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The "Open Innovation" paradigm: A contingency perspective

Marko T. Torkkeli[1]; Carl Joachim Kock[2]; Pekka A. S. Salmi[1]

[1]*Lappeenranta University of Technology (FINLAND);* [2]*Instituto de Empresa (SPAIN)*

marko.torkkeli@lut.fi; carl.kock@ie.edu; pekka.salmi@lut.fi

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Abstract: The "open innovation" model is currently being touted as a superior path for achieving long-term success. Rather than relying on their own, limited resources for research and development in the traditional, closed invention system, firms are encouraged to share knowledge across firm boundaries to enhance their innovative potential. Yet, such sharing may also have adverse consequences by reducing the rarity of a firm's inventions. This paper accordingly attempts to identify and analyze the parameters that determine whether open or closed types of innovation management are most appropriate for a given firm. Following a contingency perspective, we examine these determinants as various internal and external constraints (situational factors). More specifically, applying concepts related to absorptive capacity, complementary resources, game theory and others, we derive testable propositions and provide case study evidence regarding the value generating properties of open innovation.

Keywords: open innovation, R&D, competitive advantage, resource-based view

1 Introduction

An increasing number of academics (e.g., Chesbrough, 2003, 2004, 2006; Chesbrough, Vanhaverbeke & West, 2006; Laursen & Salter, 2005; Sakakibara, 2003) and practitioners (e.g., Huston & Sakkab, 2006; Rivette & Kline, 2000) are touting the "open innovation" model as a superior, if not the only way (see, e.g., Huston & Sakkab, 2006) for firms to achieve long-term success in today's fast

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moving market environment. The principal idea is that instead of relying on the limited resources any one firm can muster for research and development in the traditional, closed invention system, an open approach to sharing knowledge across firm boundaries can greatly expand and speed up a firm's innovative potential.

While acknowledging the great potential that lies in a correct application of this principle, this paper attempts to further define the boundary conditions that determine whether open or closed types of innovation management will actually lead to the highest value for a given firm. Specifically, sharing knowledge with others is likely to reduce the potential rarity of the eventual inventions that firms come up with as a result of this process. As this will obviously increase competitive pressures and downward bias expected returns, we need to analyze what properties associated with open innovation can compensate for this negative effect.

In the following, we identify a number of firm internal and external factors such as absorptive capacity, complementary resources or game theory, which are likely to form the key contingencies that determine whether open innovation is indeed the superior choice, and when it is not. Our analysis goes beyond recent inquiries into similar issues (e.g., Knudsen, 2005; Laursen & Salter, 2005; West, 2006), by, first, more explicitly analyzing the two sides of "openness" (i.e., the "buying" and "selling" of knowledge in the market), and, second, by offering testable propositions regarding how the impact of these issues, and accordingly the virtue of open innovation, varies among different types of firms. In addition, we use primary data that we have collected in interviews with two firms that are currently acknowledged as leaders in the open innovation field in order to deliver initial case study evidence in support of our propositions.

2 Literature review

2.1 The two sides of openness

The concept of open innovation encompasses both the acquisition (i.e., the "buying") of external knowledge (including the integration of external knowledge sources into the internal knowledge base of a firm) and the external exploitation (i.e., the "selling") of these knowledge assets in different markets. Regarding these two processes, prior research has mostly focused on external knowledge

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acquisition and the make-or-buy decision, i.e., whether to develop knowledge in-house or to acquire it from external sources (e.g., Ferretti & Romano, 2006; Granstrand, Bohlin, Oskarsson & Sjöberg, 1992; Veugelers & Cassiman, 1999). Indeed, since the 1990s scholars have extensively studied various governance modes for external technology sourcing like strategic alliances, joint ventures, acquisitions (Hagedoorn & Duysters, 2002; Lambe & Spekman, 1997; Vanhaverbeke, Duysters & Noorderhaven, 2002), or inward technology licensing (Tsai & Wang, 2007). Recently, moreover, other governance modes, such as the use of corporate VC investments to leverage external R&D, have been considered as well (see e.g., van de Vrande, Lemmens & Vanhaverbeke, 2006).

In the last few years, however, interest in external knowledge exploitation (in terms of "selling" or exchanging knowledge in the market) has also grown significantly (e.g., Lichtenthaler, 2004, 2006; Tschirky, Koruna & Lichtenthaler, 2004). A primary reason for this increased attention to the "sell" side comes from the fact that markets for technological knowledge have developed and firms have more opportunities to leverage their technological assets (Arora, Fosfuri & Gambardella, 2001). External knowledge exploitation includes, for instance, selling of technologies and intellectual property (IP) like patents, licensing-out, and collaborations in order to gain extra revenues. It may further be used to realize strategic benefits, such as establishing own technologies as industry standards (Gassmann & Enkel, 2004; Lichtenthaler, 2007a). However, since selling of knowledge assets also has negative effects (in particular, the diffusion of competitively relevant knowledge), firms are increasingly faced with a "keep-or-sell" decision (Lichtenthaler, 2007b).

2.2 The determinants of open innovation

The basic premise of the open innovation model is that by enlarging your "research organization" you may be able to tap into a much larger pool of ideas and find such ideas faster than if you limit yourself to the traditional, closed innovation model. Furthermore, you may benefit from "dead born" ideas by utilizing them outside the boundaries of your own firm, but within the business models of other firms, where these ideas may unfold their full potential (e.g., Chesbrough, 2003, 2004, 2006). By contrast, the traditional, closed innovation approach has grown out of a rather understandable desire to keep the value of innovations and ideas to oneself. This is also very much in line with the insights gained from the resource and capabilities

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view. As Barney (1991) has pointed out, value creation within firms depends on these firms' ownership of valuable and rare resources, which are difficult to imitate or substitute (where the latter two issues simply reinforce the "rarity" concept). If rarity is thus a key consideration, it is quite obvious that innovation, or the creation of new combinations (Schumpeter, 1934), is a primary source of value. By definition, the entrepreneur is the first (and initially the only) person to possess that particular new productive combination and can thus benefit from a monopoly position. Yet, as others imitate what was once a "new" combination, the entrepreneurial firm looses its ability to extract value from the market as the rarity of its resource combination, and hence its monopoly, declines (for a detailed analysis see Winter, 1995; also Peteraf, 1993).

