MANAGING OPEN INNOVATION

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Abstract

This article provides an overview of the literature on the management of open innovation. Elaborating on what exactly 'open' innovation comprises, this article integrates efforts by scholars who have studied this topic from a variety of perspectives. In doing so this article highlights that despite the virtues of openness having been stressed by much of the literature in this field, many companies still struggle to be successful with their open innovation strategies. A big question therefore for both theory and practice is under which contingencies openness is beneficial, and the article reviews internal and external factors that shape the rewards companies can derive. This results in a number of theoretical and managerial implications and suggestions for avenues of future research.

Key words

open innovation, contingencies, openness

INTRODUCTION

In recent years, few terms have gained as much attention in innovation management as *open innovation*. The concept was coined by Henry Chesbrough, who defines it as 'the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. Open innovation assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology'. (2006a:1). Although it has certainly made standalone contributions, the concept is also tightly related to previous concepts of innovation, such as user innovation (Bogers and West 2012; von Hippel 1988) or cumulative innovation (Scotchmer 1991; Murray and O'Mahony 2007). Accordingly, for this article, we use a slightly different definition of open innovation: all flows of knowledge across the

boundary of the firm, independent of the form or direction, that are deliberate and that aim to create and capture value for the firm. These knowledge flows can be both inbound (arriving at the company) and outbound (leaving the company). Finally, they can involve both monetary exchange and more informal relationships (Dahlander and Gann 2010).

At the core of the open innovation concept is a simple yet gripping idea: knowledge flows that transcend the walls of a company can allow firms to become more efficient and effective, especially in their research and development efforts. This has several potential implications for the management of innovation. First, it contests the assumption that the firm should be the nexus of all innovation it eventually introduces to the market (see Ammon's article *The sources of innovation[oxfordhb-9780199694945-e-035]*). Second, opening up the innovation process has to be anchored concomitantly in an overall innovation strategy that combines internal and external sources of innovation. Finally, implementing open innovation brings tremendous challenges to people involved in R&D. It is not trivial to combine and integrate existing expertise *within* a company, and this challenge is further exacerbated when it also comes to converting *external* knowledge to new products and services.

Whether or not open innovation is a new concept has been debated—after all, firms have long used collaborative behaviour to improve the outcomes of their R&D efforts (see Dodgson's article *Collaboration and innovation management[oxfordhb-9780199694945-e-003]*). For example, both Allen (1983) and Nuvolari (2004) have shown that industries shared research findings and documents more than a hundred years ago. Hargadon's (2003) work on the Edison laboratory shows an intricate web of relations across organizations. Freeman (1974) made a similar remark, suggesting that R&D labs are not 'castles on the hills'.

Even though the idea has a long range of precursors, two recent trends have drastically increased the ease of collaborating across firm boundaries, rendering the topic of open innovation potentially more important: globalization and the emergence of the Internet. Both trends affect the ease of collaboration by reducing transaction costs, increase the potential number of partners, increase the extent of the market, and lower barriers to communication. Accordingly, in the last few decades, firms have been exposed to more options for collaboration across their boundaries.

IMPORTANCE OF THE ISSUE

Since its introduction in 2003, the term *open innovation* has left quite a mark on both the business and the academic world. Ignoring academic volumes published on the topic (e.g., Chesbrough, Vanhaverbeke and West 2006), Figure 1 plots the number of papers published annually in journals listed by Thomson's ISI Web of Science, illustrating that the number of papers has increased rapidly. In 2010, close to 100 papers were published on the topic.

[Insert Figure 1 about here]

This literature abounds with success stories of open innovation, but we have now moved beyond anecdotal evidence. Recent research shows that a firm's engagement in open innovation positively affects its financial performance and market value (Stam 2009; Waguespack and Fleming 2010). Also, it features prominently the need to include open innovation activities strategically into larger business models—processes and practices the firm employs to create and capture value—an issue central in Chesbrough's original conception (2006b) and extensions (Chesbrough and Appleyard 2007), and built upon by several subsequent authors. Nonetheless, as we will argue, there has been little scholarly work on the conditions under which open innovation is a practical strategy, and how organizations can implement those practices. There are clearly costs of both collaboration and coordination when a firm adopts open innovation (Grant, 1996). Coordination costs stem

from differences between the partners when innovation processes transcend organizational boundaries, and costs of competition arise in protecting ideas from actors that can act opportunistically. It is therefore important to consider both the advantages and the disadvantages of implementing open innovation, as the tradeoffs reveal when this is the best strategy to pursue.

