



## Research Policy

journal homepage: [www.elsevier.com/locate/respol](http://www.elsevier.com/locate/respol)Closed or open innovation? Problem solving and the governance choice<sup>☆</sup>Teppo Felin<sup>a,\*</sup>, Todd R. Zenger<sup>b,1</sup><sup>a</sup> University of Oxford, Saïd Business School, Park End Street, Oxford OX1 1HP, UK<sup>b</sup> Olin Business School, Washington University, Campus Box 1133, One Brookings Drive, St. Louis, MO 63130-4899, USA

## ARTICLE INFO

## Article history:

Received 2 September 2012

Received in revised form

28 September 2013

Accepted 28 September 2013

Available online 7 November 2013

## Keywords:

Open and closed innovation

Governance choice

Strategy

Problem solving

## ABSTRACT

Scholars have recently highlighted the promise of open innovation. In this paper, we treat open innovation—in its different forms and manifestations—as well as internal or closed innovation, as unique governance forms with different benefits and costs. We discuss how each governance form, whether open or closed, is composed of a set of instruments that access (a) different types of communication channels for knowledge sharing, (b) different types of incentives, and (c) different types of property rights for appropriating value from innovation. We focus on the innovation “problem” as the central unit of analysis, arguing for a match between problem types and governance forms, which vary from open to closed and which support alternative forms of solution search. In all, the goal of this paper is to provide a *comparative* framework for managing innovation, where we delineate and discuss four categories of open innovation governance forms (markets, partnerships, contests and tournaments and user or community innovation) and compare them with each other and with two internal or closed forms of innovation governance (authority and consensus-based hierarchy).

© 2014 The Authors. Published by Elsevier B.V. All rights reserved.

## 1. Introduction

Open innovation has received increased attention over the past decade (Chesbrough, 2003, 2006; von Hippel, 2005; von Hippel and von Krogh, 2003; von Krogh et al., 2003; Laursen and Salter, 2006; for an overview see Dahlander and Gann, 2010; Van de Vrande et al., 2010; West and Bogers, 2011). Open innovation scholars have focused on the need for focal organizations to transcend their boundaries by sourcing knowledge and technology externally. This research argues that environmental uncertainty and the complexities of innovation and knowledge recombination have led to the increased permeability of organizational boundaries and the need for organizations to interact with their environment and external stakeholders in more open ways. The notion of open innovation has encompassed a wide range of external actors,

including users, customers, suppliers, universities, and competitors. The underlying mechanisms for accessing external knowledge and fostering open innovation have, in turn, encompassed a range of alternatives including contests and tournaments, alliances and joint ventures, corporate venture capital, licensing, open source platforms, and participation in various development communities.

Scholars have recently started to look at the governance implications of open innovation. In general, the findings suggest that increased linkages to and knowledge flows from various external partners, particularly in uncertain environments, lead to improved innovation outcomes (West and Bogers, 2011). For example, Fey and Birkinshaw (2005) (cf. Dahlander and Gann, 2010) argue and find that a firm's R&D and innovation performance increases as more relational governance modes are utilized, such as linkages to alliance partners and universities. In line with this argument, Keil et al. (2008) also find that the increased use of various, more open governance forms—e.g., alliances, CVC investments, JVs—leads to increased innovation outcomes for firms. The central intuition, whether we are talking about formal governance arrangements, or informal search (Ahuja and Lampert, 2001; Laursen and Salter, 2006; Tether and Tajar, 2008), is that an increase in the number of external linkages and breadth of search can have beneficial outcomes for organizations striving to innovate. Along these lines, Leiponen and Helfat (2010) also find that an increased number

<sup>☆</sup> This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

\* Corresponding author. Tel.: +44 1865 288912.

E-mail addresses: [teppo.felin@sbs.ox.ac.uk](mailto:teppo.felin@sbs.ox.ac.uk) (T. Felin),

[zenger@wustl.edu](mailto:zenger@wustl.edu) (T.R. Zenger).

<sup>1</sup> Tel.: +1 314 935 6399.

of external knowledge sources leads to increased innovation and better financial performance. Love et al. (2013) (cf. Powell et al., 1996) point to similar findings by highlighting how the “breadth of external innovation linkages” can lead to improved innovation outcomes. Beyond this focus on the breadth or number of external ties, yet other studies have highlighted the benefits of interacting with specific external constituents, such as users and communities (Jeppesen and Frederiksen, 2006; also see Chatterji and Fabrizio, 2013; Foss et al., 2011a,b) or universities (Bercovitz and Feldman, 2007).

While the case for increasing access to external knowledge and greater openness in innovation is compelling, the comparative and managerial governance implications of this argument are not quite as clear. The aforementioned work focuses on firm-level aggregates—for example, on how certain types or aggregate quantities of external linkages or governance modes can lead to increased innovation (Fey and Birkinshaw, 2005). But any advice or prescriptions based on firm-level aggregates (that is, for the firm as a whole to increasingly use more open governance modes) can lead to mis-specified governance solutions at the micro level.<sup>2</sup> After all, firms continue to exist and organizational boundaries appear to remain highly relevant for organizing innovation activities (cf. Williamson, 1991).<sup>3</sup> Thus a more fine-grained, nuanced and normative approach is needed, focused on the micro-level, comparative choices that managers face when innovating, with particular attention to when more open versus more closed forms—and vice versa—might be more beneficial. Thus our focus is on the respective benefits and costs of disparate open and closed forms of governance. In short, when should firms use specific open forms of governance versus when should they use alternative, more closed forms?<sup>4</sup>

Scholars have indeed begun to address these, more comparative, governance-oriented questions in the context of innovation (e.g., Afuah and Tucci, 2012; Lakhani et al., 2012; Van de Vrande et al., 2009; also see Baldwin and von Hippel, 2012). For example, Afuah and Tucci (2012) recently compare two governance forms, crowdsourcing versus internal sourcing, and highlight how the “probability of crowdsourcing” increases depending on the nature of the problem (cf. Nickerson and Zenger, 2004). Van de Vrande et al. in turn look at how “firms tackle different types of uncertainty with different governance forms” (2009: 62). And, Veugelers and Cassiman (1999) (cf. Geyskens et al., 2006) study the make or buy decision in the context of innovation and place emphasis on the role of firm size and industry characteristics in determining governance choice. We seek to contribute to this emerging body of research on the comparative aspects of governing innovation.

Our specific focus is examining how attributes of the innovation “problem” (cf. Nickerson and Zenger, 2004) define the choices of governance. We seek to articulate the microanalytic benefits and costs of disparate forms for governing innovation and their respective limits in application (cf. Zenger et al., 2011). Importantly, our contribution is in comparatively examining the unique problem solving attributes of distinct governance

forms associated with innovation. We examine the composition of forms by evaluating their access to (a) different communication channels for knowledge sharing, (b) different types of incentives, and (c) different types of property rights.<sup>5</sup> We first discuss the importance of problems as the central unit of analysis. We then delineate two closed (hierarchy and consensus) and four open (markets/contracts, partnerships/alliances/CVC, contests/tournaments/platforms, users/communities) forms of governance and discuss how each, respectively, implicates communication channels for knowledge sharing, incentives and property rights. Our goal, in all, is to provide theoretical reasoning for when and why certain forms of governance work best, specifically in the context of problem solving and innovation. Our approach is normative and prescriptive, adopting the perspective of the manager of a focal firm tasked with organizing to optimize innovative output. Naturally, managing innovation is likely to be a complex amalgamation of open and closed governance forms, where organizational boundaries are more permeable in some situations—depending on the nature of the innovation problem—and less so in others. But focusing on problems as a unit of analysis provides an unapologetically pragmatic and managerially oriented approach for studying the microanalytics of innovation governance and choice.

## 2. Innovation, problem solving, and governance choices

Innovation is a multi-faceted, multi-level concept and scholars have focused on varied aspects of innovation (for an overview of the innovation literature, see Crossan and Apaydin, 2009).<sup>6</sup> Without getting mired in the vast literature and varied definitions of innovation, we simply focus on innovation as the process by which existing knowledge and inputs are creatively and efficiently recombined to create new and valuable outputs. More specifically, our interest is in how this recombinative process of innovation is efficiently organized or governed. Our effort therefore encompasses inputs, processes, and outputs across varying levels of analysis, but with the aim of examining how firms efficiently manage and govern the process of assembling and organizing inputs to generate valuable outputs.<sup>7</sup> The central actor in our theory is the manager, who seeks to effectively govern, manage and organize problem solving associated with innovation.<sup>8</sup>

<sup>5</sup> We might note that we treat the respective governance forms as relatively discrete choices (as idealized pure types), in line with existing work in transaction cost economics (Williamson, 1991). But we certainly recognize that these forms are not completely discrete, but rather, continuous. But for purposes of theorizing we feel that an idealized approach will surface key considerations (cf. Weber, 1949), both for scholars and managers.

<sup>6</sup> Crossan and Apaydin, based on their extensive literature review, provide the following, broad definition of innovation—“innovation is: production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services and markets; developments of new methods of production; and establishment of new management systems. It is both a process and an outcome” (2009: 1155).

<sup>7</sup> In line with our broad definition, as argued by others (e.g., West and Bogers, 2011: 4), the open innovation literature also adopts “an expansive definition of innovation,” focused broadly on “new”-ness: new products, technologies, processes and so forth.

<sup>8</sup> Extant work on open innovation focuses not just on the inflows of knowledge, but also outflows. We thank an anonymous reviewer for pointing this out. We focus largely on the inflows of knowledge. There is indeed relatively little work on outflows, for example, outflows are only mentioned once in each of two recent reviews of the open innovation literature (e.g., Dahlander and Gann, 2010; West and Bogers, 2011). These outflows, however, have recently been discussed in the form of externalities to openness, where more open firms essentially seem to benefit from positive externalities (Roper et al., 2013).

