

Managing Distributed Innovation: Strategic Utilization of Open and User Innovation

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Research from a variety of perspectives has argued that innovation no longer takes place within a single organization, but rather is distributed across multiple stakeholders in a value network. Here we contrast the vertically integrated innovation model to open innovation, user innovation, as well as other distributed processes (cumulative innovation, communities or social production, and co-creation), while we also discuss open source software and crowdsourcing as applications of the perspectives. We consider differences in the nature of distributed innovation, as well as its origins and its effects. From this, we contrast the predictions of the perspectives on the sources, motivation and value appropriation of external innovation, and thereby provide a framework for the strategic management of distributed innovation.

Introduction

For most of the 20th century, both the practice and theory of technological innovation emphasized controlling innovations within the firm. In fact, the need to fund and control such innovations was long believed to be a major reason for the existence of the modern industrial corporation (Chandler, 1977; Armour & Teece, 1980; Freeman, 1982). Until recently, only limited objections were raised to this dominant view (e.g., Allen, 1983; von Hippel, 1988; Robertson & Langlois, 1995). More recently, both managers and researchers have increasingly considered exceptions to this vertically integrated innovation model, as reflected by studies of technological innovations created outside organizations and contemporary phenomena such as open source software and crowdsourcing.

There are two major streams of research on these distributed processes of innovation. The research of von Hippel (1976, 1988, 2005) established the importance of *user innovation*, and how such innovations can be disseminated to others. Meanwhile, Chesbrough's (2003a, 2006a) *open innovation* focuses on firms co-operating across firm boundaries to create and commercialize innovations. Other distributed innovation processes have included cumulative innovation, communities, social

production and co-creation (Benkler, 2006; Murray & O'Mahony, 2007; West & Lakhani, 2008; Bogers, Afuah & Bastian, 2010). These perspectives differ in their views of the locus of and motives for innovation, as well as the nature of innovation, its commercialization process and its relevance for firms.

Together, the researchers within the domain of distributed innovation challenge the vertically integrated model and its assumption of innovation being created and commercialized within a single firm. All allow for dispersed market and technical knowledge leading to distributed innovation creation and commercialization. However, these views have largely been disjoint – with researchers building within each stream rather than across the various streams – and in some cases assuming that one is a proper subset of the other. Thus, the managerial implications of this research offer conflicting predictions for some phenomena and congruent predictions for others. The research also examines different types of external innovation, including raw knowledge and innovation reduced to practice in externally produced components or complements.

The remainder of this paper contains four sections. First, we consider the various definitions of innovation (and innovativeness) in such research. Then, we discuss research on the traditional and distributed views of firm

innovation, as well as research on related phenomena such as open source software and crowdsourcing. Next, we consider the strategic implications for firms of distributed innovation. From this, we discuss the implications of this integrated view for theory and practice.

Divergent Views of 'Innovation'

The research on distributed innovation has used differing definitions of what constitutes 'innovation'. Here we consider two areas of divergence: the attributes of technological innovations and the degree of innovativeness. We focus particularly on the two major distributed perspectives: open innovation (e.g., Chesbrough, 2003a, 2006a) and user innovation (e.g., von Hippel, 1988, 2005).

Innovation Attributes: Knowledge, Components and Complements

Discussions of distributed innovation processes tend to blur the distinctions between innovation and its origins and effects. However, all the firm-centric perspectives consider how firms access external sources of knowledge to supplement their own knowledge as an input to their innovation efforts.

The idea that commercially valuable knowledge is dispersed outside the firm is the key antecedent to the distributed view of innovation. For example, Chesbrough (2006a, p. 9) writes, 'In open innovation, useful knowledge is generally believed to be widely distributed, and of generally high quality'. Moreover, von Hippel (2005, p. 70) argues that, as 'different users and manufacturers will have different stocks of information . . . each innovator will tend to develop innovations that draw on the sticky information it already has'. Some distributed production processes such as open source software and Wikipedia would also not exist without bringing together different knowledge bases distributed across the world (Benkler, 2006; von Hippel, 2007).

In some cases, firms will rely on external actors to supply knowledge that serves as an input to creating their own innovations. This includes basic scientific research produced and disseminated through open science¹ processes, knowledge of market needs and demands obtained from customers, or broadcast search used to identify promising avenues for future innovation (David, 1998; Lilien et al., 2002; Jeppesen & Lakhani, 2010).

In other cases, the external parties may supply innovations, which are then used or commercialized by firms (e.g., Chesbrough, 2003a; Baldwin, Hienerth & von Hippel, 2006;

von Hippel, 2007). Von Hippel (1994, 2005) focuses on the 'sticky information' held by users that is more effectively developed through user innovation than by transferring that information to producer-innovators. Moreover, innovations developed by one firm may involuntarily spill over to rivals (Allen, 1983). Either way, these externally developed innovations are obtained by the firm – either on an exclusive or non-exclusive basis – and incorporated into a firm's goods and services.

The external innovator may also commercialize his or her innovation in the form of a product that is sold to the focal firm (cf. Shah & Tripsas, 2007). These products may be components or other materials that are integrated by the firm into its own products, as has become the norm in the personal computer industry (Dedrick & Kraemer, 1998). Alternatively, the research and development (R&D) of an equipment supplier is used to produce innovations incorporated in tools purchased by producers, as when domestic machine tools improved the post-war German auto industry. Supplier innovations may thus come in the form of materials, components and equipment; Laursen and Salter (2006) found that suppliers were the most common source of external knowledge for innovation among 2,707 UK manufacturers.