The concept of open innovation has also made a striking impact on the practitioner world. For example, as a result of P&G's renowned 'Connect + Develop' initiative, P&G nowadays sources more than 50% of innovations from outside its corporate boundaries. GlaxoSmithKline's 'Centre for Excellence in External Drug Discovery' manages a pipeline of options on drugs in development by external parties that rivals its in-house pipeline in size. Yet GSK has more than 10,000 employees in R&D; CEEDD has only about 20 (Alexy, Criscuolo, and Salter 2009).

RESEARCH THEMES

Even though the number of papers using the open innovation concept has increased, it has been difficult to compare their findings because their interpretation of 'open' varies. Dahlander and Gann (2010) extended the work of Gassmann and Enkel (2006), devising a simple categorization based on the flow of knowledge and type of exchange, leading up to the two-by-two matrix illustrated in Table 1. This table outlines two forms of inbound innovation—Acquiring and Sourcing—as well as two forms of outbound—Selling and Revealing.

[Insert Table 1 about here]

Acquiring

Acquiring relates to buying inputs to the innovation process in the marketplace. Work in this vein explores how openness can be understood by investigating how licensing and acquiring knowledge from outside constituents affect companies. The challenge is viewed as one of

combining the acquisitions of knowledge with internal expertise to search for and evaluate potential inputs. In accordance with transaction cost economics (Arora et al., 2001; Williamson, 1975), firms will find that, sometimes, it might just be cheaper to license or buy an existing and available outside technology than to develop it from scratch.

Sourcing

Sourcing stems from how firms scan and use the external environment as input to the innovation process. Scholars who use this lens focus on how firms explore their environment as a complement to their internal knowledge production, which might in fact be limiting them in their quest for new ideas to use in innovation. First, a lack of assets, such as skilled employees, cash, or machine tools, may constrain the solution space from which the firm can choose (Chesbrough, 2003). Second, because of the evolutionary nature of their knowledge base (Cohen and Levinthal, 1990; Kogut and Zander, 1992), firms might look in vain in some areas for solutions which could be readily available in others (Jeppesen and Lakhani, 2010), and their inclusion be highly beneficial to the firm (Rosenkopf and Nerkar, 2001). The story of the longitude prize provides a fitting example. A clockmaker beat astronomers, including Sir Isaac Newton, to the solution to the measurement of longitude at sea (Sobel, 1995). Similarly, von Hippel's work (1988; 2005) shows that for a wide array of innovations, their functional source is not the focal firm (manufacturer) but a downstream (user) or upstream (supplier) actor. In particular, he notes the importance of lead users, pointing out how their foreshadowing general market trends and developing of prototypes can assist corporations in designing new and highly successful innovative products.

Laursen and Salter (2006) show that there are limits to the benefits from sourcing knowledge externally. They find that openness with respect to making use of external knowledge sources has a U-shaped effect on innovative performance. Their result highlights the fact that openness may be advantageous to the firm but also raises the issue of the

appropriate degree of openness, by showing that both too little and too much sourcing from outside may be detrimental to the firm.

Selling

This type of openness refers to how firms commercialize their inventions and technologies through selling or licensing the resources they have developed to other companies. Underlying this research is the idea that some companies have ‘Rembrandts in the attic’ that are unused (Rivette and Kline 2000). By selling or licensing those through agreements, companies can increase their own profits while allowing technologies to be commercialized by someone more suitable. Some scholars argue that the potential of selling technologies has not been fully exploited: Gambardella, Giuri, and Luzzi (2007) even suggest that the market for technology could be close to 70 per cent larger if some obstacles could be overcome (see Gambardella, Giuri, and Torrisi’s article *Markets for technology[oxfordhb-9780199694945-e-024]*).