<sup>2</sup> Some have also voiced concerns that increasingly engaging external constituents and outsourcing might “hollow out” the firm (Foss, 2003).

<sup>3</sup> Some have argued that the knowledge economy, and the associated need for external linkages, will essentially make firm boundaries superfluous (e.g., Benkler, 2002; Hadfield, 2011).

<sup>4</sup> Firm boundaries, after all, still exist, even though some have argued that the knowledge economy and the associated need for external linkages will make them superfluous (Benkler, 2002; Hadfield, 2011).

**Table 1**  
Optimal solution search methods by alternative problem types.

		Problem complexity	
		High	Low
Hidden knowledge	High	Open, theory-guided search	Open, directional, trial and error search
	Low	Centralized, theory guided search	Centralized, directional, trial and error search

### 2.1. Dimensionalizing problems and search

We focus on the problem as our central unit of analysis in guiding the governance of innovation.<sup>9</sup> The problem provides a managerially relevant, practical and more micro-level unit of analysis around which governance choices are selected, with the aggregation of these choices defining the degree to which a firm is open or closed. The problem solving perspective (Nickerson and Zenger, 2004; Leiblein and Macher, 2009) builds on Herbert Simon's intuition in viewing problems as complex systems that differ in structure and complexity (Simon, 1973; Fernandes and Simon, 1999). Differing problems, in essence, demand differing approaches to solution search. Our effort is therefore to match problem types with governance forms that differentially support alternative forms of solution search when innovating. To enable this matching, we begin by identifying key attributes of problems most relevant in selecting governance forms (for an overview, see Table 1). We examine two key dimensions of problems: problem complexity, consistent with prior work (Leiblein and Macher, 2009), and the hiddenness of dispersed knowledge, specifically knowledge deemed relevant to the innovation problem at hand. We also explore two dimensions of search: the source of direction that guides search and the mechanism that solicits participation in search. The form of search direction is either simple, decentralized trial and error, or theory driven search. Participation in search is thus either centrally identified and centrally selected or self nominated and self selected.

In the two sections that follow, we match the above problem dimensions to optimal search attributes, as summarized in Table 1. Thereafter we examine the capacity of governance forms to support these two dimensions of search. While our central unit of analysis is the problem, we should note that our goal is *not* to explain the process of problem formulation (see Baer et al., 2012; Nickerson et al., 2007)—an important topic, but not our focus. Rather, our aim is to highlight how particular problems, once identified and formulated, are efficiently solved through optimal governance choices. While our arguments are informed by Nickerson and Zenger's (2004) focus on "problems" as the central unit of analysis in governance, we extend this analysis by examining an expanded set of problem attributes, matching these problem attributes to search mechanisms and governance forms with their unique bundles of supporting instruments.

### 2.2. Problem complexity and structure

Innovation problems differ in their complexity. Complex problems are like complex systems that are "made up of a large number of parts that interact in a nonsimple way" (Simon, 1962: 468). Complex problems involve a vast array of highly interdependent elements, choices, and knowledge sets that must be creatively recombined to compose valuable solutions. With complex problems, the value of solutions will shift dramatically based on small

shifts in choices. Solving complex problems therefore requires the firm to compose some understanding—or a theory (Felín and Zenger, 2009)—of the patterns of interaction among choices and relevant knowledge. Simple problems, by contrast, are problems where the value of solutions is not strongly shaped by interactions among the choices and relevant knowledge sets (Leiblein and Macher, 2009; Macher, 2006). This allows for rather independent design choices by those possessing more distinct and separate knowledge to generate high value solutions. Similar intuition concerning problem complexity is reflected in NK models (Kauffman, 1993), which define the search for increased performance as navigating a rugged landscape where the terrain is defined by the number of solution design choices (N), and the degree of interaction among them (K) (Levinthal, 1993). Complex problems possess high levels of K. Such problems are consequently less decomposable, meaning that control over particular choices is difficult to delegate to any given entity or individual, as all choices depend on the configuration of all other choices.

Complex problems also differ in how well these interdependencies are understood. Complex problems that are ill-structured not only possess substantial interdependencies among relevant knowledge and solution design choices, but the nature of these interdependencies is not well articulated (Fernandes and Simon, 1999; Macher, 2006; Leiblein and Macher, 2009). Such uncertainty about the nature of interdependencies exacerbates efforts to decentralize design choices or thereby decompose the solution search process. By contrast, solution search for simple problems can be extensively decentralized or decomposed, allowing autonomous actors with their own separate knowledge to independently evaluate their choices or experiments. We can therefore rank order problems in terms of their complexity beginning with simple, decomposable problems, moving to moderate, nearly decomposable problems, and ending with complex, non-decomposable problems. Moreover, complex problems demand a different approach to governing search than simple problems (see Table 1).

Solving simple problems requires directional search—simple trial and error, or search guided by simple feedback (March and Simon, 1958; Cyert and March, 1963). New solutions are discovered as independent actors, either inside or outside the firm, sequentially alter one solution design choice at a time (Gavetti and Levinthal, 2000), observe whether the solution value improves or declines in response (Cyert and March, 1963) and then update accordingly. If the solution value increases, then search continues down this same path until improvement ceases, at which point a different element is adjusted (Nickerson and Zenger, 2004). One benefit of directional search is that a broad set of actors can receive independent invitations to participate in problem solving, as participation in the process of innovating for the focal firm requires no form of coordination among independent problem solvers. Governance forms that simply support decentralized, autonomous search are here sufficient.

Directional search, however, is not well suited to solving more complex, ill-structured problems. Considerable interdependence among relevant knowledge and solution design choices, especially when these interdependencies are poorly understood, render feedback on simple design adjustments of limited value to problem solvers. Instead, a more holistic approach to solution design is

<sup>9</sup> All innovation admittedly does not begin with a clear problem, though deliberate or non-serendipitous forms of innovation do. It might also be that solutions in fact find problems, as discussed by Cohen et al. (1972) in their garbage can model of organizational choice.

required (Macher, 2006). Here efficient search mandates that the firm first assemble relevant knowledge, then recombine it, and then compose a theory (cf. Felin and Zenger, 2009)—a simplified representation of a problem's underlying performance landscape.<sup>10</sup> This theory is then used to pursue solution search by enabling experiments that evaluate the likely outcome of alternative choice combinations. Thus, unlike directional search, which invites any and all to participate who possess knowledge they deem as relevant, theory-based search requires first identifying and synthesizing the relevant knowledge that the firm seeks to explore. Of necessity therefore, governance forms that support theory-driven search are more centralized or facilitate more extensive knowledge sharing. We thus conclude:

**Proposition 1.** *As problems become more complex, the firm adopts governance that facilitates the extensive knowledge sharing required to form theories and heuristics to guide solution search. By contrast, as problems become simpler, the firm adopts governance that motivates more autonomous trial and error search based on local knowledge.*

### 2.3. Hidden knowledge

The hiddenness of knowledge is particularly relevant in the context of innovation. Problems thus also differ in the degree to which the sources or location of knowledge deemed relevant are known to the manager, or “available with practical amounts of search” (Fernandes and Simon, 1999: 226). Simon (1973) actually identifies this awareness of relevant knowledge as a necessary feature of well-structured problems. However, we believe this dimension merits separate and independent consideration, as it has substantial bearing on innovation and the approach to governing solution search. Prior work has focused on the dispersion and scope of knowledge relevant to solving a problem as a critical problem dimension that drives governance (Lakhani et al., 2012; Afuah and Tucci, 2012; also see Jeppesen and Lakhani, 2010). Thus, Bill Joy, the Sun Microsystems founder's famous quip that “most of the smartest people work for someone else” recognizes the distributed nature of knowledge relevant to solving many problems.

However, the problem is not merely the dispersion of relevant knowledge, as prior work suggests. If the manager knows the location of the requisite dispersed knowledge (and can access or acquire it), dispersion need not be an impediment. The real difficulty arises when the manager is unaware of the location of the relevant knowledge for solving particular innovation problems. Under these circumstances, the manager cannot acquire knowledge, or contract for it, but must instead invite and motivate those possessing it to reveal themselves.<sup>11</sup> Individuals or organizations with relevant knowledge may be unknown to the firm, and thus mechanisms for self-selection or self-identification are critical.

The manager faces a fundamental choice concerning how to govern this process of assembling the knowledge relevant for problem search. The manager can choose to centrally identify knowledge relevant to a problem and then acquire or hire it. Or, alternatively, the manager can choose to broadcast a problem and induce a process of self-selection by inviting those with relevant knowledge to self-identify and provide proposals for solving the innovation problem

at hand. The match to problem types here is rather straightforward. When the location of relevant knowledge is unknown to the manager, the manager's task is to craft governance that prompts self selection, for instance, widely broadcasting the problem in hopes that those with valuable information or valuable solutions will reveal themselves (cf. Jeppesen and Lakhani, 2010). By contrast, when the location of relevant knowledge is known, then the governance exercise is more straightforward and centrally directed. For instance, simple invitations, typically with compensation, to disclose knowledge, perhaps in the form of employment contracts or licensing agreements, may be sufficient. We thus conclude:

**Proposition 2.** *As problems require hidden knowledge to solve, the firm adopts governance forms that widely broadcast problems, and relevant knowledge is then self-revealed rather than centrally identified by the focal firm.*

### 3. Matching problem types to governance forms

To this point we have argued that problems differ along two key dimensions, complexity and the hiddenness of knowledge, and have argued that these dimensions demand alternative approaches to solution search. Complex problems demand governance forms that support the composition of a theory to guide search to then run “experiments” consistent with that theory. Composing theory necessitates an organizational environment that supports broad knowledge exchange and creative knowledge recombination. By contrast, simple, decomposable problems require little knowledge sharing, but instead incentives for decentralized, trial and error search. Indeed, governance structures that support extensive knowledge sharing are unnecessarily costly in this context. Again, when the knowledge relevant to solving a problem is both broadly distributed and its location unknown, then governance must induce the revelation of this knowledge. And, when the relevant sources of knowledge are known, governance can centrally identify knowledge.