Finally, complementary innovations produced by external participants may be provided directly to users. In some cases, these complementary products are sold by for-profit firms, as is common with third party computer software (West, 2006). In other cases, the complements are provided by individuals, whether in the form of user support (Lakhani & von Hippel, 2003), synthesized musical instruments (Jeppesen & Frederiksen, 2006) or game modifications (West & Gallagher, 2006). While such information, goods or services do not directly involve the firm, they do increase the value of the firm's products and thus improve its ability to profit from its innovations (cf. Teece, 1986).

Varying Degrees of Innovativeness

Extant research on technological innovation has drawn distinctions as to the degree of innovativeness, both for micro-level new product development and macro-level technological change. However, these distinctions have not always been explicitly acknowledged in research on distributed innovation.

What Constitutes an Innovation?

A given innovation is typically classified across two orthogonal dimensions of technical novelty. First, technological novelty refers to

whether the innovation constitutes a discontinuous (or radical) or an incremental technological change (Abernathy & Utterback, 1978; Tushman & Anderson, 1986). The discontinuous innovation has a greater impact on the production and use of the technology, while incremental innovation is more frequent and customary.² Second, the geographic scope of novelty refers to whether the innovation is new to the world or new to a specific producer or adopter (Cooper, 2001).

Researchers must consider how much of an innovation counts as 'innovative' or at least is worth measuring. For example, should innovation in packaging or support be considered in the same category as a change to the product function? The boundaries (between innovation and non-innovation) become even more blurred as user and open innovation researchers consider areas beyond product innovation, including process innovation, service innovation and administrative innovations. In all three cases, it may be difficult to draw a 'bright line' distinction as to what constitutes an innovation, particularly for those so-called innovations that are not disseminated to others (such as an incremental improvement of how a user uses a commercial product).

One way to solve this problem is to operationalize an innovation as one that is disseminated to others, whether through commercial or non-commercial processes (cf. Freeman, 1982; Rogers, 1995). However, efforts to tighten the definition of innovation risk excluding important innovations: a series of incremental process improvements in producing a good can together lead to a major change in the performance (or cost) of the good (Abernathy & Utterback, 1978).

Innovation 'Radicalness' in Distributed Innovation Processes

In general, open innovation research considers all possible combinations and recombinations of externally created innovations, as long as the firm can successfully commercialize the insourced innovation. Most specifically, open innovation implies that firms acquire technology that is new to them but not new to the market, whether incremental innovations in personal computers (Chesbrough, 2003a) or discontinuous innovations in consumer electronics (Christensen, Olesen & Kjær, 2005). Laursen and Salter (2006) specifically explore new-to-the-world versus new-to-the-firm innovation and find that the importance of external knowledge search is largely similar for each type of innovation. Nevertheless, large parts of the distributed innovation research implicitly argue that openness is particularly

effective to find more radical innovations – exemplified by the concept of crowdsourcing as a means to identify innovative input from non-obvious sources through global searches (Jeppesen & Lakhani, 2010).

Both consumer users (e.g., end users) and intermediate users (e.g., user firms) may be the sources of both radical and incremental innovation, although the existing research on user innovation often fails to identify the degree of innovativeness for user-generated innovations (Bogers, Afuah & Bastian, 2010). In some cases, both business and consumer users incrementally improve upon the work of producers and other users in a process that reflects many of the principles of cumulative innovation (cf. Murray & O'Mahony, 2007).

At the same time, lead users often develop innovations that are new to the world and thus set off a new industry or market niche (e.g., Baldwin, Hienert & von Hippel, 2006). Firms can also solicit innovative input from users to develop breakthrough innovation, as shown through 3M's use of the lead user method (Lilien et al., 2002). Less frequently, researchers have also identified examples of user-developed radical innovations, as exemplified by the study by Lettl, Herstatt and Gemuenden (2006) in robotic neurosurgery of a producer-funded doctor's prototype development.

A subset of the distributed innovation research tends to focus on the process of incremental advances within an existing product or technology. In particular, cumulative innovation focuses on the incremental improvements made by innovators to each other's technology – often in the context of a radical innovation that is being refined to become useful (e.g., Nuvolari, 2004). The refinement of radical innovation by competing firms towards creation of a dominant design – as in Utterback's (1994) account of the manual typewriter – directly corresponds to such a process. Direct collaboration in cumulative innovation is often an important goal of R&D alliances (cf. Hagedoorn, 2002).

Integrated and Distributed Models of Firm Innovation

Decades of research has identified how firms develop technical inventions into technological innovations, and then commercialize these innovations through an internal process of R&D, production and distribution. Such research has established both technical and business aspects of the innovation process, as exemplified by the vertically integrated industrial giants of the mid-20th century (Freeman, 1982; Chandler, 1990).