Revealing

Revealing proprietary knowledge will be beneficial if the firm can appropriate value from its diffusion (von Hippel 1988). In general, knowledge ought to be revealed selectively—that is, only when it is advantageous to the firm (Henkel 2004; Henkel 2006). Firms reveal knowledge strategically and at the same time appropriate the rents of other parts of their business privately to gain advantages over their competitors (Chesbrough 2006b).

Particularly for information technologies (Varian and Shapiro 1999), sharing underlying technological specifications is central to the generation of standards. The existence of a standard might lead to an increase in the size of the market, thereby enlarging the pie from which the firm can appropriate its piece (Varian and Shapiro 1999; von Hippel 1988).

If the company defines (parts of) a standard—even if it is an open one—it is highly likely that it includes parts that are beneficial to only that one company, either because only this firm knows of them or because they are already optimally realized in the firm's existing products (Henkel 2004). Spencer (2003) finds positive effects on the innovative performance of firms actively choosing to reveal some of their IP. She argues in particular that a firm will do so in order to attract other organizations to join its technological trajectory, which may help in both standard-setting and the development of industry structure. Gawer and Cusumano (2002) observe similar behaviour in Intel's platform development strategy, which makes use of openness to establish new markets and increase adoption of the PC platform in certain areas.

If one strong standard or a dominant one already exists, releasing related know-how can make it part of the standard or at least increase compatibility of the standard with existing intra-firm knowledge (Harhoff, Henkel, and von Hippel 2003; Henkel 2004). Such increased compatibility will create network effects that encourage diffusion and adoption not only of the released know-how, but also of related innovations and second-generation innovation built on it (e.g. Farrell and Gallini 1988; Shepard 1987). Information may also be leaked strategically to commoditize layers of the product architecture in which the focal firm is weak and to shift competition to layers where the firm has a competitive advantage (Raymond 2001; West 2003).

Coupled models: Combining different types of openness

The preceding categorization distinguishes between types of openness, although they are often combined in practice. But only a few studies have analyzed how different types of openness are interrelated (see, e.g. Acha 2007; van de Vrande et al. 2009), possibly because of confusion about what openness entails. With a better understanding of different types of

openness, one can discuss and analyze how they are interrelated in specific initiatives that organizations adopt.

For instance, voluntarily revealing and sourcing ideas from the environment often go hand-in-hand. Companies co-create new knowledge through forging and sustaining collaboration with external partners. Von Hippel (1988) argued that firms often trade knowledge to achieve mutual benefits if the rent a firm can expect from sharing is higher than when it keeps the knowledge proprietary, especially when the knowledge holds little competitive advantage (Allen 1983). This concept is formalized in Henkel's (2005) model. It shows that when two firms voluntarily reveal developments of complementary technologies, both firms' profits and product quality can increase.

Furthermore, exchange of knowledge across organizational boundaries enables organizations to benefit from the improvements made by other parties. Such inputs help organizations to tailor existing and future products to the market, leading to faster product development and higher success rates (Dalle and Jullien 2003; von Hippel 1988). In addition, if customers are allowed to make changes to products, they will be more likely to commit fully to the product and to impactful improvements (Jeppesen and Frederiksen 2006; von Hippel 2001). In this way, the company receives knowledge that is often difficult to find, transfer, or acquire otherwise, so-called 'sticky information' (von Hippel 1994). Also, people outside a company sometimes even do mundane tasks such as user support or documentation (Lakhani and von Hippel 2003). And finally, even in situations where the relevant knowledge is vital to the firm's competitive advantage, know-how trading can be beneficial. For example, two competitors, each of which needs the other's technical know-how, might decide to offer a joint bid for a government contract because they would be unable to complete the respective technologies independently (von Hippel 1988).

Companies often combine selling and acquiring as they seek to streamline their own R&D processes. Unused technologies are sold to external partners that are better suited for commercializing the technology, providing additional sources of revenue. On the flip side, companies also acquire outside technologies they seek as inputs in the innovation process. In all these cases the underlying rationale is to find the company most suitable to commercialize a technology.

CONTINGENCIES OF OPEN INNOVATION: WHEN IS IT BENEFICIAL?