Governance forms differ in their capacity to support the broad knowledge exchange central to theory building. They also differ in their capacity to induce the self-revelation of otherwise hidden knowledge. Hence, the governance exercise involves matching problem types, which differ in their need for knowledge exchange and in their need for knowledge discovery, to governance forms, which in turn differ in their capacity to support these two key governance attributes.

We examine here *six distinct* governance forms, or categories of forms. Two are internal to the firm: authority-based hierarchy and consensus-based hierarchy. Four are external, more “open” forms: partnerships/alliances, markets/contracts, contests/platforms and user/community innovation (for an overview, see Table 2). Each of these forms or categories of form represents novel and distinct means of governance. However, our aim is *not* to be exhaustive in describing the full set of governance options available to managers. For example, we say little about internal hybrids (cf. Zenger and Hesterly, 1997). Moreover, we bundle some forms into categories, such as alliances, partnerships, and corporate venture capital (CVC), that share a similar configuration of the governance attributes upon which we focus, though we recognize important distinctions exist among the forms within categories (e.g., Dushnitsky and Lavie, 2010: 25). We then compare categories of forms based on the access that each provides to three distinct mechanisms or instruments: (a) communication channels for transferring knowledge, (b) incentives for motivating search, and (c) property rights over solutions and knowledge. We then match these governance forms, comprised of bundles of governance instruments, with attributes of solution search and with the problems that vary in complexity and the level of hidden knowledge relevant to solving them (see Fig. 1).

<sup>10</sup> The notion of “theoretical search” is further discussed in Felin and Zenger (2009). The basic idea is that entrepreneurs, managers and firms—particularly when pursuing novelty and innovation—necessarily engage in a process of theorizing akin to how scientists compose theories to understand their relevant world.

<sup>11</sup> Our focus with the hiddenness of knowledge is specifically about cases where the manager does not know where the relevant knowledge resides: who has it and/or where it is located. We recognize, as noted by an anonymous reviewer, that managers may know where knowledge resides but it may nonetheless remain hidden if the relevant parties don't want to reveal it, thus for example implicating incentives (as we discuss later).

**Table 2**  
Comparative analysis of governance forms.

	Firm/closed		Open innovation			
	Authority-based hierarchy	Consensus-based hierarchy	Markets/Contracts	Partnerships/alliances/CVC	Contests/tournaments/platforms	Users/communities
Communication channels	Vertical, socially embedded within firm	Horizontal, socially embedded within firm	Limited, selective invitations	Bilateral, socially embedded	Horizontal, broadcast, IT supported	Horizontal, socially embedded outside the firm
Incentives	Low-powered	Low-powered	High-powered	Cooperative, high-powered	Moderate powered	Low-powered
Property rights	Possessed by focal firm	Possessed by focal firm	Externally owned and exchanged	Negotiated	Varied (dispersed or focal firm)	None

3.1. Hierarchical governance: authority-based and consensus-based

The features of hierarchy as a governance form for problem solving have been compared with market forms and discussed extensively elsewhere (Nickerson and Zenger, 2004; Leiblein and Macher, 2009). This prior discussion highlights two distinct forms of internal governance, authority-based hierarchy and consensus-based hierarchy, each possessing distinct governance attributes. Because our particular focus here is on open (or non-hierarchical) forms for governing innovation, we review the distinctive governance attributes of hierarchy only rather briefly, so as to permit a more extensive comparison with open governance forms. Stated simply, while both authority- and consensus-based hierarchy are similar in their approach to knowledge identification, they differ in their approach to solution search. As we elaborate below, these similarities and differences reflect the bundles of supporting instruments each possesses. While the two forms of hierarchical governance largely share a common approach to the use of incentives and property rights as governance instruments, they differ significantly in their approach to communication channels and associated knowledge sharing.

Within firms, property rights over solutions or knowledge generally are not assigned to individual employees, or even groups of employees, but rather to the firm itself. In agreeing to

employment, employees essentially assign to the firm all rights to their innovative outputs, ceding property rights in exchange for a guaranteed salary (Coase, 1937). The very notion of hierarchical fiat recognizes employers' rights to "direct the factors of production" (Coase, 1937: 391). In fact, many employment contracts today, particularly for employees hired to generate knowledge and invent, stipulate that intellectual property generated from their work is assigned to the firm, though, historically this has not always been the case (see Fisk, 1998). Productive work within the firm is jointly produced and highly co-specialized among employees. Consequently, the assignment of property rights to firms avoids the rather arbitrary and costly task of trying to impute the specific contributions of disparate actors within the firm who participate in joint problem solving. This approach to property rights also allows the firm to promote the flexible recombination of knowledge within the firm without having to incur complex contracting costs to promote knowledge sharing.

Consistent with this approach to property rights, the incentives for solving problems within hierarchies are low-powered, relative to the incentives accessible through market exchange. While strong incentives such as piecework pay may exist within some hierarchies, these high-powered incentives are seldom used to compensate knowledge workers. Rather than reward individuals for each exchange of knowledge or for their contributions to knowledge generated, firms instead pay salaries in exchange for owning

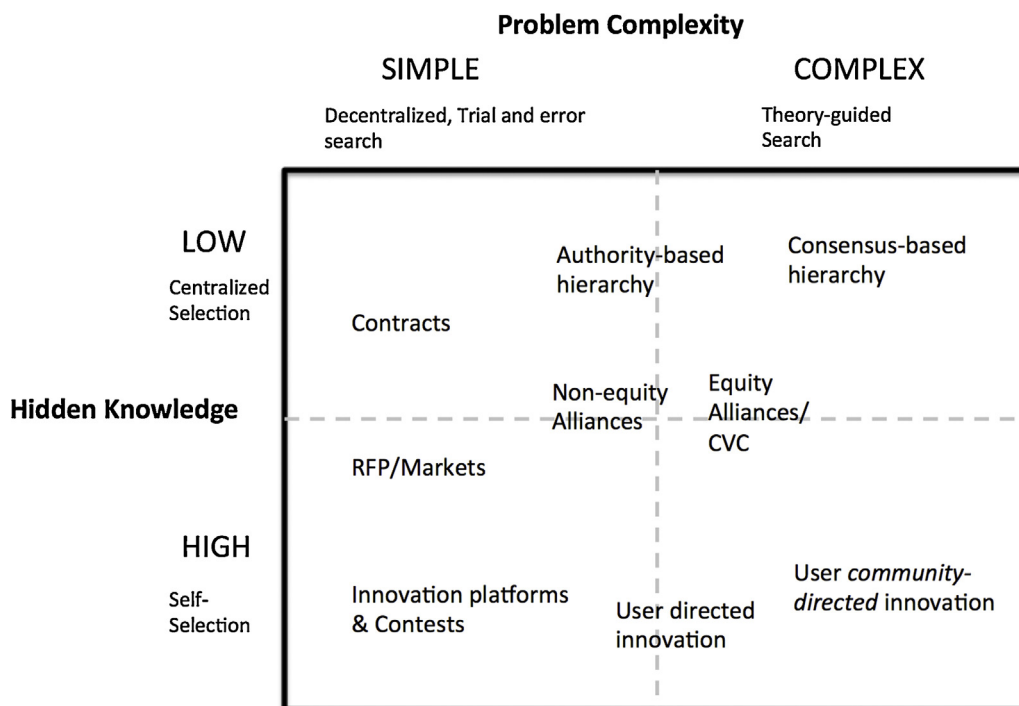


Fig. 1. Solution search/problem complexity.

both the present and future knowledge generated. This approach also discourages individuals from strategically hoarding knowledge or seeking to strategically shape the theories that emerge in ways that are personally advantageous (Nickerson and Zenger, 2004). Instead, these incentives promote efficient teamwork, interaction and knowledge exchange. The incentive-related costs of hierarchy are nonetheless significant (cf. Williamson, 1991; Zenger, 1992; Holmstrom, 1999), as the absence of direct incentives for effort can encourage greater free riding or social loafing, and thus diminished effort. The inability to provide high-powered incentives is in part due to the imprecision of measurement. Within the firm social comparison is also particularly pervasive and efforts to differentially reward in any aggressive way are likely to trigger costly social comparison activity (lobbying for pay, reducing effort, sabotaging others' efforts) (Nickerson and Zenger, 2008; Zenger, 1992).

Low-powered incentives and property rights to knowledge owned by the firm promote communication channels that differ significantly from those provided in the market, including most open forms of innovation governance. While, as we discuss later, many forms of open innovation rather poorly support the form of explorative knowledge recombination required to solve complex problems, hierarchies offer rich forms of communication.

Following prior work (Nickerson and Zenger, 2004), and as noted previously, we distinguish between two hierarchical forms: authority based hierarchy and consensus-based hierarchy. Each yields a distinct approach to supporting communication and each is advantageous with differing problem types. The distinctive feature of hierarchy is its capacity to more effectively facilitate the flow of knowledge. Within the boundaries of the firm, the manager composes an environment where communication costs—the costs of knowledge transfer—are considerably lower. A common identity and language facilitate extensive and efficient knowledge sharing (cf. Kogut and Zander, 1996).<sup>12</sup> This efficient knowledge transfer is of course ideally suited to promoting the knowledge recombination vital to forming theories necessary to guide solution search for complex problems.