The open innovation model, however, contradicts these ideas by suggesting that sharing knowledge and innovating jointly with others, even competitors, is a superior way of generating value. Obviously, however, this "sharing" will reduce the rarity of a given innovation for each of the firms. To the extent that the "old" wisdom discussed above is correct in suggesting that value appropriation has to be based in some way on charging prices that exceed average costs, and that that is only possible if at least some element of rarity exists (i.e., a market structure different from that of perfect competition – Winter, 1995), there is a need to analyze where this superior value may come from. This, in turn, will then point to tradeoffs that may determine when an open system of innovation is indeed superior to a closed one and when not.

Before we can analyze the sources of value, we ought to understand the various perspectives implied in an open innovation view. Whereas the traditional perspective is that of a firm, and the primary question asked is that of how this particular firm can maximize its value (e.g., Afuah, 1998; Dougherty & Hardy, 1996; Lieberman & Montgomery, 1988), an open innovation perspective encompasses multiple such perspectives. First, similar to the traditional model, a specific firm may be analyzed and the question becomes how that firm can benefit by tapping into external sources of innovation (i.e., acquiring new ideas). Here, we are still close to the traditional economic model of value creation – all that changes is that the firm gains access to additional knowledge that it may add to its own and turn into innovations. In fact, Cohen and Levinthal (1990) have defined the concept of "absorptive capacity" specifically in order to understand the ability of firms to acquire and make use of such external knowledge. To the extent that the

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additional knowledge is available to other market participants on similar terms, this will not lead to any competitive advantage by itself; however, if a combination with firm specific knowledge yields an innovation that is not directly available to others (because of the firm specific component), we have a classical case of value through rarity. Relevant concepts that help us understand under what circumstances a specific firm could gain such an advantage include that of complementary assets (Teece, 1986) and the abovementioned idea of absorptive capacity (Cohen & Levinthal, 1990). The former concept suggests that pre-existing resources of various kinds (e.g., R&D knowledge, brand equity, distribution systems, etc.) may give the focal firm an edge over competitors even when the innovation is at least partially based on public information, while the latter concept helps us identify firms that may be better able to distill the critical elements of value out of public information than other firms – again, leading to competitive rarity.

We can extend this perspective by including the reverse flow of knowledge, i.e., from the focal firm into the market. In fact, a key characteristic of the open innovation idea is that of a two-way flow of information (e.g., Chesbrough, 2003). Three considerations may help us understand how this flow may create added value. First, the focal firm may realize additional cash flows from selling knowledge resources that are underutilized or not related to the firm's core business (usually its existing business model), second, in the presence of potential network externalities spreading knowledge may give rise to a virtuous cycle of market share increases, and finally, the willingness to reciprocate in knowledge exchange may be a critical step to make knowledge exchange possible at all. While the latter consideration points to the value of using game theoretic concepts (Nash, 1950, 1953) to inform our thinking about open innovation, the first set of issues pertain to the general area of scale and scope economies, and of course to network externalities (Arthur, 1989). As Penrose (1959) has suggested early on, as firms become more experienced, they become more efficient and may need to use less of their resources, thereby freeing them for other uses. Similarly, particularly knowledge based resources tend to be improved with use and are often non-competitive (or "non-rivalrous") assets, in the sense that using them in one location does not preclude them from being used elsewhere as well. Hence, as firms find additional applications for knowledge, they tend to generate even more knowledge in turn, making them more efficient in the process of knowledge generation in addition to realizing added value in the market. Yet, the flipside of

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the coin is that, on one hand, knowledge based resources are quite prone to market failure (Arrow, 1964, 1996), and, on the other hand, that while such assets may be non-competitive and can be used in various locations, actually doing so obviously again reduces the scarcity value of these assets (see, e.g., Chesbrough, 2004, for a discussion of the virtues of managing false negatives, but also the dangers of passing on the value of knowledge given to the market).

These considerations, which stem from expanding the traditional perspective by including knowledge outflows lead over to the perspective of the dual interests of two firms interchanging knowledge (or the network of multiple firms in a more complex exchange relationship). Specifically, the individual perspective of a firm of course finds its mirror image in the individual perspectives of the firms it is attempting to exchange knowledge with – the decisive question becomes: when is what is good for A also good for B? This brings up again the issue of game theoretic interactions, and particularly the question of why or under what circumstances firms will agree to cooperate, and of course the related question of what type of payoffs individual strategies may yield and how players may influence the resulting game.

In the following, we will take up each of these issues in turn and analyze how they affect a particular firm's willingness to either acquire knowledge from outside of its boundaries ("buy"), or to provide knowledge into the market domain ("sell"), which, put together, will determine the overall degree of "openness" we should expect to find in particular types of firms. This approach should lead to a more fine-grained understanding of the potential advantages of open innovation than the previously employed focus on a general level of "openness" comprised of both, buying and selling of knowledge (e.g., Laursen & Salter, 2005).

In order to provide a clear structure to the following discussion, we will examine the determinants of open innovation from a contingency perspective (e.g., Lawrence & Lorsch, 1967; Woodward, 1965). Specifically, following the contingency theory's claim that optimal decision-making depends upon various internal and external constraints (situational factors), we will categorize the determinants of openness into two main groups: internal and external. Internal determinants include factors that are characteristics of a given firm like size, endowment of complementary assets or absorptive capacity. Also economies of scale and stocks of knowledge within the firm are primarily internal factors that we

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assumed to have an effect on the firm's openness. External factors, on the other hand, are related more to the firm's external environment. Here we will discuss the role of network externalities and appropriability regimes, as well as game theoretic rationales that may affect the firm's decision to engage in knowledge exchange. Finally, we also analyze the interactions between these internal and external contingencies of open innovation practices and a key strategic dimension, the overall innovative strategy of a firm. In particular, our question is how a focus on either exploitation or exploration (March, 1991) is affected by (or in turn affects) a firm's involvement in knowledge acquisition or selling activities.