Managers often ask a highly relevant question about open innovation: Does it pay off? Researchers ask a related question: Under what conditions is open innovation worth pursuing? The answers to those questions require an understanding of contingent factors that affect whether and when openness is beneficial for the organization. Some of these contingencies are internal to the firm, others external, a categorization we use below.

Internal contingencies

Cognitive bias—Not Invented Here

To find the best seed for innovation is not easy because people who work in organizations are subject to cognitive bias. People simply like what they are. Employees inside an organization often reject innovations from the outside because they challenge established wisdom inside the company: the ‘not invented here syndrome’ (Katz & Allen 1982).

The not invented here syndrome is often an outcome of repeated external collaboration with unsatisfying outcomes (Alexy, Criscuolo, and Salter, 2012). In particular, firms at the forefront in a technology often struggle to identify external parties who can add value to their innovative efforts and consequently develop a negative attitude toward external collaboration. In other cases, ‘not invented here’ is caused by a fear that working with

external partners will expose individual weakness, and that associated organizational change will disrupt individuals' work routines and even put their jobs at risk. In support of this argument, Alexy, Henkel and Wallin (2013) find that less-skilled employees exhibit higher degrees of skepticism toward open innovation. Their reluctance implies that further educating people inside the company not only increases the human capital, but also employees' ability to recognize and work with important knowledge from the outside.

Skillsets

Alexy, Henkel, and Wallin (2013) show that engagement in open innovation trickles down to the micro-level of how people organize inside companies. Some tasks within the R&D processes undergo significant changes in both the skills required to execute them and the degree of control individuals have to share with outside actors. These changes are strongest for people whose job roles are of 'executing' character, such as developers in software, R&D engineers, and project managers. Consequently, companies intending to engage in open innovation need to address potential concomitant employee concerns. For example, they may choose to adapt existing reward systems to reflect the different nature of project planning and execution necessary to benefit from knowledge that stems from outside the organization. Other organizations find it easier to adapt their HR policies and hire external people with the necessary skills or train their internal staff to develop them.

Attention

Laursen and Salter (2006) depict open innovation as a search process. Companies can use various sources; each of the search channels provides different sources of information but requires different norms of exchange. Thus, while each source brings novel information, accessing it comes at a cost. Companies that use more search channels are more innovative, but some organizations spread the attention of the top managers and R&D experts too thinly and thus perform worse (Laursen and Salter 2006).

Many companies seek to tap existing outside knowledge by running so-called unsolicited idea submission processes, but struggle because of attention-related issues. Specifically, although such processes often succeed in attracting external ideas, existing company selection processes are overstrained by the increase, preventing any improvement in overall innovation performance (Alexy et al., 2012). Simply put, while it seems as if open innovation answers the problems of limited reach and paucity of ideas available inside the firm, it may only replace them with an equally complex problem of selecting the right ideas.

A potential solution may be to involve specialist intermediaries to decrease transaction costs. Several authors describe how companies such as InnoCentive and NineSigma support businesses by presenting their internal problems to a broad range of knowledgeable outside parties and facilitating the transfer of only a selected number of highly probable suggested solutions (Jeppesen and Lakhani 2010). In doing so, they may also assist in solving the issue contamination described below.

Compatibility

One of the main sources of coordination costs stems from a lack of compatibility between partners which can affect both content (matching solutions to problems) as well as structure (different languages and norms of exchange).

Regarding inbound open innovation, the higher the content compatibility of external knowledge—the better external knowledge fits current or anticipated future needs—the higher its potential value to the firm. Thus the general availability of an external partner providing such matching knowledge (Universities doing research in the area for example) is a mandatory precursor for inbound innovation to be valuable. Second, the greater the structural compatibility—that is, the more closely aligned are the parties' internal and external structures and the language used to comprehend and describe certain problems and

solutions—the less effort the firm will need to invest in making external knowledge usable and the higher will be the potential net benefit resulting from engaging in open innovation.

