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Innovation creation and commercialization beyond the firm: A multi-level framework

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Keywords

Ambidexterity; Cumulative innovation; Open innovation; User innovation; Strategy

1 Introduction

In most telling, the central actor in the process of open innovation is the firm. As Chesbrough (2006a: 1) defined the concept, “Open Innovation is a paradigm that 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.” Open innovation has often been conceived as a strategic choice of the firm (Chesbrough, 2003a, 2003c) and thus researchers have examined the open innovation decisions at the level of the firm (e.g. Keupp & Gassmann, 2009; Laursen & Salter, 2006; Rohrbeck et al., 2009).

However, a firm’s choice of open innovation is often constrained by factors external to the firm, such as its industry, technological or national environment. For example, the availability of suitable external partners are essential for external commercialization of internal innovations. Many new biotechnology firms had unique abilities to develop new lifesaving therapies, but, lacking the necessary commercialization assets, out-licensed their technologies to established pharmaceutical companies (DeCarolis & Deeds, 1999). Similarly, fabless semiconductor firms such as ARM and Qualcomm created new business models through use of independent foundries (Chesbrough, 2006c). A firm’s ability to pursue an open innovation strategy may also depend on its embeddedness in external networks or communities (West et al., 2006; West & Lakhani, 2008).

Moreover, firms often make the choice of openness¹ at the level of a specific product, innovation or development project: this innovation-centric level of analysis is rare but not unheard-of in the open innovation literature. The original *Open Innovation* book (Chesbrough 2003a) offered IBM as an example of an integrated company that out-licensed key technologies and sought out external technologies for inbound licensing; subsequent studies

¹ Here we use openness to refer to permeable organizational boundaries (Chesbrough, 2006a; Dahlander & Gann, 2010), not weak IP regimes or reduced proprietary control (cf. Baldwin & von Hippel, 2011; von Hippel, 2005).

have documented how firms selectively use inbound (e.g. Bröring & Herzog, 2008) or outbound (Du et al., 2012) open innovation practices for specific innovations or projects. Research on cooperative university-industry agreement has also revealed the importance of the project-level as a unit of analysis (Cassiman et al., 2010).

And while a comprehensive innovation framework thus needs to address multiple levels of analysis — innovation, firm and environment — our understanding is still incomplete — both for innovation research in general (Gupta et al., 2007) and for open innovation in particular (West et al., 2006). This paper therefore examines open innovation strategies at both the macro and micro level. It begins by identifying the environmental-, firm- and innovation-level factors that might allow firms to utilize internal or external innovation creation and commercialization strategies, as well as the attributes of the innovation that will influence their choice of an internal or external strategy. It then uses this internal-external distinction to identify four possible modes of innovation creation and commercialization — integrated, inbound, outbound and outside — and considers the firm activities associated with each. The paper next discusses when and how firms combine multiple modes, either simultaneously or sequentially. The paper concludes with the implications of applying these modes and levels of analysis to our understanding of firm strategies and the capabilities necessary to implement these strategies — while also considering what we label “ambidextrous open innovation” as well as non-commercialized innovation or failure cases.

2 Openness in Creating and Disseminating Innovations

In the traditional two-step model of creating and commercializing technical inventions, the steps were assumed to be integrated within a firm (Chandler, 1977; Freeman, 1982; Schumpeter, 1934). More recent research has focused on a distributed process of creation and commercialization that places greater emphasis on the separation of actors between and beyond organizations (Arora et al., 2001; Chesbrough, 2003a; Dahlander & Gann, 2010; von

Hippel, 1988). Both the vertically integrated and distributed views of innovation (e.g. Chesbrough, 2006a; Freeman, 1982) share common precepts about the different stages from scientific discovery, further basic and applied research, product development, manufacturing, distribution and support — the process Porter (1985) dubbed the “value chain”.

Here we focus on two crucial steps in this process: first, the act of technical invention; second, the process of commercializing and disseminating this invention to eventual users. As noted earlier (e.g. Chesbrough, 2003a; Teece, 1986; von Hippel, 1988) these steps may occur internally or externally (Table 1). For both creation and commercialization, the viability of the internal alternative may be (at least partly) under the firm’s control, but the external alternative is not: the relative attractiveness of the internal and external choice thus is a function of both endogenous and exogenous forces.

For both creation and commercialization, we consider factors at the level of the firm and external to the firm that constrain a firm’s openness strategies, as well as attributes of innovations that influence the choice of openness for a given innovation, product or project.

Insert Table 1 here

2.1 Creation of Innovations

A firm’s specific series of “innovative activities” (to use the phrase of Dosi, 1988) may begin with a scientific discovery made through its own basic research, or may leverage publicly funded research, typically at a university, nonprofit organization or a government laboratory (Rosenberg, 1990; Salter & Martin, 2001). If such innovative activities are successful, this basic science will lead to technical invention(s) commercialized through the development and sale of new products or services. This technical invention activity may be captured through a patent or another form of intellectual property (IP); such patent outputs correlate well with the degree of R&D inputs within a given industry (Griliches, 1990).