Authority-based hierarchy more centrally directs search and thereby economizes on the costly transmission of knowledge that characterizes consensus-based hierarchy. Thus, hierarchy through its access to authority, low-powered incentives, and property rights can both selectively facilitate and selectively avoid the transmission of knowledge. As Arrow (1974) argues “the centralization of decision making, serves to economize on the transmission and handling of knowledge” (1974: 69). It frees the manager from needing to convince individual actors of the economic value of taking particular actions, sharing knowledge or solving particular problems. In this manner, “[d]irection substitutes for education (that is for the transfer of knowledge itself)” (Demsetz, 1988). In authority-based hierarchy, the central actor identifies knowledge relevant to problem solving and then orders a pattern of trials and assigns sub-problems to individuals and teams. Authority permits the manager to efficiently structure the flow of knowledge, facilitating it where needed, and otherwise avoiding unnecessary or costly knowledge exchange.

Both forms of hierarchy are thus well suited to solving more complex problems, where the location of relevant knowledge is known to the focal firm (see Fig. 1). To govern through hierarchy presumes that the manager can centrally identify, hire or acquire knowledge relevant to problem solving. Low-powered incentives and firm-owned property rights over the solutions generated

encourage the requisite knowledge sharing for forming theories to guide search. Consensus-based hierarchies, with their focus on rich horizontal communication channels that support knowledge exchange among peers, are ideally suited to solving the most complex, non-decomposable problems, where widespread knowledge sharing is critical to the formation of theory essential to exploration. By contrast, authority-based hierarchy provides an efficient vehicle for solving moderately complex problems by economizing on unnecessary or costly knowledge transfer, while still permitting guided search. Authority can be used to structure moderately complex problems into sub-problems that individuals or subgroups can solve relatively autonomously, with only limited central coordination. Consistent with this general logic on hierarchy's advantage, empirical studies suggest that hierarchy is both more frequently selected and higher performing when firms confront complex or ill structured problems (Macher and Boerner, 2012; Kapoor and Adner, 2012).

Hierarchy's drawback is the tremendous burden it places on the manager to centrally identify relevant knowledge. For many problems, such central identification is infeasible. At the same time, for many problems the knowledge sharing facilitated by low-powered incentives, centrally controlled property rights, and rich communication channels are of no value and damage motivation. Thus, while hierarchical forms are well suited to supporting theory-guided search, hierarchy has clear limits. Managerial authority can serve as an impediment to efficient decentralized search, as managers have a propensity to meddle (cf. Foss, 2003), and authority of course does not equate with expertise in directing search. In all, when critical knowledge lies outside the firm in unknown locations, centrally directed search is problematic. Table 2 summarizes the governance instruments associated with each of these forms, while Fig. 1 locates these forms in terms of the capacities for search guidance and knowledge identification.

### 3.2. Forms of open innovation

While low-powered incentives, firm-owned property rights, and rich communication channels define hierarchical forms, well suited for solving complex and moderately complex problems using knowledge identifiable by managers, open forms of innovation offer modified governance attributes that permit access to a broader array of knowledge, and often more powerful motivation for decentralized search well suited to alternative types of problems. Indeed, open innovation is often defined as and equated with the use of external markets. For example, West (2007) (openinnovation.net, 8/28/2007) argues that “open innovation is using the market rather than internal hierarchies to source and commercialize innovations” (also see Raymond, 2001). We discuss four categories of more open governance forms: markets/contracts, partnerships/alliances/CVC, contests/platforms/tournaments, and user/community innovation. Each of these categories represents a novel configuration of communication channels, incentives, and property rights—and we thus lump forms together where governance attributes are shared. Each of these categories of governance form is reasonably consistent within forms, but is distinct from the other categories (see Table 2). Our goal is by no means to be exhaustive in our discussion of these forms, and future work certainly might also make more fine-grained, within-category distinctions. We simply use these categories as illustrations of how distinct governance forms are defined by distinct approaches to communication channels, incentives and property rights that enable distinct forms of solution search and problem solving.

#### 3.2.1. Markets and contracts

By market or the contractual governance of innovation, we mean a focal firm that identifies a problem and then either selectively

<sup>12</sup> Echoing Arrow's earlier arguments (1974: 56), Kogut and Zander (1996) suggest that firms develop distinct identities that reduce the costs of communicating and establish “rules of coordination and [influence] the direction of search and learning” (1996: 503).

identifies or broadly invites those thought to possess potential solutions or relevant knowledge to submit these for sale. Unlike more socially complex governance arrangements such as partnerships, alliances, joint ventures, or CVC that can support greater ongoing collaborative knowledge sharing and problem solving, through markets and contracts the focal firm seeks to match problems with those external parties that possess solutions or solution elements (often already solved, in the form of extant products or services) at mutually agreeable prices. These market exchanges may also involve contracting for the generation of a tightly specified problem solution, with payment contingent on delivery of that completed solution. The capacity to identify or invite external actors with relevant solutions or knowledge depends on the network, reach, and knowledge of the focal firm.

Through market and contractual governance, focal firms seek access to externally owned technology, knowledge, or solutions largely through the exchange of property rights. These rights are externally retained and recognized, until contractually exchanged at an agreed upon price. This transfer of property rights may take the form of a licensing arrangement in which rights to use the solution are transferred for narrowly specified applications. For many firms, licensing external technologies represents a critically important source and input of innovation (Arora and Fosfuri, 2003). Alternatively, property rights to technology may be completely sold and reassigned (e.g., in the case of the sale of a patent).

Reflecting in large part this clear assignment of property rights, markets provide high-powered incentives to those with relevant knowledge to develop and sell their solutions (Williamson, 1991). Clear property rights motivate outside actors to develop knowledge, meet customer specifications, and generate solutions for sale. Markets invite identifiable external parties to self-select and propose solutions to innovation problems (Felin and Zenger, 2011; Hayek, 1945). The capacity of these external parties to effectively appropriate value from their solution proposals supports high-powered incentives.

Markets or contracts provide limited support for communication and knowledge exchange. As noted above, knowledge transfer generally takes the form of completed solutions (such as, for example, patents purchased). Markets are rather poor at supporting open, collaborative knowledge exchange. Indeed, markets are plagued by the Arrow information paradox—reflected in the simple observation that the value of knowledge is unknown until after it is conveyed or explained, but once conveyed there is little need to pay for it. Resolving this dilemma through contractual protection is difficult, discouraging the form of open knowledge transfer critical for theory guided search. While markets may invite those with relevant knowledge to self-reveal, the focal firm often has limited means to widely broadcast problems to those who might possess relevant knowledge. Instead, the focal firm is generally restricted to a process of formal invitations or requests for proposal (RFP), distributed to a selective set of firms deemed to already possess the requisite knowledge or capability. Thus, while markets may provide greater access to broad sources of external knowledge than hierarchy or even alliances, they are more restricted in their access to external knowledge, compared to the more open forms of innovation governance discussed below.

Market or contractual governance, composed of the above bundle of instruments, is ideally suited to solving rather simple, well structured, and decomposable problems—problems that do not demand extensive knowledge sharing with the focal firm, but benefit greatly from high-powered incentives that motivate external actors' search. However, market governance is only well suited to solving these decomposable problems when the focal firms can identify those with the relevant knowledge and resources to solve their problems. By contrast, complex problems that demand extensive knowledge sharing consistent with theory guided search

benefit from the more robust communication channels that alternative governance forms provide.

### 3.2.2. Partnerships, alliances, and CVC

Partnerships, alliances, and corporate venture capital (CVC) comprise a category of governance forms that support solving problems of intermediate complexity (see Table 2 and Fig. 1). While these individual governance forms are somewhat distinct, they share much in common with regard to their support for governing solution search and their approach to property rights, incentives, and communication channels. In contrast to authority-based hierarchy, which focuses on providing central direction, partnerships, alliances, and CVC are a more open, collaborative category of governance forms that invites identifiable external partners to more openly exchange knowledge with the focal firm. This more open exchange of knowledge invites the focal firm and its partners to jointly compose theories to guide solution search for complex problems. Thus, relative to markets, we can think of partnerships and alliances as a set of governance forms that generate richer, more multi-faceted relationships that support active problem solving and provide access to external knowledge (Dyer and Singh, 1998; Kogut, 2000) from a wide range of external constituents, such as suppliers, competitors, and universities (e.g., Bercovitz and Feldman, 2007; Hagedoorn et al., 2011; Laursen and Salter, 2006).<sup>13</sup> Moreover, this category of forms not only supports knowledge transfer, but richer forms of communication that enable the recombination of knowledge and theory formation. Like authority-based hierarchy, however, the use of alliances and partnerships to manage complex, nearly decomposable problems, requires the central or focal firm to carefully manage the overall problem architecture and interfaces among sub-problems and their solutions.

Similar to authority-based hierarchy, partnerships, alliances, and CVC rely on either the focal firm or an external partner to recognize external knowledge that is valuable and relevant to an identified problem. Unlike markets and contracts or open contests, as discussed below, partnerships and alliances often include rich communication channels between the focal firm and partner to support knowledge exchange. Moreover, to support such cooperative exchange, contracts and property rights are more open ended, often focusing on efforts rather than unspecifiable outcomes (Poppo and Zenger, 2002; Reuer and Arino, 2007).