Table 1. *Contrasting Integrated and Distributed Innovation Research*

Attribute	Vertical integration	Open innovation	User innovation
Main research question	How do firms control end-to-end innovation processes?	How can firms maximize innovation effectiveness?	How can users be supported to become innovators?
Key stakeholder	Firm	Firm	User
Other stakeholders	–	Other firms in value network	Producers
Level of analysis	Firm	Firm	Innovation
Key success measures	Profit	Profit	Quantity of (significant) innovations
Locus of innovation/knowledge	Within firm	Outside firm	Within users
Type of innovator Assumed	Organizational Pecuniary	Organizational Pecuniary	Individual* Utility
Innovation mode	Internally controlled	Best of breed	Cumulative
Norms	Managerial hierarchy	Market exchange	Co-operation
Relationship with other innovators	None	Exchange	Co-operate
Spillovers	Blocked	Paid	Free
Representative works	Chandler (1977, 1990)	Chesbrough (2003a, 2006a)	von Hippel (1988, 2005)

* A limited amount of research considers innovations by user firms.

A more recent view of innovation builds upon this research while rejecting the vertically integrated paradigm as incomplete. Pointing to the prevalence of innovation that relies on multiple sources of knowledge not controlled by a single firm, it advocates an external search for sources of innovation. Following von Hippel (1988), we use the term 'distributed innovation' to refer to sources of innovation outside the focal firm, whether held by individuals, firms or communities. Lakhani and Panetta (2007) have also used this term to refer to the fact that sources of knowledge and innovation are distributed within a society – as exemplified by the case of open source software.

The two major streams of distributed innovation – open innovation and user innovation – were originally motivated by the observation of gaps between the actual practice and the accepted vertically integrated innovation model. These and other distributed perspectives are based on a fundamental rejection of one or more of the premises of the older model. Accordingly, these complementary perspectives offer a shared critique of the vertically integrated model of firm innovation by

considering innovations created beyond the boundaries of a single firm.³

Table 1 summarizes key differences between the vertically integrated, open and user innovation perspectives, which are developed further below. Subsequently, we also offer a brief review of other perspectives, which together contribute to the distributed innovation model. We conclude this section by describing open source software and crowdsourcing as two contemporary applications of these distributed perspectives.

A Vertically Integrated Model of Industrial Innovation

As conceptualized by innovation scholars, the industrial innovation process comprises both a technical component (invention) and also the commercialization of that technology (innovation). Schumpeter (1934, p. 88) concluded that technical inventions 'not carried into practice... are economically irrelevant', while Freeman (1982, p. 7) argued that 'inventions... do not necessarily lead to technical innovations. In fact the majority do not. An

innovation in the economic sense is accomplished only with the first *commercial* transaction'. However, because innovations can have economic or societal impact even if diffused through a non-commercial process (Rogers, 1995) – as with many open source software projects – a more generalized definition is given by Roberts (1988, p. 12): 'Innovation is composed of two parts: (1) the generation of an idea or invention, and (2) the conversion of that invention into a business or other useful application'.

The traditional innovation process is thus a path from basic scientific discoveries, through firm R&D, and then commercialization and distribution to the customers through the market (Chesbrough, 2006a). Freeman (1982) divides that process into four stages: basic research, invention, development and production. Such technical aspects of the innovation process include basic and applied research to discover scientific knowledge, invention of new commercially relevant technologies, and the development of those technologies into marketable innovations to serve a specific market need.

These scientific discovery, invention and R&D processes are enabled by the knowledge of the participants – not only of science, technology and development processes, but also the knowledge of basic or applied problems in search of a solution (Freeman, 1982). Controlling this end-to-end process is a key reason for the existence and success of large industrial firms (Chandler, 1977; Armour & Teece, 1980). Vertically integrated firms exist because they are better able than markets to internalize and control dispersed knowledge (Kogut & Zander, 1992; Galunic & Rodan, 1998), due to failure of markets and the inability to appropriate benefits of innovation (cf. Chandler, 1977, 1990). Smaller firms that lack the complementary assets to control this commercialization process face (often insurmountable) difficulties in profiting from their technical innovations (Teece, 1986). As such, vertical integration is the direct and indirect outgrowth of industry maturation. As the rate of change slows, firms seek to control their value chain. Eventually, mergers, exits and other sources of consolidation give firms the scale (often by creating oligopolies) necessary to perform their own R&D (Allen, 1983; Utterback & Suárez, 1993).

A distributed perspective on industrial innovation goes beyond this view by arguing that innovation is not (purely) a vertically integrated process, but rather relies on recombining knowledge that is available outside the focal firm's boundaries, across various external stakeholders. We now review the main streams of literature that fuel such a critical view.

Open Innovation

As conceived by Chesbrough (2003a), open innovation describes a modification to the vertically integrated paradigm in which firms are more open to external innovation-related activities.⁴ This stream of research postulates that firms are often better off commercializing external sources of innovations, and finding external paths for commercializing internally developed innovation (Chesbrough, 2003a, 2006a; Dahlander & Gann, 2010; Enkel, Gassmann & Chesbrough, 2009). Open innovation has many similarities to the vertically integrated model of industrial innovation, combining with and supplementing the practices and concepts of the integrated model, including an emphasis on firm success (Chesbrough, 2006a, 2006b). Unlike other distributed perspectives, such as user innovation, open innovation often allows for (if not depends on) achieving economies of scale, as when Intel designs standardized microprocessor components that are used as external innovations by systems integrators (West, 2006).