Differences in the quality or quantity of innovative output may be due to heterogeneity at different levels of analysis, whether the individual, intra-organizational (teams, divisions, functions, projects), organizational or inter-organizational (industries, networks, regions, nations) level. Researchers have sought to identify causal linkages between such levels of analysis, which within an organization are typically classified as top-down or bottom-up (Klein et al., 1999; Gupta et al., 2007; Rothaermel & Hess, 2007).

Environmental-Level Factors. The firm's choice of openness in creating innovations is influenced by key environmental-level factors. For example, the firm's location relative to other firms and universities affects whether the required knowledge is available externally (e.g. in the ecosystem) or needs to be developed inhouse (Chesbrough, 2006b; Rohrbeck et al., 2009; van der Borgh et al., 2012). Similarly, industries with widely dispersed relevant technical knowledge — whether with rivals, universities, suppliers — will tend to encourage external search for knowledge, as will external markets for technology (cf. Arora et al., 2001). Such knowledge may come in the form of information, a patented invention available for license (exclusive or otherwise), a tool or component, or the supply of a complementary good or service (Bogers & West, 2012). At the same time, highly turbulent pre-paradigmatic technological environments may make it difficult to identify the most valuable knowledge (Teece, 1986).

Firm-Level Factors. The ability and willingness to use such external supplies will also depend on firm-level factors. Firms with little or no internal R&D will be forced to use external sources. For firms with strong internal R&D capabilities, those capabilities can both enable internal creation of innovations as well as increase the firm's absorptive capacity and thus its ability to utilize external innovations (Cohen & Levinthal, 1990; West & Bogers, 2013). Economies of scale also play a role: firms that are seeking R&D economies of scale have an incentive to create internal innovations that are externally licensed (West &

Gallagher, 2006), whereas firms that are unable to achieve such economies face pressure to reduce internal R&D and in-license external innovations.

Innovation-Level Factors. For firms that have the ability to use either source, the ultimate decision will be determined by the characteristics of the desired innovation or product. Is the external knowledge available? Are there strong enough incentives for sharing it with the firm, whether for pecuniary motives espoused by Chesbrough (2003a), or nonpecuniary motives such as psychic gratification or a propensity for free revealing (Dahlander & Gann, 2010; Harhoff et al., 2003; West & Gallagher, 2006)? In some cases, such knowledge is readily available through uncontrolled (or intentional) spillovers that enable a pattern of cumulative innovation by direct competitors (Meyer, 2006).

2.2 Commercialization of Innovations

A technical invention is only half the battle; this invention is followed by a (typically) longer and more sustained period of product or service development. As the late Chris Freeman wrote: “An *innovation* in the economic sense is accomplished only with the first *commercial* transaction” (Freeman 1982: 7). Differences in the ability of firms to commercialize innovations have most often been attributed to characteristics of the firm, groups of firms or the national economic or legal environment (e.g. Teece 1986; Nelson, 1993). While it is difficult to measure individual-level differences for commercialization, Shane (2000) identified differences among entrepreneurs that explained the relative success of their startup companies in commercializing the same MIT technology, that of 3D printing.

Environmental-Level Factors. A key factor in the decision of a firm to commercialize its technology externally is the strength of appropriability mechanisms that make such commercialization profitable (Teece, 1986). For technical inventions that are not fully developed, another key factor is the availability of markets for technology (cf. Arora et al., 2001). An institutional framework that facilitates knowledge accumulation and access is then

a precondition for such exchange (Murray & O'Mahony, 2007). The decision may also be influenced by industry structure, including firm concentration and buyer-supplier relationships (cf. Vanhaverbeke & Cloudt, 2006).

Firm-Level Factors. At the firm level, firms choose external commercialization strategies when they lack the complementary assets necessary to capture the returns of the innovation, assets that might include manufacturing, distribution, marketing, sales, and support capabilities (Teece, 1986). Lacking such capabilities will encourage alternative approaches to monetize the invention through external commercialization, whether via licensing, joint venture or a spinoff company (Chesbrough, 2003a; Chesbrough & Rosenbloom, 2002; Teece, 1986). Whether a firm is successful in commercializing innovation internally or externally also depends on the corporate culture, in particular related to the “not invented here” or “not sold here” attitude of R&D staff (Chesbrough, 2006b; Herzog & Leker, 2010; Katz & Allen, 1982).

Innovation-Level Factors. For a given innovation, open innovation posits that the fundamental issue driving the choice of an open commercialization strategy is the alignment of that innovation to a firm's business model (Chesbrough, 2003a, 2006c; Chesbrough & Rosenbloom, 2002). At the same time, firms will seek to control their innovation outputs (and avoid external commercialization) if they believe a technology to be highly strategic and thus want to create barriers to entry and imitation. The overall dispersal of innovative activity across individual and organizational boundaries also depends on the communication costs (Baldwin & von Hippel, 2011).