For outbound open innovation, content and structural compatibility are important in identifying firms who would be suitable recipients (i.e. buyers) of the firm's internal knowledge. The better internal knowledge fits an external party's needs and the smaller the cost to them to make the knowledge usable for themselves, the more willing they should be to adopt it, and the higher the price they should be willing to pay to acquire or license it from the focal firm. Notably, if the focal firm realizes that no external party has a need for its knowledge, or that costs of adoption are prohibitive, internal measures can be taken to increase the attractiveness of the to-be-opened knowledge to outside parties. Many software firms for example provide additional documentation or toolkits together with the actual software they open up in order to show potentially multifaceted applications of their software to external parties and smooth the adoption process.

Boundary-spanning and internal legitimacy

Much of the early work on boundary-spanning (Allen 1977; Tushman and Scanlan 1981; Ancona and Caldwell 1992) analyzed how people within R&D labs forged connections with outside people. They found that 'communication stars' who were connected with people both inside and outside the organization were better able to innovate. They gained fresh insights from engaging with outsiders, while retaining credibility inside the organization, to bring ideas to fruition.

But cultivating broad networks within as well as outside an organization is not easy and has the potential for people to spend more time on forging connections than getting the work done (Dahlander, O'Mahony, and Gann, 2011). Time is a scarce resource: seeking more external engagement can have unintended consequences if it distances employees from their own company. Firms need to ensure that knowledge and partnerships identified by their

outside scouts are in fact being harnessed by the internal organization, and then to build the necessary absorptive capacity (Cohen and Levinthal 1990).

Complementary assets

Complementary assets are needed to commercialize an innovation, but they do not include the assets directly tied to the innovation. They include access to distribution, service, and manufacturing facilities and often explain who profits from innovation (Teece 1986). In open innovation settings, complementary assets are particularly important because their ownership radically mitigates concerns about loss of intellectual property (Dahlander and Wallin 2006; Henkel 2006). Regarding outbound innovation, if a firm holds complementary assets, releasing internal knowledge related to them might ultimately be profitable.

Sometimes sharing internal knowledge fuels diffusion in such a way that the value of possessing complementary assets increases more than the loss the firm incurs from leaking to competitors. On the other hand if a firm has weak complementary assets it may be forced to enter relationships with partners enjoying stronger positions, evidenced by the central importance of alliances in the biotech industry (small biotech and big pharma). On the inbound side, firms holding strong complementary assets may undertake systematic identification of external parties that need them to increase the utilization and profitability of already-made investments.

External factors

Appropriability regimes and the problem of contamination

Teece (1986) describes the appropriability regime (see Gambardella, Giuri, and Torrisi's article *Markets for technology[oxfordhb-9780199694945-e-024]* and Leiponen's article *Intellectual property rights, standards and the management of innovation[oxfordhb-9780199694945-e-020]*) as 'environmental factors, excluding firm and market structure . . .. The most important dimensions of such a regime are the nature of the technology and the

efficacy of legal mechanisms of protection' (Teece 1986:287). Legal mechanisms in particular may be crucial in the establishment of formal relationships. The more strongly enforced the legal mechanisms that define ownership over intellectual property along clearly demarcated boundaries, the easier it will be for two parties to contract over the exchange of innovation. Many firms even refuse to speak to externals who have not filed for intellectual property protection, because their ideas may 'contaminate' internal R&D (Chesbrough 2006b; Alexy, Criscuolo, and Salter, 2012; West 2006).

The problem here is that if no documentation or boundary exists to delineate what exactly the external has to offer, it will be difficult in the case where collaboration does *not* proceed for the firm to prove in the future that the external knowledge did *not* influence internal R&D. And in those situations where firms decide in favour of collaboration, IP rights are important to facilitating negotiations by mitigating the paradox of disclosure—the problem that once valuable knowledge is disclosed to facilitate collaboration, its market price drops to zero—and to enable transfer of ownership by a simple trade of the IP right for money.

Issues such as these clearly show that markets for technologies (see Gambardella, Giuri, and Torrisi's article *Markets for technology[oxfordhb-9780199694945-e-024]*) depend on the existence of tradable assets demarcated and protected by IP rights. Nevertheless, some fields reject private ownership of knowledge, creating an issue of moral repugnance (Roth 2008): 'open science' (Gans and Stern 2010) and 'open source software' (O'Mahony 2003) are spaces where some actors reject the establishment of tradable IP rights, making financially based transactions difficult to achieve.