The core research questions in open innovation research are how and when firms can commercialize the innovations of others and commercialize their valuable innovations through others. Open innovation is especially concerned with the economic (pecuniary) implications and opportunities provided by external sources of innovation and commercialization. In contrast to some other streams, it focuses mainly on the revenue-generating practices from a firm perspective (Vanhaverbeke, van de Vrande & Chesbrough, 2008; van de Vrande et al., 2009). Typically, the level of analysis is either an individual firm or dyadic pairs of firms, although a limited amount of research has examined value networks of multiple firms/organizations, or communities of individuals (Vanhaverbeke, 2006; West, Vanhaverbeke & Chesbrough, 2006; Chesbrough & Prencipe, 2008; West & Lakhani, 2008).

While some open innovation research has considered outbound commercialization of a firm's technology (e.g., Lichtenthaler & Ernst, 2007), like most research, here we focus on the inbound process, in which firms source external knowledge to reduce cost or increase opportunity related to innovation (Enkel, Gassmann & Chesbrough, 2009; Dahlander & Gann, 2010). Such research identifies a variety of external stakeholders as possibly valuable sources of knowledge for innovation, such as suppliers, customers, competitors and universities (Chesbrough, 2003a, 2006a; Christensen, Olesen & Kjær, 2005; Laursen & Salter, 2006).

User Innovation

Research on user innovation assumes that users have the knowledge and motivation to create innovations that solve needs unmet by existing producers. Thus, while open innovation research is ultimately interested in innovation benefits for a producer firm, user innovation research focuses on the conditions under which users innovate and how users can be supported to be more innovative. User innovation research typically explores innovation as an outcome variable in empirical studies – with innovation often defined as a new or improved product or service (von Hippel, 2005). The level of analysis is usually that of individual users and user communities, and the contributions they make to firms, although there is also (renewed) interest in user firms and other user organizations as the sources of innovation (Bogers, Afuah & Bastian, 2010).

User innovation is different from other perspectives in that it explores the ‘functional relationship’ that a stakeholder has with an innovation.⁵ It thus investigates users or user communities as the main stakeholders, and explores when these users innovate and share their innovations among each other or with producers (Harhoff, Henkel & von Hippel, 2003; von Hippel, 2007; de Jong & von Hippel, 2009). Most recently, the dynamic aspects and significance of user innovations have become of interest to user innovation scholars (Baldwin, Hienerth & von Hippel, 2006; Shah & Tripsas, 2007; Baldwin & von Hippel, forthcoming).

User innovation differs from firm-centric perspectives such as open innovation, because the questions and findings revolve around the utility gains for the user rather than any pecuniary benefits. Nevertheless, opportunities for commercializing external innovation created or co-developed by users can exist for profit-seeking firms, as exemplified by the research on toolkits that enable co-innovation with users (von Hippel & Katz, 2002; Franke & von Hippel, 2003), on user communities and open source software (Dahlander & Wallin, 2006; Jeppesen & Frederiksen, 2006), and on user entrepreneurship (Shah & Tripsas, 2007).

Other Distributed Processes

In addition to these dominant research streams that focus on knowledge flows up and down the value chain (Figure 1), there are three other complementary flows of knowledge: between firms, between users and other stakeholders, and then interactive processes between firms and users.

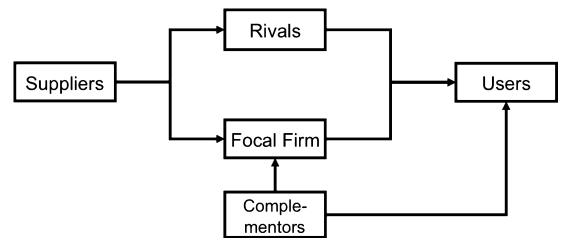


Figure 1. Stakeholders in a Focal Firm's Value Network

Cumulative Innovation

Research on cumulative innovation assumes that unmonetized knowledge spillovers between rivals play a crucial role in advancing technological progress and thus improving societal welfare. The emphasis of cumulative innovation is on rival firms seeking to increase revenues and profits through technological innovation, normally when that technology is immature or otherwise not fully commercialized. These spillovers may reflect intentional collaboration or unintended spillovers that cannot be stopped.

The initial focus of cumulative innovation research considered cases where various parties successively refine a single technology until the improved technology is widely used by a range of producers (Allen, 1983; Nuvolari, 2004). The other pattern of cumulative innovation is when firms build upon a common, ever-increasing pool of enabling science, as in biopharmaceutical drug discovery (Rai, 2001; Murray & O'Mahony, 2007).

Community or Social Production

Some forms of innovations are developed, disseminated or interpreted through communities – whether for open innovation or user innovation. The interactions in these communities are between individuals, but these individuals could be representing their personal (consumer) interest or instead the interest of their employers (West & Lakhani, 2008). Some communities are sponsored by firms to support their objectives, while others may arise organically to meet user objectives (Jeppesen & Frederiksen, 2006; West & O'Mahony, 2008).

Research has particularly focused on communities of individuals practising user innovation, whether in software (Lakhani & von Hippel, 2003) but also physical products (Franke & Shah, 2003).⁶ Such production by user communities has also been termed ‘distributed production’ (Weber, 2004) or ‘social production’ (Benkler, 2006). Firms practising

open innovation may leverage user communities as sources of external innovation, by assigning employees to participate in these communities (Jeppesen & Frederiksen, 2006; West & O'Mahony, 2008; Henkel, 2009).