3 Development of propositions

3.1 Internal determinants

Complementary assets

Essentially, the more complementary assets (Teece, 1986) a firm has, the more it stands to benefit from "buying" external knowledge. A distinction can be made between two types of complementary assets – first, complementary knowledge (that is kept proprietary) can be combined with external knowledge to form an innovation that is still essentially unique to the focal firm; second, other complementary assets such as brand names, distribution or service networks, or manufacturing capabilities can be used to leverage external knowledge in a way that would not be possible for other firms, again bestowing competitive rarity on the "new combination". Thus, a basic proposition is simply:

- Proposition 1a: Firms with high levels of complementary assets will derive larger gains from adopting external knowledge than firms with low levels.

The corollary of this proposition is that large, established firms, which likely have larger stocks of complementary assets, will thus be more active seekers of external knowledge.

- Proposition 1b: Large established firms will be active buyers of external knowledge.

Illustrative evidence for this comes from the fact that several large firms have actively embraced the open innovation paradigm and attempt to source new

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knowledge from firm external sources (e.g., Huston & Sakkab, 2006). The large asset bases of such firms likely offer high degrees of potential synergies for the integration of external knowledge or acquired whole firms (see, e.g., discussion in Blonigen & Taylor, 2000, p. 50; Berkovitch & Narayanan, 1993). Knudsen (2005) has recently argued along similar lines, albeit from the opposite perspective. She suggested that in order to commercialize innovations, firms may try to source complementary assets externally by collaborating with other companies – which is similar to saying that some firms let others, who have complementary assets (i.e., large firms), in on their innovations (i.e., the focal firm "sells" access to its knowledge, and the firm bringing in complementary assets "buys" this access). Supporting indirectly our proposition, Knudsen (2005, p. 6) goes on to suggest that "the need for complementary assets to secure commercial success is of course more common in a small firm with limited access to assets inside the company."

However, large firms commonly also have high levels of inertia (e.g., Hannan & Freeman, 1984), which expresses itself, for example, in a resistance to accept knowledge that was "not invented here". Hence, the propensity of large firms to "buy" knowledge will be somewhat muted because of internal resistance that will work against opening the firm too much to outside knowledge. In fact, Veugelers and Cassiman (1999) report that large firms usually follow a mixed strategy of making and buying, which is due to internal organizational resistance to a sole focus on outside knowledge. Hence, a corollary to the previous proposition is simply that:

- Proposition 1c: Large established firms will not rely fully on buying external knowledge.

For small firms, on the other hand, the opposite relationships appear to hold – fewer complementary assets suggest that sourcing external knowledge may be less beneficial to such firms as compared to larger ones, yet, their relative lack of inertia makes it easier to implement those ideas that are indeed sourced externally.

- Proposition 1d: Small firms will, on average, be less active buyers of external knowledge than large firms, but when acting as buyers rely on this external knowledge to a larger extent.

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Veugelers and Cassiman's (1999) finding that small firms focus either on creating all of their knowledge in-house (probably reflecting concerns about leakage of their core technologies as suggested by Gans and Stern, 2003), or on more or less exclusively sourcing it externally, provides some support for this proposition.

Scale and learning effects

Previous researchers (e.g., Chesbrough, 2003; Knudsen, 2005), have already argued that economies of scale are an important incentive for engaging in open innovation. Specifically, few if any firms have the financial resources needed to undertake all the R&D projects they want to exclusively by themselves, and significant cost savings can be achieved by leveraging economies of scale in R&D, and avoiding the duplication of already achieved results (Sakakibara, 2003).

However, such economies may not provide equal incentives for all firms. As suggested above, particularly knowledge assets are prone to increase over time as a firm gains experience. Hence, in large, established firms, we ought to find large stocks of knowledge, some of which may not pertain to the core processes utilized by the firm and thus lie dormant. Chesbrough (2004) refers in this context to false negatives – knowledge or innovations that may have value, but perhaps not within the current context of operations or the present business model. In this case, giving such knowledge into the market may help the firm to realize at least some additional cash flows, and, depending on the specifics of the knowledge application, for instance, as a spin-off firm or as an equity investment in another firm, may provide the focal firm with additional growth options as well. At the same time, since the knowledge in question is by definition not related to core production processes, selling such knowledge does not compromise the firm's competitive position. Coupled with this development is the general observation that larger scale and accumulated production experience lead to a decrease in product costs. To the extent that such efficiencies also apply to the production of knowledge, large established firms are not only repositories of (at least in other contexts) potentially valuable knowledge, but should also be the lowest cost producers of this type of assets.

Clearly, in our first set of hypotheses we have already implicitly defined scale as an incentive for "buying" knowledge, as we have argued that large firms are more prone to engage in such practices. The arguments presented in the current section,

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however, also suggest that large firms will have a strong incentive to engage on the other side of the open innovation equation. Hence:

- Proposition 2a: Large established firms will be active sellers of (non-core) knowledge.

Nevertheless, often small, new firms are those that come up with the brightest new ideas (as they are, e.g., unencumbered by inertia – for recent examples, just consider the host of start-up ventures like Google, Amazon, ebay, and so on, which have used the Internet to redefine industry after industry) and could thus be sources of knowledge (i.e., "sellers") in the open innovation context as well. And, in fact, much knowledge seems to flow from small entities to larger ones – for instance, at Procter & Gamble (Huston & Sakkab, 2006), in Biotech, etc. Yet, to the extent that new firms are less likely to have knowledge unrelated to their core processes, which they could unload without competitive implications, their main knowledge "for sale" is likely to be closely related to their core (and, in fact, Laursen and Salter, 2005, deliver some evidence that knowledge intensive small firms are less likely to be open, presumably for this very reason). Accordingly, one must ask what is the value for a small firm of giving away its main asset? The answer is essentially the hope that the purchase price is higher than what they could hope for themselves – which in turn is a function of the value of the knowledge to the acquirer as stipulated in proposition 1a. If a large, established firm receives such knowledge, it can then apply complementary assets to exploit the knowledge at a much larger scale and pay off the small firm (Dierickx & Cool, 1989, also speak of "asset mass efficiencies" to describe the phenomena that firms with large asset bases will find the development of further assets easier or cheaper than firms with smaller bases). Hence, small or new firms may be inclined to sell even core technologies as the value of the same may be higher in the open innovation context than when they try to market these themselves, while larger, established firms per the value of their complementary assets are buyers of such innovations and sellers of knowledge less central to their operations:

- Proposition 2b: Newer and smaller firms will be more likely than large established firms to sell knowledge central to their operations.