Whereas strong IP regimes are typically positively related with pecuniary forms of exchange, weak IP regimes can facilitate more informal means of interaction. Von Hippel and von Krogh (2003) submit that an inability to protect knowledge developed in-house

because of weak appropriability regimes may spur companies to identify strategies in which the selective disclosure of such knowledge will be to their advantage.

Cumulative nature of knowledge

Most early work on open innovation has focused on high-technology industries with a significant manufacturing component, and on the pharmaceutical and biotechnology industry. This selection, as well as the general importance of collaboration in these industries, reflects that the areas of technology they rest on build on a science base that is cumulative. Invention is usually built on the current knowledge base, allowing inventors to 'stand on the shoulders of giants' when they make progress.

These processes of knowledge production naturally lend themselves to joint inventive activity because knowledge flowing between actors with different but related knowledge bases will lead to an increased likelihood of scientific advancement. The innovation process is viewed as box of Lego, where the kid with the greatest diversity of pieces can recombine them into the most novel outcomes.

More recent work has begun to shed light on open innovation in project-based industries (Davies, Gann, and Douglas 2009) as well as the services sector (Chesbrough 2011), highlighting that principles of open innovation should be applicable to more industrial sectors. When the knowledge frontier is less cumulative, it becomes more difficult to divide tasks, resulting in significant coordination problems.

Technological maturity (Abernathy and Utterback 1978) also plays an important role in open innovation (Christensen Olesen, and Kjær 2005). The earlier in its life cycle a technology is, the more likely that rallying a crowd behind one technology can give one company a lead in establishing a dominant design—but sometimes an existing dominant design is displaced through strategic engagement in open innovation (Varian and Shapiro 1999). In turbulent technology environments, companies will often struggle to identify

partners on their journey. On the flip side, when stormy seas have settled and technologies become well understood, recognizing suitable collaborators and establishing mutually beneficial partners will be relatively easy.

Type of technological advance

An extensive literature points to the fact that many, perhaps most, radical innovations have been made not by established companies (Schumpeter 1942), but by individual inventors, start-ups, or university researchers, or as part of government programmes. The Internet is a popular example.

Existing companies, on the other hand, very often specialize in improving the technology they already have in-house—to use March's (1991) terminology, they exploit rather than explore—and few companies have the skill to do both, especially at the same time. Here, open innovation may be a useful pathway to allow companies to continuously renew themselves through new technologies (Dodgson, Gann, and Salter 2006). Practices such as the lead user method (von Hippel 1988) involve external actors in the design of novel and imaginative products and services. GSK's CEEDD milestone-based approach to collaboration is a further design model to harness the environment as a source of radical innovation (Alexy, Criscuolo, and Salter 2009). And Intel has developed 'Intel Research' as an open-innovation-based sensor network to discover nascent trends around its Silicon platform (MacCormack and Herrman 2004).

If designed appropriately, open innovation activities can also be used to sustain incremental innovation. For example, the continuous and joint development of open source software platforms such as the Apache web server or the Linux operating systems allows companies such as IBM to save hundreds of millions of dollars each year.

Number of partners available

Implicit in much reasoning on open innovation is that potential partners are just ‘out there’ ready and waiting to collaborate with other companies. Any company that has sought to collaborate with other partners knows this is a cumbersome task. The focal organization may not be an attractive collaboration partner, leading companies to invest in internal R&D to gain a ‘ticket of admission’ to a collaboration network (Nelson 1991).

One further problem is that companies often do not know who holds ‘matching’ knowledge (i.e. compatible in its content and structure), such as solutions to the problems they are facing. Here, intermediaries have emerged to bring together two parties to their mutual benefit. In contrast, companies that have a rough understanding of where to look will need to ask themselves what it is they are actually looking for when they are seeking external knowledge. Is it one specific partner with certain assets or attributes? Or is it rather the ‘crowd,’ from which companies want to identify average opinions, general needs, or market trends? Depending on these choices, extant research has made clear that different patterns of interaction and IP protection will be mandated to achieve increased innovation performance (Alexy, Criscuolo, and Salter 2009).

DISCUSSION

Open innovation promises to leverage internal R&D and allow organizations to benefit from engagement with external partners. Some companies are more successful than others in implementing open innovation. Why?

