘thinking paths’ (Wright et al., 2013). This process-oriented approach helps manifest several traits valued by managers in strategy tools (Jarzabkowski and Kaplan, 2015; Wright et al., 2013), including a step-by-step systematic analysis of the situation, considering different viewpoints (of different actors), exploring linkages between inter-related elements of the system, focusing on the critical factors that are likely to determine the success of an ecosystem, as well as potentially identifying needs for additional data.

The illustrative case in the previous section together with many other examples (e.g., Plompidou, 2017; Red Eléctrica de España, 2018; Salminen, 2017) demonstrate that the EPM is highly instrumental in developing strategic insight across several contexts. It delivers insights in a prospective outlook, by considering future ecosystems with novel EVPs; but it can also be used retrospectively, to reflect upon an existing ecosystem and then redesign its operational structure (cf. Jarzabkowski and Kaplan, 2015). In addition, our experiences suggest the EPM can deliver value to ecosystem insiders, but also to external experts that seek to map and analyze a particular ecosystem for purposes such as evaluating investment opportunities or developing research funding policy. As such, the EPM can successfully facilitate highly different modeler profiles and modeling purposes. Furthermore, it can guide the strategy process of a single actor, and create inclusivity in developing strategy across actors (Hautz et al., 2017). In the latter, several organizations would engage in ecosystem design together, using the EPM process to explore opportunities for common innovation efforts, to guide potentially uncomfortable conversations on topics such as dependence and risk, and/or to resolve misalignments.

The second major area of contribution for the framework enclosed is academic research. In ecosystem research, a core topic of inquiry is ecosystem strategy: how do firms change their behavior or attempt to assert influence on the behavior of others, based on the analysis of their ecosystem setting (Adner, 2017; Dattée et al., 2018; Davis, 2016; Hannah and Eisenhardt, 2017). The proposed EPM framework for ecosystem modeling empowers researchers to study this topic in at least four novel ways. First, the main challenges in developing ecosystem strategy arise from the context of the ecosystem, as represented by the interplay between its structural elements. The EPM framework serves to explicitly consider the structural elements of a particular ecosystem (Adner, 2017), thus setting the stage for contextualizing scholarly inquiries into strategic decision making in and around a particular ecosystem. Second, scholars can use the visual representation offered by the EPM to conceive the crafting of ecosystem strategies as design interventions. Third, researchers may use the EPM framework for representing different innovation ecosystems, which enables comparability of research input/output. Fourth, by presenting research outcomes in the form of a synthesized visual form and detailed strategic implications, scholars can effectively create offerings to organizations in exchange for access to data collection opportunities.

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