Co-creation

Other researchers have moved beyond the single-inventor perspective to consider co-creation as the collaborative development between two or more stakeholders. This process involves knowledge inflows and outflows between complementary partners, including horizontal and vertical alliances (cf. Bogers, Afuah & Bastian, 2010). These may reflect formal alliances between direct rivals (Mowery, Oxley & Silverman, 1996; Hagedoorn, 2002) or efforts by suppliers to collaborate with customers (Sawhney, Verona & Prandelli, 2005). Beyond creating product innovation, co-creation can also be a way to create value more generally (Prahalad & Ramaswamy, 2003; Vargo & Lusch, 2004).

Applications of the Perspectives

Open innovation, user innovation and the other perspectives have studied various distributed innovation phenomena. Here we consider how these perspectives have been applied to two such phenomena: open source software and crowdsourcing.

Open Source Software

Open source software has been extensively studied by user innovation scholars who build upon the maxim of open source pioneer Eric Raymond (2001) that 'every good work of software starts by scratching a developer's personal itch'. While they recognized early on how open source software demonstrated principles of user innovation in terms of, for example, feature improvements and peer-to-peer support (Franke & von Hippel, 2003; Lakhani & von Hippel, 2003; von Hippel & von Krogh, 2003), the development process has strong parallels with the social production/community perspective.

At the same time, from an open innovation perspective, firms can use open source as a source of external innovations, or to spin off technologies that cannot be commercialized by the firm, while they can also combine efforts to use open source software to create pooled R&D as inputs to their own innovation processes (Dahlander & Wallin, 2006; Jeppesen & Frederiksen, 2006; West & Gallagher, 2006). However, we believe that the understanding of the phenomenon would be enhanced by

approaches that combine the various perspectives on distributed innovation.

Crowdsourcing

Coined by Howe (2006, 2008), crowdsourcing refers to the outsourcing of a task that is traditionally carried out by an organization's employee(s) to an undefined, generally large group or network of people in the form of an open call. When the sourcing serves a corporate goal, these are consistent with the open innovation paradigm, while in other (overlapping) cases the crowd is being asked to share its knowledge as users to improve its own experience – as with user innovation.

This umbrella term 'crowdsourcing' subsumes a range of different approaches, including corporations acting as open innovation intermediaries, firms managing their own crowds, communities that aggregate online content or co-ordinate peer production, or the open call organized as a contest (Ren & Levina, 2010). It should be noted that not all of the research on crowdsourcing – or even 'open innovation' and 'user innovation' – involves the creation of innovations (as defined by Freeman 1982 or Roberts 1988); in particular, most user-generated content would not qualify as an innovation in the usual sense of the term.

Researchers have recently examined examples of each of these approaches, including the innovation intermediaries such as InnoCentive (Jeppesen & Lakhani, 2010), direct firm solicitation of innovation by Procter and Gamble (P&G) for consumer goods and Threadless for T-shirts (Dodgson, Gann & Salter, 2006; Ogawa & Piller, 2006), or the open contests represented by TopCoder (Archak, 2010). Some research has contrasted the internal and distributed sources to innovation, as with Huston and Sakkab's (2006) study of P&G's 'Connect and Develop', which contrasts searching for a solution in its global networks of individuals and institutions with those within a particular lab.

Strategic Management of Distributed Innovation

Firms that seek to profit from distributed innovations face three challenges (cf. West & Gallagher, 2006): identifying a supply of external innovations, making sure that supply continues, and finding a way to appropriate value from those innovations (Figure 2). Here we consider those three issues in turn as they have been presented by prior research in distributed innovation, with most emphasis on the core perspectives of open and user innovation.

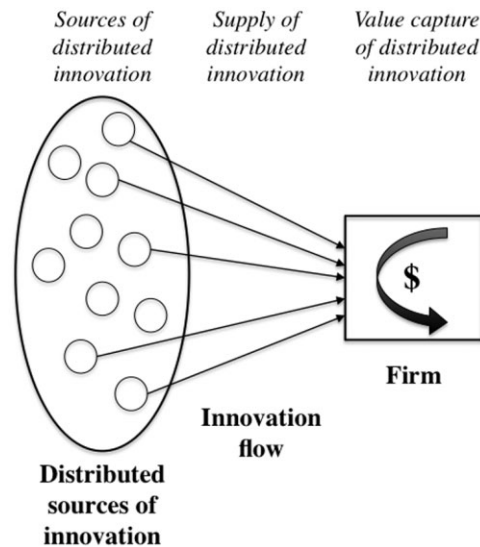


Figure 2. Strategic Management of Distributed Innovation

Identifying/Searching for Distributed Innovation

Where can a firm find innovations that originate from its many external stakeholders? Here we apply a value network perspective, which considers the sources of innovation outside of a focal firm and thus reveals how knowledge and innovation might effectively flow across various stakeholders in general and to the focal firm in particular. Such a framework suggests how the different perspectives on distributed innovation emphasize different external stakeholders and other members of the value network, including suppliers, rivals, users and complementors (see Figure 1).