While the early literature on open innovation argued that being open was generally beneficial, more recent work has moved on to study under what specific conditions openness can contribute to improving firms’ innovative performance. This literature has looked at contingencies both internal and external to firms. In turn, these contingencies will also determine their decision whether or not to engage in related practices. We have built on

related work on the topic and specified some of these contingencies, and it is our hope that future work will refine them further.

Future Research on the Phenomenon

A logical next step is to improve our understanding of how firms active in this new, open environment can be managed—specifically, which 'standard' management practices (known from closed innovation) apply 'as is' and which do not work? Which can be adapted? Which new ones have to be developed?

For example, incentives function differently for people outside an organization. These people are often motivated to take part, but for reasons different from members of the focal organization, suggesting that one cannot implement the same practices as used within organizations. The role and effect of monetary rewards differ widely across varying types of arrangements. For example, people solving problems for firms via the intermediary InnoCentive expect payment, and money may be seen as a prime motivator (Jeppesen and Lakhani 2010). For problem-solvers in a similar intermediary, TopCoder, however, status within the peer group is a far more important motivator (Boudreau, Lacetera, and Lakhani 2011). In open source communities, financial rewards may even have negative effects under certain conditions (Alexy and Leitner 2011). In short, providing incentives to people outside the corporate boundaries is much more complex than to internal actors. It requires a lot of careful planning and deliberation—the same should apply to other 'closed innovation' management practices.

The competitive dynamics of being open is poorly understood. Although existing work has identified the crucial importance of this question (Christensen, Olesen, and Kjær, 2005), the specific effect of being open today on a company's future competitive position needs further work. Although some research describes how companies seek to benefit in the present from open and hybrid business models (Chesbrough, 2006b; Bonaccorsi,

Giannangeli, and Rossi, 2006), it is unclear how this translates to competitive advantage in the future. Competitive dynamics also surface between outside actors that participate in the focal firm's open innovation initiatives. For example, Boudreau and Lakhani (2009) show that outcomes are substantially affected by whether open innovation activities are designed to facilitate collaboration or competition between contributors.

Careful deliberation is important when one considers being more open. Although some firms gain from opening up, it remains unclear that others can and will reciprocate such moves. Opening up innovation processes promises to involve a broad range of external people, speeding innovation. But coordinating between external people with different interests who are also beyond hierarchical reach is a challenge for many organizations. To balance and reach agreement among a wide array of partners requires attention and a deep understanding of each others' needs. These challenges should not be trivialized, especially because alliances between companies, as well as interpersonal relationships between individuals, often wither and die (Burt 2002).

More research is needed on the competencies and practices companies need to implement in-house to benefit from being open. Open questions include suitable models for allowing individuals and departments to collaborate externally, where the famous slack models propagated by firms such as 3M or Google have caught the public's attention, but have not been scrutinized for their efficacy and efficiency. It is unclear whether these success stories translate into benefits for more 'average' companies. The expectations of job and skill profiles are also changing in an open environment—how much should individuals collaborate? Which positions should they hold in their companies? How can these people bring into the firm the externally acquired knowledge? And finally, there is the crucial issue of aggregation, linking to work on absorptive capacity (Cohen and Levinthal 1990): How

does the external and internal engagement of all actors in the organization actually come together to lead to beneficial outcomes for the focal organization?

Improving management theory

The number of papers on the topic has increased at an astonishing rate, but it does not constitute a field on its own. It is therefore important to discuss how it links to other streams of literature and find points of common interest (see Bogers and West 2012; Dahlander and Gann 2010. We elaborated on contingencies that explain when certain open innovation strategies are beneficial to a focal firm. A comprehensive explanation of when and to what extent firms share valuable resources with others will enhance the explanatory power.

Sustained and substantial engagement in open innovation may be somewhat counterintuitive as firms increase the number of external actors they depend on for innovative success. Some recent research has however argued that the strategic use of open innovation allows changing the nature and potential impact of such external constraints (Alexy and Reitzig 2011). Other work describes solutions to the problem of competing institutional logics when open and closed innovation clash (Perkmann 2009). We encourage more research on questions such as how open innovation is shaped by institutional pressures, as well as how the strategic use of open innovation allows companies to shape institutions around them.