To whatever degree is feasible or useful, property rights over solutions or new knowledge generated are negotiated a priori (Lerner and Merces, 1998). While a common structure is for one party to negotiate for rights to the solutions generated by the other, the party providing solutions seeks to narrowly limit the control rights of the procuring firm, while the procuring firm seeks the broadest possible range of control rights, including rights over knowledge unrelated to the problem proposed (Lerner and Merces, 1998; Robinson and Stuart, 2007). Again, the approach to property rights here is more open ended and perhaps dynamically negotiated than the negotiation of property rights in market exchanges. Necessarily, therefore, incentives are structured to invite collaboration, joint production, and knowledge exchange rather than solely self focused effort. Consequently, incentives are more lowered-powered than those operating in market exchanges. In all, given the highly uncertain nature of problem solving, the difficulty of assessing effort and the quality of solutions, and the ex post hold-up problems that surround highly specialized problem solving,

<sup>13</sup> Forms such as CVCs also have a close relationship with partnerships and alliances. For example, Dushnitsky and Lenox (2005) discuss how CVC can play a role in providing information for subsequent alliances with specific partners. Others have used real options logic to link CVC with technology alliances (Van de Vrande and Vanhaverbeke, 2012).

the contracts that support alliances may focus on efforts or time and materials rather than outputs. Such contracts yield inherently lower-powered incentives. While they encourage cooperation with alliance partners, they may discourage the exceptionally high levels of effort that can accompany the higher-powered incentives of more market-like governance.

In summary, the governance features of alliances, partnerships and CVCs are therefore well suited to moderately complex, nearly decomposable problems that also benefit from knowledge that may or may not be partially hidden from the focal firm (Fig. 1). Solving these problems benefits from significant knowledge exchange, but at the same time benefits from the somewhat higher-powered incentives and autonomy that alliances provide over full integration. Partnerships, alliances, and CVC also invite a limited process of self-revelation, vital to uncovering relevant hidden knowledge, though this self-revelation process is nowhere near the levels that user communities and contests can offer, as discussed below.<sup>14</sup>

### 3.2.3. Contests, tournaments, and innovation platforms

Contests, tournaments and innovation platforms are a category of governance forms that seek to efficiently match firms possessing problems to solve with a wider set of firms or individuals that may possess relevant knowledge, including complete solutions.<sup>15</sup> This category of forms also offers distinctive features with regard to communication channels, incentives, and property rights (see Table 1). Contests are frequently supported by third party platforms that provide extensive systems to support communication and coordination, particularly the capacity to broadcast problems to a large constituency, which then provides potential solutions for consideration (Boudreau et al., 2011; Boudreau and Lakhani, 2013; Jeppesen and Lakhani, 2010). By soliciting broad participation in problem solving, the focal firm hopes to discover those unknown to them, who have the knowledge or capability, and for whom generating solutions is of exceptionally low cost.

Communication channels provided by these contest or tournament platforms are generally broad, but not deep. These contest platforms leverage information technology to solicit and engage problem solvers and provide assistance to focal firms in defining and formulating problems. While such contests and tournaments have become increasingly prevalent, there is also a rich history of these types of contests dating back at least to the 19th century (Brunt et al., 2011). Contests and platforms broadcast problems to a large set of actors, who can then decide whether they have the relevant knowledge that facilitates their efficiently providing a solution. Thus, the burden of identifying relevant knowledge is not with the focal firm or manager, but rather with the problem solvers who hear of the problem. Individuals themselves judge whether their knowledge and expertise lends itself to best solving the innovation problem at hand—they thus self-identify. Those possessing information and knowledge that the focal firm may view a priori as quite unrelated to the problem, may in fact provide distant knowledge that ultimately proves critical to generating breakthrough solutions (Bingham and Spradlin, 2011).

Incentives of various forms are central to contests and tournaments (Nalebuff and Stiglitz, 1983; Taylor, 1995), with prizes for the most valuable solution being a common feature. Motivation to participate therefore involves two elements: (1) the expected

probability of winning the prize, net of costs of effort, and (2) the intrinsic rewards of participation. Often these intrinsic benefits are central to motivation, since for many participants, even their own upwardly biased calculation of the probability of winning, times the magnitude of the prize, fails to provide adequate compensation for their time spent and costs incurred. As Malone et al. (2011) note, in some cases the actual R&D costs of generating solutions far exceed the prize money. Intrinsic motivation to participate is likely to vary by problem and problem solver. More importantly, the actual costs and probabilities of generating effective solutions will vary significantly. Thus, efficiently matching problems to problem solvers is a key element of contests, tournaments, and the platforms that support them. Successful participation in contests and tournaments of course may also have important reputational benefits that offset the need for significant pecuniary rewards (cf. Lerner and Tirole, 2002). Contest solvers may appropriate value by signaling their abilities and increasing their reputation, thereby positioning them to capture value, for example, by obtaining better jobs or starting new companies.

The property rights associated with innovation contests and tournaments are specified upfront. The property rights to the winning solution are commonly ceded to the focal firm and the prize (and associated reputational gains) is awarded in exchange. Firms essentially buy the rights to the best solution—while the prize and intrinsic rewards from participation compensate solvers for their efforts and intellectual property. From a societal perspective, prizes may have some advantages over patent systems (Stiglitz, 2008; cf. Eickelpasch and Fritsch, 2005). Here the innovation may be more quickly discovered, deployed, and then diffused. But, firms of course have various options in how they structure the property rights associated with winning solutions.

Contests and tournaments are ideally suited to solving decomposable problems—clearly defined, well-structured and simple (i.e. non complex) problems or sub-problems (see Fig. 1). Furthermore, contests and tournaments are optimal for solving innovation problems that allow for post hoc evaluation and comparison of solutions in a relatively straightforward manner. The problem types that are optimal for contests are simple or decomposable problems where solution generation requires little interaction or coordination with other problem solving efforts within (or without) the firm. Most importantly, contests and tournaments are ideally suited to problems where the optimal sources of relevant knowledge are unknown to the focal firm, and therefore broadcasting the problem to a wide constituency in hopes of rather randomly discovering an efficient solution is desirable. But, contests and tournaments are poorly suited to governing complex, non-decomposable problems where solution discovery demands collective theory formation through extensive knowledge sharing.<sup>16</sup>

### 3.2.4. Users and user communities

Accessing users and user communities represents another path to governing innovation that is quite distinct from markets, partnerships, and contests or tournaments. While an extensive literature has examined user and community innovation (e.g., Cohen et al., 2002; Jeppesen and Frederiksen, 2006; Shah and Tripas, 2007; von Hippel, 1986; von Hippel and von Krogh, 2003), these discussions have not explicitly been comparative in the sense of looking at the specific benefits and costs of this governance form relative to markets, partnership, tournaments and contests and hierarchies or internal innovation (though scholars have looked at user innovation compared to “producer” innovation—see Baldwin and von Hippel, 2012). Moreover, user innovation is viewed as largely

<sup>14</sup> We categorize alliances and CVCs in the same governance form, due to similarities on our dimensions of interests. Scholars have indeed pointed out how CVCs and alliances reinforce each other, though there are also important differences (e.g., Dushnitsky and Lavie, 2010).

<sup>15</sup> The companies engaged in setting up and running various platforms and contests can be seen as engaging in many of the same functions as “innovation intermediaries” (cf. Howells, 2006). The links between these forms, contests/platforms and intermediaries, provides an opportunity for future work.

<sup>16</sup> Contests may also be effectively used to solicit input regarding how to effectively decompose complex problems.



outside the purview of producers, i.e. users select their own problems to explore, not a focal firm or producer. Nonetheless, some work has recently looked at how firms find ways to actively engage with users and user communities (see [Chatterji and Fabrizio, 2012, 2013](#)), for example by setting up platforms for interacting with external constituents. One manifestation of this is firm-hosted user and innovation communities ([Jeppesen and Frederiksen, 2006](#)). Firms themselves have developed innovation communities for the specific purpose of accessing the dispersed knowledge and expertise that lies with users, particularly “lead” users. Contributing users in these communities are often highly knowledgeable, leading-edge experts who can provide valuable knowledge and feedback to the focal company regarding innovation and product improvement. In these settings, there are generally no assigned property rights nor incentives: “sharing and free revealing of innovation are commonplace” ([Jeppesen and Frederiksen, 2006: 57](#)). Users reveal information and knowledge in hopes that this information and knowledge will be incorporated by the focal organization and implemented in future innovations, which in turn benefits lead users themselves, who seek high-quality products.

Like the forms for governing innovation previously discussed, user and community innovation also possesses a rather unique mix of governance features. Property rights over the solutions generated are typically not retained by the inventor, but ceded voluntarily to the community or in some cases even captured by the producer or firm whose product is being modified. But, more realistically, property rights are simply ignored as irrelevant within user communities, as the motivations for contributing are either intrinsic (cf. [Benkler, 2004](#)), or linked solely to the personal gains from using the innovation generated. Thus, the incentives to solve problems are rather lower-powered, relative to markets or even contests.

When users or the user community generate solutions deemed to be of value to a focal firm, these innovations can simply be adopted and the benefits are then shared by the community as a whole, for example in the form of better products or added features. For example, participants in the free software movement actively engage in creating various software solutions (e.g., the aforementioned Linux operating system) and open source software indeed now is a platform used by firms in the generation of value (see [Fitzgerald, 2006](#)). Companies such as Red Hat then explicitly build on and extend open source platforms in the development of innovations. Furthermore, platform initiatives such as Android serve a similar function. Android was originally a closed mobile operating system developed by a private company, but then transformed into an open source platform and operating system. Android itself, in turn, is built on the open source Linux platform. Firms thus interact with innovation communities in highly complex ways as they seek to generate value and look for optimal ways to organize their problem solving and innovation.