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However, the arguments above suggest that small firms will only be willing to open up in this way if the purchaser of their knowledge can, indeed, ensure the large-scale commercialization of these technologies. Thus:

- Proposition 2c: Newer and smaller firms who sell knowledge central to their operations will prefer to deal only with large firms as "buyers".

In other words, the small or new firms implicitly consent to sharing core technologies (as this is all they have so far – prop. 2b), but they do that in the context of working with a very large firm that can offer them large-scale implementation of their ideas (prop. 2c).

Absorptive capacity

A critical condition for firms that "buy" knowledge in order to actually use and benefit from the same is, quite obviously, the degree to which these firms posses extant absorptive capacity that allows them to recognize, assimilate and use external knowledge (Cohen & Levinthal, 1990). Hence, the higher the degree of absorptive capacity, the larger the success of integrating external knowledge, which suggests:

- Proposition 3: Firms with greater levels of absorptive capacity will derive larger gains from adopting external knowledge than firms with low levels.

Laursen and Salter (2005) make a similar suggestion (see their hypotheses 2 and 3), and find that firms with high levels of absorptive capacity (particularly skills and access to external networks) are likely to be more open. Fontana, Geuna and Matt (2006) similarly find that larger firms with heavy R&D activities are more likely than small ones to engage in collaboration with Universities, a result also found in Laursen and Salter (2004), who argue that this shows the high level of absorptive capacity that exists in these large firms.

3.2 External determinants

Network externalities

The earlier propositions regarding complementary assets and absorptive capacity suggest that larger and more established firms should be the most active users ("buyers") of knowledge as it would be more valuable to them than to smaller

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firms. Yet, Chesbrough (2003), for instance, describes that following the open innovation paradigm has helped particularly new start-ups (e.g., Microsoft, Intel, Sun, Oracle, or Cisco – when they were young) with relatively little own R&D to establish themselves as strong competitors. A reasonable explanation for observing a large number of (initially) small firms that are successful with an open innovation approach (particularly in terms of "buying" knowledge) despite their shortcomings in terms of complementary assets and absorptive capacity, is that such small firms or newcomers could compensate for the large resource bases of established firms by combining knowledge from a wide network of external players. For instance, assembling various elements of a new technology from multiple sources may help to create an offering to the customer that beats the one any one firm could offer by itself. Nintendo (HBS case study by Coughlan, 2001), for example, early on relied on a large network of software manufacturers to create the largest videogame library, which then fueled the purchase of its game base-stations.

In another possible form of such cooperation, a firm may join in with others on a new technology in order to promote a specific technology to become a standard, which then benefits all firms that joined early on, and thus creates rarity with respect to those firms betting on other standards (e.g., Arthur, 1989). Such cooperative arrangements have been set up, for instance, within the multimedia and the wireless telecommunications industries in order to make an impact on standards development (Chiesa & Toletti, 2003; Leiponen, 2006). Winning such a standard war, in turn, confers the ability to limit and thus charge for access to the standard to all firms joined in the winning network. Importantly, this effect occurs as firms join an existing technology that, by virtue of several partners joining, eventually becomes the standard. Hence, the firm "buying" into an emerging network has less if any need for large stocks of complementary assets and absorptive capacity as the knowledge in question is already rather concrete and easier to assimilate, and the network itself takes the place of the most important complementary asset, i.e., the unique standard. Since this reduces the advantage that large firms should otherwise enjoy in terms of benefiting from open innovation (propositions 1a and 3) the following proposition should hold:

- Proposition 4a: In the presence of network externalities (and before the emergence of a standard) the effects of complementary assets and absorptive capacity will be muted, and the propensity to use external knowledge increases particularly for small firms.

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The implication is that for knowledge import, industries with high network externalities will not necessarily see a dominance of established firms in the use (as buyers) of external knowledge (i.e., network externalities are a moderating variable for propositions 1a and 3).

Yet, network externalities may also be quite important in explaining the desire to "sell" or provide information to others (see above). In this context, sharing your know-how may lead others to join the technology you are promoting, helping it to become the standard. West (2006), for example, suggests that firms may voluntarily surrender appropriability in order to achieve other firm goals, such as seeking adoption in the presence of demand-side economies of scale. As demonstrated successfully by firms like Sun, key to being able to benefit from this strategy appears to be to maintain a (proprietary) innovation lead in the core and particularly related products. In other words, there have to be some proprietary elements that either allow the focal firm to "own" the resulting network, or at least stay ahead of the pack. If we focus, for the moment, on those cases where a firm does not have a tight appropriability regime (i.e., it cannot selectively exclude others from using its knowledge assets; e.g., Teece, 1986), the key to success seems to be to have enough complementary assets in place so that the focal firm can either maintain the lion share of the market (as IBM did for a while with the PC market, which arguably was an early open innovation success), or sell successfully into the established network (the Sun approach). Hence:

- Proposition 4b: In a weak appropriability regime but with strong network externalities, selling/providing knowledge (that is still related to the firm's core) will create the highest value for firms with high levels of complementary assets.

If, however, a firm has tight appropriability over its inventions even when sharing some of the knowledge with others, this reliance on complementary assets (other than the asset that guarantees appropriability) looses its importance, as the firm can simply directly charge for access to its knowledge base.