Sources within the Value Network

Research on distributed innovation has identified a number of valuable sources of knowledge and innovation. More generally, open innovation assumes external actors with different knowledge and perceptions (Chesbrough, 2003a, p. 43). Possible sources of external innovation that have been identified are suppliers, customers, competitors and universities (Mowery, Oxley & Silverman, 1996; Chesbrough, 2003a; Christensen, Olesen & Kjær, 2005; Laursen & Salter, 2006). There is also increasing recognition of the importance of innovation networks more generally (Vanha-verbeke & Cloudt, 2006; Chesbrough & Prencipe, 2008). Universities are not only generally important but scientists can, moreover, serve as sources of external innovation through processes such as open science and crowd-

sourcing (David, 2002; Perkmann & Walsh, 2007; Jeppesen & Lakhani, 2010).

Customers or users are identified by many studies on distributed innovation as a main source of innovative knowledge. They are often the key source of innovation in crowdsourcing and open source software (von Krogh & von Hippel, 2006; Poetz & Schreier, 2010). Because innovation requires combining knowledge of the user's need with knowledge of the solution to meet that need (von Hippel, 2005), users play a central role when the local and sticky nature of innovative knowledge makes it difficult or costly to transfer the knowledge (von Hippel, 1994; Ogawa, 1998; Lüthje, Herstatt & von Hippel, 2005). Because revealing their innovation can enhance users' utility, they often distribute that information to both producers and other users (Harhoff, Henkel & von Hippel, 2003). Consequently, it is beneficial for users to organize their innovative activities in communities with other users (Franke & Shah, 2003; Lakhani & von Hippel, 2003; von Hippel, 2007).

Searching for Distributed Innovation

Firms have various ways to search for distributed innovation, while the external stakeholders may approach firms to reveal their innovation on their own initiative (Harhoff, Henkel & von Hippel, 2003; von Hippel, 2007). Some distributed innovation approaches rely on actively soliciting innovations from external stakeholders by using platforms such as innovation toolkits and crowdsourcing. In other cases, external stakeholders create (personal) value from an innovation, which must be identified and captured by the firm.

Searching for and internalizing innovative knowledge from the external environment thus becomes a central part of a firm's innovation strategy. Laursen and Salter (2006) provide a holistic perspective with regard to firms' search for external knowledge for innovation, arguing that firms must optimize the search for and use of external knowledge. One complementary approach to search for distributed innovation is making use of communities of external stakeholders, turning community management into an integral part of a firm's innovation search strategy (cf. Dahlander & Wallin, 2006; Jeppesen & Frederiksen, 2006; O'Mahony, 2007).

Maximizing/Motivating the Supply of Distributed Innovation

Given the large variety of possible sources of external innovation in a firm's value network, firms are challenged by how to maximize the

Table 2. *Motives and Locus of Innovation*

		<i>Locus of innovation</i>	
		Individuals	Organizations
<i>Motive</i>	Pecuniary	Open innovation Co-creation	Vertical integration Open innovation Co-creation Cumulative innovation
	Non-pecuniary	User innovation Social production	User innovation

supply of innovations that originate beyond their boundaries. Motivating external stakeholders to supply innovations is a particular challenge because of possible misaligned interest between these stakeholders and the focal firm (cf. von Hippel, 2005; West & Gallagher, 2006).

Here we discuss how distributed innovation creates value for different stakeholders, and how such innovation can be identified and motivated through both pecuniary and non-pecuniary mechanisms. Table 2 gives an overview of different integrated and distributed innovation perspectives with respect to the main implied motives (pecuniary vs. non-pecuniary) and the type of innovator (individual vs. organization), while Table 3 gives an overview of the types of innovation flows (use and restrictions) according to the different perspectives and some related phenomena.

While firms may wish to incorporate external innovations into their product, this depends on motivating an external supply of innovations (West & Gallagher, 2006). Dahlander and Gann (2010) distinguish between pecuniary and non-pecuniary incentives for obtaining external innovations: user innovation emphasizes the latter while open innovation considers both.

For user innovators, the non-pecuniary benefits include meeting their own needs (personal utility) as well as direct and indirect benefits of sharing their newly developed knowledge in their community (von Hippel, 2007). The prevalence of knowledge sharing can often be explained by the direct benefits users gain from freely revealing their knowledge (Harhoff, Henkel & von Hippel, 2003). Meanwhile, firms create 'toolkits' to facilitate the supply of user innovations (von Hippel & Katz, 2002; Franke & Piller, 2004). Users also gain status and reciprocity benefits from

Table 3. *Classification of Use and Restrictions on Innovation Flows*

Type of innovation flows (revealing)	Innovation perspectives (and selected phenomena)
Blocked	User entrepreneurship Vertical integration
Unintended spillover	Cumulative innovation Free culture
Free revealing	User innovation Social production Co-creation Open innovation (knowledge benefactor) Open source software Open science
Paid revealing	Open innovation Crowdsourcing

belonging to a community and donating their contributions to it (cf. Shah, 2006). Communities more generally offer great potential value for firms seeking external innovation. These firms thus need to develop a strategy for motivating community members to create and share innovations (Lakhani & Wolf, 2005; Dahlander & Wallin, 2006).

Open innovation may also include non-pecuniary motives. In the case of open source software and game modifications, programmers may donate their innovations to improve their reputation – whether for ego reasons or

to signal their skills to the labour market (West & Gallagher, 2006). However, open innovation most typically emphasizes the pecuniary motivations for firms to supply their innovations to other firms (Chesbrough, 2006b). In crowdsourcing, individuals are usually paid directly for their innovation contributions, as with InnoCentive's problem contests (Jeppesen & Lakhani, 2010).