Relative to both contests and markets, communication channels in user communities are relatively rich and robust. Participants in these user communities have self-selected in, have often ceded control of property rights, and confront very low-powered incentives. Communities are indeed based on a culture in which the recognition of property rights and incentives is viewed as antithetical to the overall ethos and motivation of contributors ([Benkler, 2004](#)). Communities instead rely on a diverse array of non-pecuniary incentives. Intrinsic motivation, passions, hobbies, or simply the desire to cooperate for the public good may drive participation ([Franke and Shah, 2003; Shah and Tripsas, 2007](#)). Communities, then, feature an abundance of voluntary knowledge sharing unimpeded by concerns of ownership, which in turn supports the knowledge recombination and theory formation vital to solving complex problems. At the same time these user communities provide a diverse array of highly relevant knowledge to which focal

firms can broadcast their problems. Thus, user communities may at once provide access to diverse, and otherwise hidden knowledge, while at the same time providing in some circumstances support for rich forms of knowledge exchange.

The combination of low-powered incentives, unrecognized property rights, and rich communication channels of user communities are actually most similar to the governance attributes that prevail within consensus-based hierarchies. Both consensus-based hierarchies and communities support extensive knowledge sharing and cooperative problem solving. The clear advantage of communities over consensus-based hierarchies, however, is the capacity to access an abundance of otherwise hidden information. The governance attributes of the user community render it somewhat more versatile in terms of the scope of problems it can efficiently solve. As noted, the combination of diverse knowledge and incentives and an approach to property rights that encourages knowledge sharing allows this form of governance to support problem solving for relatively complex problems, with significant levels of hidden knowledge (see [Fig. 1](#)). At the same time, as noted in [Fig. 1](#), community and user innovation can certainly solve simple, decomposable problems, particularly if these problems are identified by users who independently possess sufficiently strong incentives or interest to solve them. A primary challenge with adopting user and community innovation as a form of innovation governance is that a focal firm or focal actor may have rather limited control over or capacity to select, propose and effectively broadcast specific problems to these communities. Instead, the community is more likely to take up problems of interest to them. Thus, the choice to rely on community innovation as a form of innovation governance renders the focal firm a more passive actor in managing the firm’s path of innovation.

#### 4. Dynamics and countervailing forces of (open) innovation

In comparative institutional analysis, as presented here, different institutional forms essentially “compete” in providing efficient governance to solving various problems. As the efficiency of one form improves through innovation, or as the distribution of problems shifts, so will the distribution of observed governance. There has in fact been a noted shift toward more open governance forms in recent decades. Indeed, the governance of innovation has rather consistently evolved since the Industrial Revolution ([Langlois, 2006; Mowery and Rosenberg, 1998; Nigrinis, 2009](#)) and even firm-centric R&D is a relatively new innovation that did not meaningfully exist prior to the 20th century. We should anticipate continued innovation in the governance of innovation itself. While we might ask about the determinants of a variety of historical shifts in governance, consistent with the topic at hand, we specifically focus here on those factors that have prompted the shift toward more open forms of innovation governance.

First, firms have developed or deployed technologies and platforms that lower the communication costs of connecting with external actors possessing disparate knowledge through various forms of open innovation (cf. [Garicano and Kaplan, 2001; Baldwin and von Hippel, 2012; Chesbrough, 2007](#)): partnerships, markets, contests and tournaments and user or community. The increased communication efficiency of more open forms of governance enables these open forms to more closely replicate some of the horizontal and vertical communication capacities of hierarchy, and shift optimal governance choices at the margin. As communication costs have diminished—for example, via improved technologies and the development of common standards—firms are able to more efficiently communicate both broadly to a wide range of actors with knowledge, and deeply or richly with those selected through open governance including markets ([Langlois, 2003](#); cf. [Baldwin, 2008](#)) and peer communities ([Benkler, 2002](#)). Thus, the Internet,

innovation and web platforms for reverse procurement auctions have lowered the communication costs so that firms can now find and broadcast their problems to a very wide set of constituents, who then self-select to participate based on the relevance of their knowledge—themselves deciding whether they can efficiently offer a solution. Innovation prizes similarly offer an efficient mechanism for soliciting potential solutions to innovation problems from a wider set of constituents (e.g., [Jeppesen and Lakhani, 2010](#)). These technologies allow firms to benefit from the matching function of markets, the efficiency with which problems are matched with a wide array of potential solvers (see [Felin and Zenger, 2011](#)). Thus, technologies have lowered the cost not just for firms posing problems, but also for the external audiences that provide potential solutions. Solvers of problems in fact may have readily available information and knowledge to solve problems, and thus their costs to contribute are also lower.

Second, firms have increasingly invested in innovatively transforming previously complex, non-decomposable problems into simpler, more decomposable problems often guided by the composition of theory. Firms make upfront investments in high-level design, commit to high-level architecture that reflects this theory, and then outsource sub-problems. Such modularization allows firms to decompose innovation into smaller sub-problems around which the firm can engage the productive (and sometimes voluntary) efforts of external constituents. A key driver in this design innovation is the declining costs of communication and computation ([Baldwin and von Hippel, 2012](#)). Though not without substantial challenges, Boeing shifted toward significantly outsourcing innovation in its development of the 787 Dreamliner ([Kotha, 2012](#)). The enabling step was modularizing design and establishing distinct interfaces (also see [Argyres and Bigelow, 2010](#) for an example from the early US auto industry). In a similar vein, firms committed to greater openness in their innovation have redirected their internal R&D efforts away from problem solving and toward problem formulation ([Baer et al., 2012](#)). Thus, a key step in enabling greater open innovation is providing clear definitions of decomposed problems, which innovators can then take up with considerable autonomy in solution search. The importance of such modularity and well-defined interfaces on sourcing decisions is of course central to the arguments in the “modular theory of the firm” ([Langlois, 2006](#); cf. [Baldwin and Clark, 2003](#)).

Third, the growth of open innovation, specifically contests and community and user innovation, has benefitted from simple network externalities that promote and enable the innovation platforms that support these forms of open innovation. The key element to increasing the probability of problem solving is to widely broadcast the problem in hopes of discovering those who possess highly relevant knowledge and who therefore have exceptionally low cost in efficiently solving your problems. Innovation platforms, contests and intermediaries provide visible, centralized focal actors that can attract large numbers of prospective problem solvers. The critical resource therefore is discovering or developing an optimal platform for broadcasting problems to those likely to possess the most relevant knowledge. The effectiveness of these platforms is governed by simple network externalities in that the benefits of participation for those proposing problems expand as the number of relevant problem solvers increases. Similarly, the benefits of participating in problem solving increase as the number of relevant problems (and associated rewards) increases. Thus, as firms have drawn ever-greater traffic to their proprietary platforms (cf. [Jeppesen and Frederiksen, 2006](#)) or as these firms participate on third party platforms ([Bingham and Spradlin, 2011](#)), the efficiency and value of these platforms as vehicles for open innovation expands. Nonetheless, regardless of how efficient such problem broadcasting has (or will) become, as noted above, there are categories of problems for which such governance is poorly suited.

Fourth, platforms that support contests or user and community innovation have not only better matched problems to those individuals or entities with uniquely applicable knowledge, they have also reached out and innovatively tapped into the diverse preferences and motivations that individuals possess for solving particular types of problems. Thus, as we have noted, user and community innovation typically operates on the basis of voluntary contribution, often outside the bounds of traditional extrinsic or pecuniary rewards. The personalized and intrinsic incentives that underlie such volunteerism of course vary by individual, reflecting for instance private benefits that may accompany helping an organization (or cause). Individuals can also benefit from problem solving participation in other ways. Their high quality contributions may signal their ability to others (cf. [Lerner and Tirole, 2002](#)), or individuals may contribute to causes that they consider intrinsically worthwhile (for example, as shown by recent efforts toward “citizen science” or “game-ifying” science—[Good and Su, 2011](#)). In other words, user and community innovation can also be seen as another vehicle for volunteering, where actors self-select and choose to contribute time and effort to causes that privately benefit them or they care about. Thus, the growth of these more open forms of innovation is partly a reflection of the increased efficiency with which these platforms access this diversity of preferences and incentives to contribute and volunteer.

In all, improvements in both governance instruments and technologies are providing increased opportunities to more efficiently govern innovation. While traditional market-hierarchy distinctions, as well as transaction costs, remain relevant for understanding the structure of production ([Williamson, 1991](#)), in this paper we have moved beyond traditional market-hierarchy distinctions to look at this broader array of governance forms used in organizing innovation. Reflecting the process of matching and dynamics discussed above, firms are increasingly a complex amalgamation of both “closed” and “open” governance forms. Moreover, as the selection of problems pursued by a firm shifts, these shifts may also result in dynamic shifts in governance.

## 5. Managerial implications and future directions

We believe our theoretical arguments have significant managerial implications and also point to important avenues for future research. First, our focus has been on developing a theory of the comparative governance of innovation, focused on how managers can optimal match identifiable innovation problems with governance forms and the forms of search they support. Thus, in a very direct manner our theory provides guidance to managers (see [Fig. 1](#)). However, what we have not discussed is the fact that managers and firms are likely to differ in their ability or capability to effectuate these alignments. Thus a central opportunity for future research lies in studying the antecedents of such managerial or firm-specific heterogeneity and its implications for governance choices. A natural, future direction, for example, is to study how some forms of governance may be more accessible or familiar to certain organizations and thus lead to differing governance choices. In other words, some firms may become more adept at formulating or decomposing problems (cf. [Baer et al., 2012](#)), or perhaps more capable or experienced at crafting differing forms of governance (cf. [Argyres and Mayer, 2007](#)). Furthermore, certain firms may also possess firm-specific characteristics—such as absorptive capacity ([Vanhaverbeke and Cloudt, 2014](#))—which allow them to benefit from more open governance forms. Other firms may discover innovative ways to interact with users or user communities that shape governance choices ([Chatterji and Fabrizio, 2013](#); [Jeppesen and Frederiksen, 2006](#)). A readily apparent opportunity for future work, then, is to study these types of firm-specific and managerial factors that shape the governance of

innovation. This nexus of firm-, transaction cost- and problem-specific factors indeed provides an important area for future research in governing innovation (cf. Argyres et al., 2012).