- Proposition 4c: In the presence of network externalities and tight appropriability the effects of complementary assets will be muted.

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The implication is that any firm that has a clever technology and a way to keep it private even when sharing, stands to gain from doing so; firms with complementary resources are not at a particular advantage.

Game theoretic issues

So far, we have discussed several issues that will determine what type of firms will most likely generate value from open innovation and are thus most likely to engage in it. Yet, it seems necessary to combine the viewpoints of the provider and user of knowledge on the level of the interaction as such. Part of this has been done above. There may, for instance, be value for new or small firms in giving up core ideas as these are simply more valuable for established players with complementary assets, creating the conditions for a trade where everybody is better off and the resulting added value can be split in some way (prop. 2b and 2c). Likewise, both large and small firms have incentives to put knowledge out into the market and, under certain circumstances to also pick up knowledge there, validating the basic idea of open innovation.

However, there may also be other issues involved that affect the willingness of the individual firms to get involved. One such issue pertains to the reciprocity of information sharing. If the potential user of a focal firm's knowledge stands to gain substantially from applying that knowledge, the focal firm may hesitate to actually provide the knowledge lest it may loose out on the future value of it. This is similar to market failures that occur due to the problem of demonstrating and thus giving away tacit knowledge assets (e.g., Arrow, 1964, 1996), and may be ameliorated by a choice of a governance mechanism (e.g., joint venture, merger) that aligns interests by allowing both firms to share in the benefits from the eventual application of the knowledge (e.g., Williamson, 1979). Another way could be to reciprocally exchange information (of perhaps about similar ex-ante value) and thus create a situation that provides positive options for both parties. This is a more game theoretic approach of finding a mutually agreeable equilibrium of providing vs. not providing information – essentially, a way of creating commitments to enforce a beneficial situation where both firms collaborate by creating a climate of cooperation through the underlying exchange of hostages.

- Proposition 5a: Firms will tend to sell knowledge to the same exchange partners from whom they also buy other knowledge assets.

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Huston and Sakkab (2006) deliver some evidence in support of this proposition since they report that some of P&G's most successful open innovation projects involved reciprocal knowledge sharing. In other words, we expect that a certain degree of observed "openness" will contain a deeper structure that binds certain partners with strong ties, while interactions with others are much less pronounced. Furthermore, reciprocal knowledge exchanges are often institutionalized in joint ventures and similar equity partnerships (Kogut, 1989).

Hence, "openness" may be a relative term – a high degree on this scale may not necessarily imply that firms are constantly looking for, or are willing to exchange knowledge within a market, but simply reflect the fact that even initially limited market interchanges (with a few partners) of knowledge lead to more pronounced two-way flows of knowledge in order to support the relationships. This leads to a number of propositions regarding the nature of openness:

- Proposition 5b: Openness will be reflected in a series of bilateral exchange relationships rather than random interactions with firms in a population.
- Proposition 5c: Openness "structures" will develop over time and reduce the amount of broad search and random partner selection in favor of established ties.
- Proposition 5d: Communities of openness will develop over time consisting of firms with repeated buy/sell transactions.

Further, in line with previous propositions, the value to firms of receiving knowledge should increase with their pre-existing complementary assets and their absorptive capacity. Thus, the following proposition should hold:

- Proposition 5e: Reciprocal sharing of information will be most prevalent in knowledge sharing interactions between large established firms.

3.3 Interactions with innovation strategy

In the previous subsections we have discussed how various internal or external contingencies may affect a firm's involvement in open innovation practices as well as the likely structure of exchange relationships that may emerge. We now expand on these ideas by analyzing how these effects in turn interact with a key strategic dimension, i.e., the firm's overall innovative strategy. Specifically, the type of

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innovative activity (or "search" for new productive combinations – e.g., Cyert & March 1963; Levitt & March, 1988; Nelson & Winter 1982) that a firm pursues, or that, in turn, attempts at open innovation may induce in a particular firm, is likely to affect the benefits the firm can derive from such an open approach, as well as the processes by which it will approach the buying, selling and utilization of knowledge. An extensive literature has suggested that firm learning proceeds either in incremental steps in the process of continued exploitation of already existing firm capabilities, or in a more radical way in terms of the exploration of rather novel ways of doing things, leading to the creation of altogether new types of knowledge within a firm (e.g., Gupta, Smith & Kelly, 2006; Levitt & March, 1988; Nelson & Winter 1982). March (1991) has furthermore suggested that firms need to find a balance between such "exploitation" and "exploration" moves.

In the context of open innovation, as discussed above, larger firms are likely to possess significant levels of absorptive capacity, scale or complementary assets – yet, these resources are most likely applicable only in a certain area around the current business model of the firm. An investment bank has little absorptive capacity in textile milling, or vice versa, and neither its scale of banking or complementary assets like a network of financial specialists will be of much use when it comes to using knowledge originating in the textile business. Nevertheless, within their own area of business, large firms have sizable advantages in terms of identifying and using (buying) outside knowledge to further "exploit" their position. Essentially, exploitation search for these firms is guided by their large existing knowledge which allows these firms to define with relative accuracy what additional knowledge they are looking for. In other words, large firms have a high level of absorptive capacity for exploitation, and they can use this to develop specific guidance to query for precise solutions to their specific problems. Furthermore, given their size, and the resulting large incentive for external providers of knowledge (see propositions 2b and 2c), a large number of information providers will likely be willing to work with them. Thus, following an exploitative search strategy, large firms have the advantage that they know rather precisely the nature of knowledge they are missing, and they can address a large collection of outsiders to work on their specific problem. Huston and Sakkab (2006), for instance, report how P&G defines precise technological question that it then raises with its networks of outsiders. The resulting open innovation transaction if an outside provider succeeds in answering the specific question, will then likely be a

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licensing agreement that gives the large firm exclusive use, and the provider of the knowledge a stake in the large firm's production using this new piece of knowledge. P&G, so Huston and Sakkab (2006) report, does exactly that – it shares some profits with the outside provider, but otherwise still locks up the required knowledge in a proprietary way. The open innovation idea here acts primarily as offering the large firm a vast network of external knowledge providers that can be used almost like a direct extension of their own lab.