The availability of external innovations from direct competitors is more problematic. Consistent with user firm innovations (cf. de Jong & von Hippel, 2009), firms may freely reveal their innovations because they are complementary to their core business model (Nuvolari, 2004). In other cases, their efforts to block spillovers are unsuccessful, or not economically feasible (e.g., Allen, 1983); in these cases, the unwilling supply of external innovations will likely be unreliable. However, despite the exact drivers, knowledge sharing among firms or organizations more generally, such as in co-creation and cumulative innovation, typically serves ultimate pecuniary motives.

Appropriating Value from Distributed Innovation

We now explore how firms can capture the value from distributed innovation that is created and shared by external stakeholders in their value network.

Ownership of Distributed Innovation

Ownership of technology is a main driver of who is able to appropriate value within open innovation, as it determines the constraints for knowledge transactions (cf. Arora, Fosfuri & Gambardella, 2001; Chesbrough, 2003a). Because users typically innovate to solve a need and often do not attempt to draw financial profit from their innovation, ownership of the innovative knowledge is usually not an issue for users and they may even freely distribute their knowledge or innovation, even to producers (Harhoff, Henkel & von Hippel, 2003; Henkel & von Hippel, 2005; de Jong & von Hippel, 2009). In fact, innovation by users typically takes place within communities, which entails the free disclosure of knowledge and innovations (Lakhani & von Hippel, 2003; von Hippel, 2007). When there is a firm (owned by either a producer or user), ownership of the innovation and/or relevant complementary assets is required to appropriate value from the innovation, such as in the case of communities (Dahlander & Wallin, 2006) or user entrepreneurs (Shah & Tripsas, 2007).

Capturing Innovation Flows

Different mechanisms enable innovation flows to producers. While open innovation considers that strong formal or informal appropriability mechanisms allow firms to profit from innovation (Chesbrough, 2003a; West, 2006), they generally monetize their innovations rather than allowing free spillovers of knowledge (Chesbrough, 2006a). Thus, the management of intellectual property (IP) and licensing is a central means to control knowledge flows and determine ownership (cf. Granstrand, 2000; Arora, Fosfuri & Gambardella, 2001). In general, the distributed production of innovation relies on an IP regime that supports knowledge spillovers and collaborative ownership of innovation. Free spillovers can moreover come from innovation benefactors such as universities (Chesbrough, 2003b). In addition, a producer's internal characteristics and capabilities affect its ability to insource useful knowledge for innovation (cf. Mowery, Oxley & Silverman, 1996).

Intellectual Property Rights Restricting Flows

There is a stark contrast between open innovation and user innovation and related perspectives in their respective implications for the strength of IP protection – most typically patents but also copyright in the case of software and user-generated content. Outbound open innovation emphasizes strong IP protection (e.g., Chesbrough, 2003a), while inbound open innovation that comes from external firms depends on those firms being able to profit from their innovation, usually via formal appropriability mechanisms (Teece, 1986; West, 2006; van de Vrande et al., 2009). Of course, firms are also certainly willing to accept unmonetized inbound spillovers of knowledge and innovation, such as from public universities or research laboratories (Chesbrough, 2003b). Conversely, user innovation researchers typically view strong IP protection – specifically between producers and their customers – as retarding user innovation (von Hippel, 2005). Unlike open innovation, the normative assumptions of this research do not emphasize firm success.

Discussion

In this paper, we presented an overview of different perspectives that provide a critique to the traditional model of the vertically integrated innovation process. We showed the strategic implications of the research on distributed innovation by discussing the nature

and sources of distributed innovation, how firms can increase the supply of such innovation, and how they can capture the value that is created as such.

Implications

This paper has identified the important commonalities within research on distributed innovation spanning largely disjoint bodies of theory and empirical evidence. It suggests that careful examination of the convergent and conflicting predictions and proscriptions of these streams will improve our understanding of both the constituent streams, and more broadly how innovation can and should take place outside the boundaries of the firm.

These streams share a common critique of the long-accepted integrated model of industrial innovation as represented by Chandler (1977), Freeman (1982) and others. Such research on distributed innovation assumes that knowledge, as an enabler of innovation, is dispersed beyond the boundaries of any one firm, and thus that important innovation activities take place outside or across the boundaries of the firm. These perspectives consequently offer congruent (if not parallel) normative proscriptions for 21st-century innovation processes, about the importance to firms of searching outside their boundaries to obtain crucial knowledge (if not complete solutions) both for creating and commercializing innovations.

Similarities aside, the important differences between these perspectives suggest a family of related research rather than commensurable theories awaiting unification under some grand unified theory. At their core, they make different assumptions where and how such external sources of innovation occur, assumptions that are subject to empirical verification through, for example, a test of competing hypotheses. Prior research in distributed innovation either focuses on one perspective while ignoring the others, or blurs the definitions of each perspective (or sub-stream) at the expense of accuracy – thus minimizing the ability to draw upon the insights of these multiple research perspectives.