Second, while we have focused on six, relatively broad categories of governance forms in the tradition of Weberian ideal types, firms constantly seek to innovatively assemble alternative configurations of communication channels, incentives, and property rights to more efficiently govern the process of innovation. Firms, for example, may develop unique incentives that mimic the high-powered incentives of markets (Foss, 2003; Zenger and Hesterly, 1997). Or, firms may experiment with unique forms of property rights, where individual contributors and inventors, both internal and external to the firm, participate and appropriate value (e.g., Baldwin and Henkel, 2012). The ever expanding array of innovative governance configurations and mechanisms provides fertile ground for future research.

A third opportunity lies in studying how managers link the more micro-analytic exercise of problem solving and governance with wider, firm-level considerations. In other words, while we have treated problems in a relatively straightforward way, in effect, taking the problem for granted, there are of course difficulties associated with both problem formulation and with linking problems to the wider set of activities with which the firm is engaged. Managers in reality deal with bundles or portfolios of innovation problems, and the inter-relationships between disparate problems and their firm-level aggregate structure and scope are likely to introduce additional complexities into the managerial calculus.<sup>17</sup> Furthermore, along with dealing with an amalgam of governance-related choices, firms are also embedded in a broader social and competitive environment, which our more micro-analytic approach does not capture. Thus there is an opportunity to link these more micro aspects of problem solving, governance and innovation with the more macro, aggregate, firm- and even system or environment-level considerations that undoubtedly are central for understanding firm-level heterogeneity, value creation and innovation (cf. Jacobides et al., 2006).

## 6. Conclusion

The purpose of this paper has been to offer a comparative and fine-grained look at governing innovation via various open and closed forms. We have specifically focused on the role of the manager in specifying and articulating innovation problems and aligning governance mechanisms appropriately. Our theory is thus prescriptive in that we argue that certain types of innovation problems are best addressed by certain types of governance forms, whether open or closed. Thus the optimal governance of innovation is contingent on the nature of the innovation problem to be solved. We specifically articulate how disparate governance forms offer access to (a) different types of communication channels, (b) different types of incentives and (c) different types of property rights. These differing governance forms, some open and some closed, in turn support the differing forms of solution search that varying innovation problems mandate.

## References

Afuah, A., Tucci, C., 2012. Crowdsourcing as a solution to distant search. *Academy of Management Review* 37, 355–375.  
 Ahuja, G., Lampert, C.M., 2001. Entrepreneurship in the large corporation: a longitudinal study of how established firms create breakthrough inventions. *Strategic Management Journal* 22, 521–543.  
 Argyres, N., Bigelow, L., 2010. Innovation, modularity, and vertical integration: evidence from the early US auto industry. *Organization Science* 21, 842–853.

Argyres, N., Felin, T., Foss, N., Zenger, T., 2012. Organizational economics of capabilities and heterogeneity. *Organization Science* 23, 1213–1226.  
 Argyres, N., Mayer, K.J., 2007. Contract design as a firm capability: an integration of learning and transaction cost perspectives. *Academy of Management Review* 32, 1060–1077.  
 Arrow, K.J., Hahn, F., 1974. *General competitive analysis*. North Holland.  
 Arora, A., Fosfuri, A., 2003. Licensing the market for technology. *Journal of Economic Behavior and Organization* 52, 277–295.  
 Baer, M., Dirks, K., Nickerson, J., 2012. Microfoundations of strategic problem formulation. *Strategic Management Journal*.  
 Baldwin, C., 2008. Where do transactions come from? Modularity, transactions, and the boundaries of the firm. *Industrial and Corporate Change* 17, 155–195.  
 Baldwin, C., von Hippel, E., 2012. Modeling a paradigm shift: from producer innovation to user and open collaboration. *Organization Science*.  
 Baldwin, C., Clark, K.B., 2003. Managing in an age of modularity. *Harvard Business Review* 75, 84–93.  
 Baldwin, C., Henkel, J., 2012. The Impact of Modularity on Intellectual Property and Value Appropriation. HBS, Workign Paper.  
 Bercovitz, J.E., Feldman, M.P., 2007. Fishing upstream: firm innovation strategy and university research alliances. *Research Policy* 36, 930–948.  
 Benkler, Y., 2002. Coase's penguin, or linux and the nature of the firm. *Yale Law Journal* 112, 369–447.  
 Benkler, Y., 2004. Sharing nicely: on shareable goods and the emergence of sharing as a modality of economic production. *Yale Law Journal* 114, 273–358.  
 Bingham, A., Spradlin, D., 2011. The Open Innovation Marketplace: Creating Value in the Challenge Driven Enterprise. FT Press, Upper Saddle River, NJ.  
 Boudreau, K., Lachhani, N., Lakhani, K.R., 2011. Incentives and problem uncertainty in innovation contests: an empirical analysis. *Management Science* 57, 843–863.  
 Boudreau, K., Lakhani, K.R., 2013. Using the crowd as an innovation partner. *Harvard Business Review*, 61–69.  
 Brunt, L., Lerner, J., Nicholas, T., 2011. Inducement Prizes and Innovation. *Harvard Business School*.  
 Chatterji, A.K., Fabrizio, K.R., 2012. How do product users influence corporate invention? *Organization Science* 23, 971–987.  
 Chatterji, A.K., Fabrizio, K.R., 2013. Using users: when does external knowledge enhance corporate product innovation. *Strategic Management Journal*.  
 Chesbrough, H., 2003. Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business Press.  
 Chesbrough, H., 2007. The market for innovation: implications for corporate strategy. *California Management Review* 49, 45–66.  
 Chesbrough, H., 2006. *Open Business Models: How to Thrive in the New Innovation Landscape*. Harvard Business School Press, Boston, MA.  
 Coase, R.H., 1937. The nature of the firm. *Economica* 4, 386–405.  
 Cohen, M.D., March, J.G., Olsen, J.P., 1972. A garbage can model of organizational choice. *Administrative Science Quarterly* 17, 1–25.  
 Cohen, W.M., Nelson, R.R., Walsh, J.P., 2002. Links and impacts: the influence of public research on industrial R&D. *Management Science* 48, 1–23.  
 Crossan, M.M., Apaydin, M., 2009. A multi-dimensional framework of organizational innovation: a systematic review of the literature. *Journal of Management Studies* 47, 1154–1191.  
 Cyert, R.M., March, J.G., 1963. *A Behavioral Theory of the Firm*. Prentice Hall, Englewood Cliffs, NJ.  
 Dahlander, L., Gann, D.M., 2010. How open is innovation? *Research Policy* 39, 699–709.  
 Demsetz, H., 1988. The theory of the firm revisited. *Journal of Law, Economics, and Organization* 4, 141–161.  
 Dushnitsky, G., Lavie, D., 2010. How alliance formation shapes corporate venture capital investment in the software industry: a resource-based perspective. *Strategic Entrepreneurship Journal* 4, 22–48.  
 Dushnitsky, G., Lenox, M., 2005. When do incumbents learn from entrepreneurial ventures: corporate venture capital and investing firm innovation rates. *Research Policy* 34, 615–639.  
 Dyer, J., Singh, H., 1998. The relational view: cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review* 23, 660–679.  
 Eickelpasch, A., Fritsch, M., 2005. Contests for cooperation: a new approach in German innovation policy. *Research Policy* 34, 1269–1282.  
 Felin, T., Zenger, T.R., 2009. Entrepreneurs as theorists: on the origins of collective beliefs and novel strategies. *Strategic Entrepreneurship Journal* 3, 127–146.  
 Felin, T., Zenger, T.R., 2011. Information aggregation, matching and radical market-hierarchy hybrids: implications for the theory of the firm. *Strategic Organization* 9, 163–173.  
 Fey, C., Birkinshaw, J., 2005. External sources of knowledge, governance mode and R&D performance. *Journal of Management* 31, 597–621.  
 Foss, N.J., Laursen, K., Pedersen, T., 2011a. Linking customer interaction and innovation: the mediating role of new organizational practices. *Organization Science* 22, 980–999.  
 Fernandes, R., Simon, H.A., 1999. A study of how individuals solve complex and ill-structured problems. *Policy Studies* 32, 225–245.  
 Fisk, C.L., 1998. Removing the 'fuel of interest' from the 'fire of genius': law and the employee-inventor. *University of Chicago Law Review* 65, 1127–1198.  
 Fitzgerald, B., 2006. The transformation of open source software. *MIS Quarterly* 30, 587–598.

<sup>17</sup> We thank Ashish Arora for raising this point.