- Proposition 6a: Large firms will create quasi-captive communities of smaller firms and external research entities.

Contrast this with the situation of a small firm – having likely neither the scale to command as in-depth an understanding of the way forward as the large firm, nor the attraction for outsiders to work with it on an exclusive basis, such firms are less likely to be able to play an open innovation network as the large firms are. If they do not pose as the provider of knowledge (potentially selling out their core technology for the chance of participating in the large firm's scale based advantages), their access to "buy" technology will be of a much more generic (i.e. they cannot "custom" order solutions like large firms) and less exclusive nature. Hence:

- Proposition 6b: For exploitation-type innovations, large firms will benefit more from open innovation ideas than small ones.

In terms of exploration, however, the advantages of large firms will be less pronounced. Given that such search aims to uncover wholly new areas of business, in which, by definition, the focal firm is not yet fully competent, large firms will lack the ability to specify precisely what knowledge they require. In fact, the whole essence of exploration is that of a process of variation that brings about unexpected new insights that may or may not lead to valuable products or services. By definition, this process cannot be specified completely ex-ante. Hence, large and small firms alike, when attempting to explore new areas, cannot ask specific questions of an innovation network and expect exclusive answers. Rather, search must be conducted more broadly, perhaps going beyond the confines of the usual exchange partners, and rely on the ideas that outsiders have already generated. Vanhaverbeke, Gilsing and Duysters' (2007) finding of a positive effect of redundancy in a firm's alliance network on exploitation but not on exploration

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underscores the importance of seeking variety by working with new partners in order to explore new types of knowledge. Overall, exploration is thus a much less secure, and, as others have access to more or less the same information, a less exclusive process than exploitation.

Determinant of open innovation	Related earlier studies	Key research results
Complementary assets	Blonigen & Taylor (2000); Berkovitch & Narayanan (1993)	Large asset bases of firms offer high degrees of potential synergies for the integration of external knowledge or acquired whole firms.
	Knudsen (2005)	The need for complementary assets to secure commercial success is more common in small firms.
Scale and learning effects	Chesbrough (2003); Knudsen (2005)	Economies of scale are an important incentive for engaging in open innovation.
	Sakakibara (2003)	Firms can achieve significant cost savings by leveraging economies of scale in R&D.
Absorptive capacity	Laursen & Salter (2005)	Firms with high levels of absorptive capacity (particularly skills and access to external networks) are likely to be more open.
	Fontana et al. (2006); Laursen & Salter (2004)	Larger firms with heavy R&D activities are more likely than small ones to engage in collaboration with universities.
Network externalities	Chesbrough (2003)	Open innovation has helped particularly new start-ups with relatively little own R&D to establish themselves as strong competitors.
	Chiesa & Toletti (2003); Leiponen (2006)	A firm may join in with others on a new technology in order to promote a specific technology to become a standard.
	West (2006)	Firms may voluntarily surrender appropriability in order to, e.g., seek adoption in the presence of demand-side economies of scale.
Reciprocal sharing of knowledge	Huston & Sakkab (2006)	Some of P&G's most successful open innovation projects have involved reciprocal knowledge sharing.
	Kogut (1989)	Reciprocal knowledge exchanges are often institutionalized in joint ventures and similar equity partnerships.
Learning strategy (exploitation vs. exploration)	Huston & Sakkab (2006)	Following an exploitative search strategy, large firms can address a large collection of outsiders to work on their specific problem.
	Vanhaverbeke et al. (2007)	Since there is a positive effect of redundancy in a firm's alliance network on exploitation but not on exploration, firms need to seek variety by working with new partners in order to explore new types of knowledge.

Table 1. Determinants of open innovation and related earlier research results.

Thus, our final propositions are:

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- Proposition 6c: Large firms will engage in both, exploitative and exploratory search from external knowledge, but the modes will differ (specific network in former, broader based search extending beyond own network in latter).

- Proposition 6d: Small firms will focus on exploratory search from external knowledge.

We conclude this section by summarizing in Table 1 some of the key results of earlier studies that have analyzed certain aspects of the relationships that we are proposing in this paper.

4 Case studies

4.1 Research methodology and data collection

In order to gain a deep understanding about the firm specific determinants of open innovation, we have adopted a qualitative case study method. As our case study organizations, we have selected two companies that are currently acknowledged as leaders in the open innovation field: Intel and Philips. Both, Intel, the world's largest semiconductor company, and Philips, the largest electronics company in Europe, have used a broad mix of internal and external knowledge sources for their innovation processes and therefore serve as ideal examples of firms' that are effective in implementing open innovation strategies.

At Intel we have interviewed one project manager at "Intel Solution Services" (N.N 2007, pers. comm., Sep 24), while at Philips, we have interviewed one senior manager at the "Philips Research Strategy and Business Development Office" (N.N 2007, pers. comm., Aug 22). The interviews, which lasted from 90 minutes to three hours, were semi-structured due to the exploratory nature of our research work. Research questions were formulated on the basis of the propositions developed above, and the interview protocol consisted of a set of structured, open-ended questions that were aimed to elicit factual statements from which the degree of adherence to our propositions could be judged, rather than the opinion of the interviewee. Follow-on questions during the interviews were asked if relevant issues arose.

In addition to the personal interviews as the primary data collection method, we also collected secondary data for our case study by examining company (annual)

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reports as well as different public documents related to innovation and cooperation practices in these two companies.

4.2 Case companies and open innovation

Intel's R&D strategy is based on four key components: university research grants, open and collaborative research laboratories (lablets) located near universities, proprietary internal research projects (some of which are later moved to the lablets), and corporate venturing (Intel Capital). The strategic objective is to invest in technologies that might lead to new businesses and to identify disruptive innovations that may become the source of competitive advantage (Tennenhouse, 2004). Intel's exploratory research process starts with scanning the environment and new promising research areas. The selected research projects are then boosted with grants, lablets, internal research or Intel Capital until the output is refined enough to make the strategic decision whether to commercialize the product/technology or not.