More significantly, these distributed innovation perspectives diverge in their emphasis of the key stakeholders. Concomitantly, they differ in their consideration of motivations for creating innovation and their definitions of the desired successful outcome. In this regard, open innovation is in some ways more similar to vertical integration and thus different from the other perspectives in emphasizing firm success.⁷ A critique that remains unique to the core of user innovation research is the (empiri-

cal) emphasis on extra-organizational innovation that (largely) originates with individuals rather than inside the boundaries of other organizations.

There are also crucial normative and policy fault lines within these distributed innovation perspectives. For example, open innovation is generally dependent on the strong IP provisions that are anathema to user innovation researchers as well as those in many auxiliary perspectives. This thus puts open innovation at odds with other distributed innovation research that recommends policy regimes of weaker IP enforcement (e.g., Scotchmer, 2004; von Hippel, 2005).

Opportunities for Future Research

A more integrated view of the distributed innovation process suggests numerous opportunities for future research, both to build upon the existing streams and to identify new distributed innovation mechanisms and phenomena outside these streams.

Those cases of overlapping phenomena and causal mechanisms offer opportunities for testing competing hypotheses between open innovation and user innovation as well as the other perspectives on distributed innovation. This would allow the evaluation of a range of contemporary phenomena such as user-generated content, crowdsourcing and even user entrepreneurship. At the same time, other perspectives on collaboration such as open science (Merton, 1973; David, 2002), social production (Weber, 2004; Benkler, 2006) and free culture (Lessig, 2004) are neither fully distinct from nor fully coincident with any of the major perspectives. Identifying boundaries of these (and other) areas of distributed innovation research would allow better bounding of both the managerial and public policy proscriptions offered by each.

The overlaps also suggest opportunities for attempting integrated tests of one or more streams. For example, the various perspectives might be ideal for modelling the problem of joint maximization of innovation success criteria for the various actors in a value network – at different units of analysis, ranging from the firm-level to the level of the ecosystem or industry. Moreover, an exploration of different types and levels of openness could advance how the optimal degree of openness differs across the value network (cf. Laursen & Salter, 2006; Vanhaverbeke & Cloudt, 2006; Almirall & Casadesus-Masanell, 2010).

As this paper reviews the different perspectives in the light of managing or profiting from distributed sources of innovation – which is beyond the focus of most user innovation and

other utility-based innovation research – future research should further develop models for the strategic utilization of distributed innovation. While such an attempt will benefit from contrasting and integrating the boundary conditions as put forward by the different perspectives, it is especially important to identify causal mechanisms linking managerial decisions to identifying and achieving a continuous supply of external innovations, and finding a way to appropriate value from those innovations for superior performance. In this vein, the work on open innovation – open business models in particular – is currently most directly relevant to supporting such research (Chesbrough & Rosenbloom, 2002; Chesbrough, 2006b), while more attention to the possible risks and costs of distributed innovation processes is also needed (Faems et al., 2010).

This work also suggests a broader, more general examination of the scope of knowledge and innovation that spans or resides outside organizational boundaries. In considering firm commercialization of external innovations, both Murray and O'Mahony (2007, p. 1009) and Shah and Tripsas (2007, p. 132) identify the importance of know-why and know-what, in addition to know-how, suggesting an opportunity to apply Garud's (1997) typology of these three types of knowledge to the process of creating and commercializing distributed innovations.

Finally, the distributed view suggests a potential broadening of our understanding of the interaction between internal absorptive capacity, external knowledge stores and the boundaries of the firm (Veugelers & Cassiman, 1999; Spithoven, Clarysse & Knockaert, 2010; Bogers & Lhuillery, 2011). Developing technical skills not to create innovations but to evaluate external innovations is already an established part of the open innovation process (Chesbrough, 2006a). A distributed perspective could help address a crucial question raised by Brusoni, Prencipe and Pavitt (2001): When (and why) is there a value for a firm to acquire knowledge or innovations beyond those that it sells?

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Notes

1. 'Open science' is the term used by David (1998, 2002) to describe the spillovers between scientific

researchers that are possible when basic research is subsidized as a public good – consistent with Merton's (1973) model of government funded research in the postwar US. The recent emphasis on faculty patenting and industry collaboration has been seen to threaten these norms of open collaboration (Fabrizio & Di Minin, 2008).

2. An existing technology provided at a dramatically lower cost will often have the same impact on production and use as a discontinuous technological advance, whether termed disruptive innovations (Christensen, 1997) or radical innovations (Leifer et al., 2000).
3. User innovation and open innovation offer complementary views on the nature of distributed innovation, which are overlapping in some areas (e.g., role of users as a source of innovation) and disjoint in other areas (e.g., intellectual property markets for open innovation, non-profit user communities for user innovation.)
4. The term 'open innovation' has been used in other contexts, but in this paper we reserve the phrase for the context conceived by Chesbrough (2003a).
5. Earlier research also investigated suppliers as the sources of innovation, based on their expectation of appropriating the benefits from selling material or components complementary to the innovation (VanderWerf, 1992; von Hippel, 1988).
6. Such innovations may also be produced by networks of users that, while connected by computer-mediated virtual networks, lack a common community identity or interpersonal ties (von Hippel, 2007).
7. The earliest, exploratory phase of user entrepreneurship parallels other user innovation processes, but the later stages – after firm creation – are more similar to those of open innovation in which firms seek to commercialize external sources of innovation. Cumulative innovation assumes profit-maximizing corporate actors but does not seek to optimize their results.

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