Open innovation may be seen as a challenge to established classical theories of management. The resource-based view emphasizes that resources have to be rare, inimitable and non-substitutable to create competitive advantage (Barney 1991; Grant 1991). An implication of open innovation is that many of the most essential inputs to the innovation process are neither owned nor controlled by the firm. Yet some firms are able to reap rewards from using novel ways of extending and leveraging their resource base. More work is needed for scholars of open innovation to connect the idea to these theories of management.

Relatedly, transaction cost economies explains when activities will be organized through market transactions or within the organization (Williamson 1975). But openness is more than extending the markets for technology and also includes informal interactions with external participants (Dahlander and Gann 2010). Ongoing personal interactions are often required to transfer complex knowledge in order to develop innovations. The literature on openness has been criticized for not paying enough attention to its implications for other theories, and there are many opportunities to do this.

Managerial implications

Open innovation puts fundamental new requirements to the management of innovation. Firms that want to engage successfully in open innovation have to develop and hone new capabilities or adapt and extend existing ones. First and foremost, managers need to foster a culture of openness that accepts that the most important ideas inside the company often originate from the outside. Incentive structures and career paths often have to be adapted to encourage individual employees to look for external commercialization opportunities for ideas that do not match the firm's trajectory. For instance, in some companies employees receive bonuses for the number of patents they produce without considering their business relevance. As a result, many inventions are put on the shelf. This can potentially be overcome by rewarding individuals for the revenues their inventions generate, even from licensing to other organizations. Second, engagement in open innovation presents companies with a plethora of options for collaboration. It is then critical for the company to winnow down the harvest of opportunities by carefully selecting the most promising ones. Having access to a broad range of external sources of innovation is only beneficial to the extent that companies have the ability to focus on a few. Third, much research suggests that building and cultivating both internal and external networks is important to developing innovations. Internal ties increase the awareness of the organization's needs and build legitimacy among colleagues,

whereas external ones are more likely to tap into novel sources of knowledge (Dahlander et al. 2011). If organizations map the internal and external networks of their employees (Criscuolo et al., 2007), they can be more systematic about how they compose teams consisting of some individuals with strong internal and others with strong external networks. On a final note, it is clear that open innovation can disrupt the routines of managers and regular R&D employees. To ingrain the importance of open innovation strategies in employees' mindsets will require high upfront as well as continuous smaller investments by the company.

CONCLUSION

The coexistence of internal and external idea generation and selection and internal and external commercialization of knowledge holds great promise for firms and other players in the innovation game, whether they be individual inventors, universities, research centres, or governments. As we have argued, this has implications for the management of innovation, including our understanding of where innovation comes from, how it is brought to practice, as well as managed on a daily basis. The questions of when and how to engage in open innovation are interwoven with other aspects of the management of innovation discussed elsewhere.

With ever-increasing interconnectedness between and among these different actors, we would expect that open innovation will begin to permeate the activities of even more firms. We would expect the greatest increase in 'new' users of open innovation practices to come from small firms, from non-high-tech settings, and probably also from geographic regions on which current academic work does not necessarily focus: the developing and underdeveloped world. The last point in particular will raise new and interesting questions with regard to the institutional environments and legal frameworks prevalent in these countries, and how those might affect open innovation activities in turn. In short, we remain

convinced that there will remain ample opportunity to study interesting and relevant questions about open innovation to gain valuable insights for theory and practice about this important topic over the years to come.

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Figure 01:

Number of papers published on open innovation

Note: The number of papers declines in 2011 as an artifact of the construction of the database, which was completed in October 2011.

Table 01: Overview of types of openness

	Inbound innovation	Outbound innovation
Pecuniary	Acquiring Acquiring inventions and input to the innovative process through informal and formal relationships	Selling Out-licensing or selling products in the market place
Non-pecuniary	Sourcing	Revealing

	Sourcing external ideas and knowledge from suppliers, customers, competitors, consultants, universities, public research organizations, etc.	Revealing internal resources to the external environment

Source: Dahlander and Gann (2010).