To Philips, the most important form of open innovation is cooperation. The company has had collaborative projects with other companies since the 1970s and nowadays cooperates with academic institutes and companies in many ways. It especially favors joint ventures as a collaboration form (Tidd, Bessant & Pavitt, 2005). Moreover, Philips' research center, the High Tech Campus in Eindhoven, aims at fostering open innovation in the company. For example, an open-innovation initiative MiPlaza (www.miplaza.com) on the campus provides research infrastructure (e.g., a materials analysis lab and leading-edge test and measurement facility) and technical support (e.g., in nanotechnology and life sciences) to various other companies and institutes. Another campus resident is the Philips Technology Incubator, which provides funding, facilities, business planning and partnerships to start-up firms. Indeed, Philips is strongly encouraging its own employees to create new ventures from promising research projects and technologies that are not suitable for the company's core businesses. Finally, Philips has been very active in technology licensing. In fact, the company has a proactive IP strategy that aims at sharing technologies by licensing rather than using patents as a defensive mechanism (Philips, 2004, 2006).

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4.3 Research results

As both Intel and Philips are large companies with high levels of complementary assets, it is reasonable to assume that they will derive larger gains from adopting external knowledge than firms with low levels. In our interviews, we therefore first asked about the firm's knowledge acquisition strategies. The managers from both companies indeed emphasized the importance of searching valuable knowledge and technologies from a variety of external sources. Philips, for instance, undertakes over half of its research projects in collaboration with other companies, institutes, suppliers and customers, and is, furthermore, involved in a vast number of joint ventures and strategic alliances, many of which are intended to add to its technological know-how. Nevertheless, it still maintains a large in-house technology center at Eindhoven to guarantee an internal supply of ideas. Similarly, for Intel we have already mentioned the four key components of their R&D strategy, which balance proprietary in-house development projects with a variety of external focused initiatives like lablets or Intel Capital. With respect to propositions 1a-1c, our interviews therefore clearly support the idea that large established firms with high levels of complementary assets will be active buyers of external knowledge, but will not rely fully on buying external knowledge.

On the other hand, on the "sell" side our proposition 2a was that large established firms will be active sellers of (non-core) knowledge. Here, a strong case in point is the performance of Philips, which, with over 80.000 patents, currently is one of the most active generators of intellectual property and has the highest R&D efficiency among the seven largest firms active in the open innovation field (here, we compare the performance of Philips to that of the following other six open innovation champions: Cisco, DuPont, IBM, Intel, Procter & Gamble, and Sun). Based on this scale advantage in the production of knowledge, Philips has also become an active "seller" of knowledge, with activities spanning collaboration with smaller firms in its development campus to numerous joint ventures and spin-offs, the largest of which was worth in excess of $200 million.

Regarding our proposition 2b, i.e., that newer and smaller firms are more likely than large established firms to sell knowledge central to their operations, indirect empirical evidence comes from the fact that in our sample cases much knowledge seems to flow from small entities to the larger ones, i.e., Intel and Philips. Clearly, small and/or new firms that, for example, engage with Philips in the MiPlaza

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expose themselves and their core technologies to direct interaction with Philips, which should offer the latter the opportunity to learn about these core technologies (and, incidentally, also develop absorptive capacity with respect to them). Furthermore, our interviews also to some extent support proposition 2c that newer and smaller firms who sell knowledge central to their operations will prefer to deal only with large firms as "buyers". In the case of Philips again, participating in MiPlaza essentially allows the smaller companies to do without their own specialized R&D department and R&D sites, as they can perform their research in Philips' MiPlaza, where they can also interact with other bright researchers. The manager from Philips suggested that this offers new opportunities for both parties – Philips gains the aforementioned early insights in new technologies, while the small firms try to leverage on Philips' strong complementary assets to find large, ready markets for their products.

When asked about the role of firm's absorptive capacity in adopting external knowledge, the interviewees from both companies stressed that a high level of absorptive capacity is needed in order to benefit from knowledge exchange with other organizations. Both, Intel and Philips are good examples for large firms that are at the forefront of R&D, and that engage in significant exchanges with high-level research universities. Intel, for instance, maintains ties with top schools like MIT or Berkeley, which have, among other things, recently resulted in the development of a very inexpensive PC for under-developed countries. Moreover, the abovementioned example of Philips' MiPlaza is another illustration of this proposition – not only will the close contact with external researchers create further related knowledge within Philips and thus hone its absorptive capacity in new directions, but the installation of such an institution further suggests that Philips is confident that it will benefit from allowing the various small firms conduct their research on its premises. Hence, for Philips, it appears to be a profitable proposition to invite in all these firms, because, given its R&D intensive history, it presumably has the absorptive capacity to relate to and use these various firms' ideas. Altogether, while we cannot directly assess proposition 3 as we have no comparison to the experience of small firms, what these findings do suggest is that high levels of absorptive capacity and successful engagement in knowledge acquisition go hand-in-hand at least at Intel and Philips.

Further discussions with the interviewees relating to the effects of network externalities and appropriability regimes on the firms' propensity to acquire or sell

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knowledge in turn provided support for proposition 4b. That is, in a weak appropriability regime but with strong network externalities, selling (core) knowledge will create the highest value for firms with high levels of complementary assets. In particular, the cooperation between Philips and another large firm, the coffee roaster Douwe Egberts in creating a completely new type of coffee machine (called "Senseo") that uses cartridges, which (at least initially) were exclusively manufactured by Douwe, is a case in point. By being reciprocally exclusive (Philips allowing only Douwe coffee in its machines, and Douwe making coffee cartridges to fit only in Philips machines), these two firms set themselves up for attempting to "lock-in" (Arthur, 1989) the market for cartridge filter coffee in a very similar way as Nintendo originally used the duality of game stations and (licensed) game cartridges to create a self-reinforcing cycle of base station penetration and complementary product availability which led to the establishment of the Nintendo system as the de facto standard (Coughlan, 2001). Subsequently, courts essentially forced this duo to allow others to produce pods and interchangeable machines, which destroyed the possibility for generating a lock-in of the market. Thus, in hindsight, the firms did not possess a strong appropriability regime, other than helping each other – yet, each partner, by virtue of being a rather large firm, was able to marshal large complementary assets such as marketing prowess, distribution systems, and brand equity, in support of their joint system, which helped them to establish themselves quickly as market leaders (against imitator duos of machines and cartridges, which, prior to the court orders, tried unsuccessfully to compete with Philips/Douwe).