- Foss, N., 2003. Selective intervention and internal hybrids: interpreting and learning from the rise and decline of the Oticon spaghetti organization. *Organization Science* 14, 331–349.
- Foss, N., Laursen, K., Pedersen, T., 2011b. Linking customer interaction and innovation: the mediating role of new organizational practices. *Organization Science* 22, 980–999.
- Franke, N., Shah, S., 2003. How communities support innovative activities: an exploration of assistance and sharing among end-users. *Research Policy* 32, 157–178.
- Garicano, L., Kaplan, S.N., 2001. The effects of business-to-business e-commerce on transaction costs. *Journal of Industrial Economics* 49, 463–485.
- Gavetti, G., Levinthal, D.A., 2000. Looking forward and looking backward: cognitive and experiential search. *Administrative Science Quarterly* 45, 113–137.
- Geyskens, I., Steenkamp, J., Kumar, N., 2006. Make, buy, or ally: a transaction cost theory meta-analysis. *Academy of Management Journal* 49, 519–543.
- Good, B.M., Su, A.I., 2011. Games with a scientific purpose. *Genome Biology* 12, 135–137.
- Hadfield, G., 2011. Law for a flat world: legal infrastructure and the new economy. *Journal of Law and Policy for the Information Society*.
- Hagedoorn, J., Letterie, W., Palm, F., 2011. The information value of R&D alliances: the preference for local or distant ties. *Strategic Organization* 9, 283–309.
- Hayek, F., 1945. The use of knowledge in society. *American Economic Review* 35, 519–530.
- Holmstrom, B., 1999. Managerial incentive problems: a dynamic perspective. *The Review of Economic Studies* 66, 169–182.
- Howells, J., 2006. Intermediaries and the roles of intermediaries in innovation. *Research Policy* 35, 715–728.
- Jacobides, M.G., Knudsen, T., Augier, M., 2006. Benefiting from innovation: value creation, value appropriation and the role of industry architectures. *Research Policy* 35, 1200–1221.
- Jeppesen, L.B., Frederiksen, L., 2006. Why do users contribute to firm-hosted user communities? The case of computer-controlled music instruments. *Organization Science* 17, 45–63.
- Jeppesen, L.B., Lakhani, K.R., 2010. Marginality and problem solving effectiveness in broadcast search. *Organization Science* 21, 1016–1033.
- Kapoor, R., Adner, R., 2012. What firms make vs. what they know: how firms' production and knowledge boundaries affect competitive advantage in the face of technological change. *Organization Science*.
- Kauffman, S., 1993. *Origins of Order*. Oxford University Press, New York.
- Keil, T., Maula, M., Schildt, H., Zahra, S.A., 2008. The effect of governance modes and relatedness of external business development activities on innovative performance. *Strategic Management Journal* 29, 895–907.
- Kogut, B., Zander, U., 1996. Knowledge of the firm, combinative capabilities and the replication of technology. *Organization Science* 3, 383–397.
- Kogut, B., 2000. The network as knowledge: generative rules and the emergence of structure. *Strategic Management Journal* 21, 405–425.
- Kotha, S., 2012. Boundary emergence: a multi-theoretical approach to understanding boundary choice in a large transnational corporation. In: Department of Information Systems Friday Research Seminar Series. Washington State University.
- Lakhani, K.R., Hifshitz-Assaz, Tushman, M.L., 2012. Open Innovation and Organizational Boundaries: The Impact of Task Decomposition and Knowledge Distribution on the Locus of Innovation. HBS, Working paper.
- Langlois, R., 2003. The vanishing hand: the changing dynamics of industrial capitalism. *Industrial and Corporate Change* 12, 351–385.
- Langlois, R., 2006. The secret life of mundane transactions. *Organization Studies* 27, 1389–1410.
- Laursen, K., Salter, A., 2006. Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal* 27, 131–150.
- Leiblein, M.J., Macher, J.T., 2009. The problem solving perspective: a strategic approach to understanding environment and organization. *Advances in Strategic Management* 26, 1–24.
- Leiponen, A., Helfat, C.E., 2010. Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal* 31, 224–236.
- Lerner, J., Tirole, J., 2002. Some simple economics of open source. *Journal of Industrial Economics* 50, 197–234.
- Lerner, J., Merges, R.P., 1998. The control of technology alliances: an empirical analysis of the biotechnology. *Journal of Industrial Economics* 46, 125–156.
- Levinthal, D., 1993. Adaptation on rugged landscapes. *Management Science* 43, 934–950.
- Love, J.H., Roper, S., Vahter, P., 2013. Learning from openness: the dynamics of breadth in external innovation linkages. *Strategic Management Journal*.
- Macher, J.T., 2006. Technological development and the boundaries of the firm: a knowledge-based examination in semiconductor manufacturing. *Management Science* 52, 826–843.
- Macher, J.T., Boerner, C., 2012. Technological development at the boundaries of the firm: a knowledge-based examination of drug development. *Strategic Management Journal* 33, 1016–1036.
- March, J.G., Simon, H.A., 1958. *Organizations*. Wiley, New York.
- Malone, T.W., Laubacher, R.J., Johns, T., 2011. The big idea: the age of hyperspecialization. *Harvard Business Review* 89, 56–65.
- Mowery, D.C., Rosenberg, N., 1998. *Paths to Innovation: Technological Change in 20th-Century America*. Cambridge University Press.
- Nalebuff, B.J., Stiglitz, J.E., 1983. Prizes and incentives: towards a general theory of competition and compensation. *Bell Journal of Economics* 14, 21–23.
- Nickerson, J.A., Silverman, B., Zenger, T.R., 2007. The problem of creating and capturing value. *Strategic Organization* 5, 211–225.
- Nickerson, J.A., Zenger, T.R., 2004. A knowledge-based theory of the firm: the problem solving perspective. *Organization Science* 15, 617–622.
- Nickerson, J.A., Zenger, T.R., 2008. Envy, comparison costs, and the economic theory of the firm. *Strategic Management Journal* 29, 1429–1449.
- Nigrinis, A., 2009. *Essays on the Economic History of Industrial Research and Development*. Stanford, Dissertation.
- Poppo, L., Zenger, T., 2002. Do formal contracts and relational governance function as substitutes or complements. *Strategic Management Journal* 23, 707–725.
- Powell, W.W., Koput, K.W., Smith-Doerr, L., 1996. Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology. *Administrative Science Quarterly* 41, 116–145.
- Raymond, E. (2001). *The cathedral and the bazaar*.
- Reuer, J.J., Arino, A., 2007. Strategic alliance contracts: dimensions and determinants of contractual complexity. *Strategic Management Journal* 28, 313–330.
- Robinson, D.T., Stuart, T.E., 2007. Network effects in the governance of strategic alliances. *Journal of Law, Economics, and Organization* 23, 242–273.
- Roper, S., Vahter, P., Love, J.H., 2013. Externalities of openness in innovation. *Research Policy*.
- Shah, S., Tripsas, M., 2007. The accidental entrepreneur: the emergent and collective process of user entrepreneurship. *Strategic Entrepreneurship Journal* 1, 123–140.
- Simon, H.A., 1962. The architecture of complexity. *Proceedings of the American Philosophical Society* 106, 467–482.
- Simon, H.A., 1973. The structure of ill structured problems. *Artificial Intelligence* 4, 181–201.
- Stiglitz, J.E., 2008. Economic foundations of intellectual property rights. *Duke Law Journal* 57, 1693–1724.
- Taylor, C.R., 1995. Digging for golden carrots: an analysis of research tournaments. *American Economic Review* 85, 872–890.
- Tether, B., Tajar, A., 2008. Beyond industry-university links: sourcing knowledge for innovation from consultants, private research organisations and the public science-base. *Research Policy* 37, 1079–1095.
- Van de Vrande, V., Vanhaverbeke, W., Duysters, G., 2009. External knowledge sourcing: the effect of uncertainty on governance mode choice. *Journal of Business Venturing* 24, 62–80.
- Van de Vrande, V., Vanhaverbeke, W., Gassmann, O., 2010. Broadening the scope of open innovation: past research, current state and future directions. *International Journal of Technology Management* 52, 221–235.
- Van de Vrande, V., Vanhaverbeke, W., 2012. How prior corporate venture capital investments shape technological alliances: a real options approach. *Entrepreneurship Theory and Practice*.
- Vanhaverbeke, W., Cloudt, M., 2014. Theories of the firm and open innovation. In: Chesborough, H., Vanhaverbeke, W., West, J. (Eds.), *Open Innovation: New Directions and Applications*. Oxford University Press.
- Veugelers, R., Cassiman, B., 1999. Make and buy in innovation strategies: evidence from Belgian manufacturing firms. *Research Policy* 28, 63–80.
- von Hippel, E., 1986. Lead users: a source of novel product concepts. *Management Science* 32, 791–805.
- von Hippel, E., von Krogh, E., 2003. Open source software and the private-collective innovation model: issues for organization science. *Organization Science* 14, 208–223.
- von Hippel, E., 2005. *Democratizing Innovation*. MIT Press, Cambridge, MA.
- von Krogh, G., Spaeth, S., Lakhani, K.R., 2003. Community, joining, and specialization in open source software innovation: a case study. *Research Policy* 32, 1217–1241.
- Weber, M., 1949. *On the Methodology of the Social Sciences*. The Free Press, Glencoe, IL.
- West, J. (2007). *openinnovation.net*, blog post: what is open innovation?
- West, J., Bogers, M., 2011. Profiting from external innovation: a review of research on open innovation. In: 9th International Open and User Innovation Workshop, Vienna, Austria <http://ssrn.com/abstract=1949520>
- Williamson, O., 1991. Comparative economic organization: The analysis of discrete structural alternatives. *Administrative Science Quarterly* 36, 269–296.
- Zenger, T.R., 1992. Why do employers only reward extreme performance? Examining the relationships among performance, pay and turnover. *Administrative Science Quarterly* 37, 198–219.
- Zenger, T.R., Hesterly, W.S., 1997. The disaggregation of corporations: selective intervention, high-powered incentives, and molecular units. *Organization Science* 8, 209–222.
- Zenger, T.R., Felin, T., Bigelow, L., 2011. Theories of the firm-market boundary. *Academy of Management Annals* 5, 89–133.