With respect to firms' tendency to use knowledge from their partners to whom they sell knowledge (proposition 5a), the cooperation between Philips and Douwe again came up as an example in the interview. In other words, both contributed knowledge in order to make the cooperation work in the beginning. Yet, as the cooperation unfolded so did further knowledge exchanges between the same two partners. The MiPlaza initiative of Philips discussed above, as well as Philips' "Technology Incubator" programs, in turn, are good illustrations for propositions 5b-d. In both cases, Philips has created a community of firms that it will most likely turn to repeatedly – sheer convenience aside, it has build up trusting relations (reciprocal sharing – proposition 5a), and developed absorptive capacity with respect to these other firms' knowledge bases, which should trigger even closer relationships in the future.

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Furthermore, in the Senseo cooperation between Philips and Douwe we see, for example, that both firms had not only the capacity to relate to knowledge provided by the other party (which was probably due to similarities in important functions like marketing, or experience in overlapping markets, e.g., with Philips selling machines that work with Douwe's products as a complement), but also had the complementary assets to act on that new knowledge in terms of a) the ability to actually develop a new product with knowledge that the other party could not use on its own, and b) the ability to marshal resources for a strong market launch. This therefore provides some tentative support for our proposition 5e, i.e., reciprocal sharing of information will be most prevalent in knowledge sharing interactions between large established firms.

Finally, the interviews also provided support for our proposition 6a. Specifically, three out of the four key components that form Intel's R&D strategy, namely research grants, lablets, and Intel Capital, are designed to create an eco-system of small external knowledge sources that Intel can draw upon. But also Philips, with the MiPlaza concept recounted above, conforms very closely to the proposition that large firms will create quasi-captive communities of smaller firms and external research entities. In other words, by collecting a large variety of small firms, and researchers from a variety of institutions on their innovation campus, Philips in effect creates a community of knowledge creators that will obviously serve as a first stop for any knowledge generation problem Philips faces (similarly for Intel, which does not have a spatially co-located campus, but a geographically more dispersed network of similar entities at its disposal). Furthermore, while the individual collaborators are obviously not forced to work exclusively with Philips (or Intel), the reasoning developed above suggests that Philips will increasingly also be their partner of choice for two reasons. First, Philips can offer its smaller partners commercialization of their ideas on a large scale, and, second, by building up absorptive capacity specifically with respect to these small collaborators' skills, Philips also has the best insights into, and most accurate appreciation of the knowledge offered by these firms. As such, collaborator innovations should have a higher value for Philips than for other large firms that are not part of the MiPlaza network, and Philips should thus be in a position to offer its collaborators the best deal they can get. Of course, this preferred insight into their operations also puts these collaborators at risk of being taken advantage of by Philips. The latter, in essence, enjoys something akin to a "right of first refusal" in the sense that if

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Philips declines an offer to work with a collaborator on a particular project, it signals to the external market that the project has a low value – hence, Philips could use this to its advantage by pressuring its collaborators to accept a smaller return on their ideas. This highlights again the problems of defining either appropriate governance mechanisms, or the necessity of mutual exchanges of knowledge, as discussed for propositions 5a-d.

5 Conclusions

The main idea of this paper was to contribute to the emerging literature on open innovation by deepening our understanding of the motivations for and resulting boundaries to an exchange of knowledge among different firms. Building on prior contributions we have particularly emphasized the asymmetric incentives that exist for large vs. small firms, and the implications that stem from this distinction. That is, we have proposed several empirically testable differences in the behavior of "buying" and "selling" knowledge between large, established firms (with, e.g., large stocks of complementary assets and significant levels of absorptive capacity) and smaller firms. On the basis of these propositions, we thus expect that a certain degree of observed "openness" will contain a deeper structure that binds certain partners with strong ties, while interactions with others are much less pronounced. "Openness" can therefore be seen as a relative term, i.e., a high degree on the openness scale may not necessarily imply that a firm is constantly looking for, or is willing to exchange knowledge within a market, but simply reflect the fact that even initially limited market interchanges (with a few partners) of knowledge lead to more pronounced two-way flows of knowledge in order to support the relationships.

Of course, much remains to be done (both theoretically and empirically) in this research area. While the current paper contains the conceptual development of our arguments as well as initial case study evidence in support of several of our propositions, the next step is clearly to subject all of our propositions to more rigorous empirical testing. In particular, we are planning to develop and execute a questionnaire in order to collect a larger dataset for statistical (quantitative) analysis in order to validate our initial findings. To assess the various propositions we have advanced in this paper, data must be collected on a variety of issues, from R&D investments (to assess levels of absorptive capacity) and various ways that firms engage in knowledge exchanges with other firms (to assess the degree of

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open innovation involvement, as well as the structure of partnership behavior), to the actual outcomes of knowledge buying or selling activities. Furthermore, the sample must contain a mix of firm sizes as our predictions center on the difference between small and large firms. Finally, one way to assess the impact of appropriability regimes would be to include in the sample a number of different countries that systematically differ in the property rights protection that they afford to private firms. Once such data has been assembled, empirical analysis can proceed in a straightforward way by employing multiple ordinary and logistics regression techniques.

In any case, our arguments and findings ought to be of interest not only to the growing number of researchers in this area, but also to managers trying to position their firm in an advantageous position in the emerging game of open innovation.

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