While firm-centric research on innovation (such as Freeman, 1982 or Chesbrough, 2003a) has emphasized the commercial application of innovations, important innovations can also be disseminated through a non-commercial process (e.g. Roberts, 1988; Benkler, 2006); the impact of such innovations can be measured through the increase in use benefits and social

welfare from the availability of such innovations (e.g. Rogers, 1995; von Hippel, 2005). While such innovations tend to be funded by non-commercial actors such as foundations (Chesbrough, 2003d), firms may unintentionally or intentionally reveal a given innovation for free use by external actors (Dahlander & Gann, 2010; Henkel, 2006; West & Gallagher, 2006).

3 A Taxonomy of Innovation Modes

As outlined above, the relative attractiveness of the internal and external paths for innovation creation and commercialization will depend on both exogenous and endogenous factors. Largely beyond the firm’s control are the nature of the environment and many attributes of the nature of the innovation; however, largely under the firm’s control are the firm’s competencies, as well of its choice of innovations to pursue and markets that it targets.

Building upon the simplified two-phase model of innovation presented in the previous section, we thus identify two dimensions along which the innovation modes fundamentally differ: the locus of innovation creation, and the locus of innovation commercialization.² With the locus of each of these dimensions being either internal or external to the focal firm, this suggests a taxonomy of four distinct innovation modes: Integrated, Outbound, Inbound, and Outside (Figure 1). Based on the relevant prior research, we analyze the general conditions for each mode — both the exogenous factors that might influence a firm’s choices and the firm’s endogenous choice of a mode (whether as an overall strategy or for a specific innovation). These factors may cut across various levels of analysis as there is no coherent view on this in the literature, which we further discuss in the final section.

Insert Figure 1 here

² For consistency with prior innovation research, we use “commercialization” to refer to the process by which innovations are brought into use, but (as discussed below) explicitly include the non-commercial diffusion to other parties discussed earlier.

For each mode, we review research on the innovation creation process, the commercialization process, and then the interaction between the two. In doing so, we consider previous integrated models, particularly Chesbrough's (2006a) innovation funnel, the pecuniary/nonpecuniary distinction of Dahlander and Gann (2010), and the open innovation commercialization model of West and Bogers (2013).

3.1 Integrated Innovation: Created Internally, Commercialized Internally

The Integrated innovation mode corresponds to the traditional vertically integrated model. This innovation mode is based on internally developing new ideas, developing those ideas into new technologies, and commercializing them as products to the firm's customers. Thus, both creation and commercialization are entirely internalized and controlled by the focal firm (cf. Chandler, 1977, 1990; Teece, 1986).

Creation. An example of this would be Dupont's research into organic chemistry in the 1920s and 1930s, that both discovered and developed high-volume manufacturing processes for products such as cellulose, Freon, Teflon, acrylic plastics (Lucite), and lacquer-based automotive paints (Chandler, 1990: 183-187). Creation in this mode usually relies on strong capabilities to conduct R&D that leads to technical inventions and IP.

Commercialization. Going back to Teece (1986), successfully commercializing an innovation in the Integrated mode requires not only strong technological skills but also complementary assets. Besides selling an innovation, firms may also choose to commercialize the innovation by keeping it a secret internal process (e.g. for manufacturing efficiency) and using the innovation to improve the production of goods or services for sale. Such innovations are not revealed or sold for strategic reasons when they can give a firm a competitive advantage (Pisano, 1997).

Interaction Between Creation and Commercialization. To be successful at both creation and commercialization, the innovating firm requires strong organizational routines based on

tacit knowledge and skills (Arora & Gambardella, 1994; Nelson & Winter, 1982) and is further motivated by the potential to create economies of scale and scope (Chandler, 1990). This innovation mode also implies internal and external conditions that favor vertical integration over disintegrated organization of innovation activities (Williamson, 1985).

Besides these firm-level conditions, an important environmental condition in this respect is the appropriability regime, which will determine whether the innovating firm will be able to profit from the innovation. Again, the tacit nature of the involved knowledge and skills may increase the likelihood for the innovating firm to appropriate the benefits from its innovation (Winter, 1987), although a weak IP regime will narrow the window within which a firm can do so (Teece, 1986).

3.2 Outbound Innovation: Created Internally, Commercialized Externally

The Outbound mode considers how innovations created internally are commercialized or otherwise disseminated externally. This includes a recent and growing body of research on “inside-out” open innovation (Enkel et al., 2009). Even before this, a sizable literature existed as to the conditions under which inventors will license their (often patented) technology (e.g. Arora, 1997; Arrow, 1962; Teece, 1986) or when they will collaborate with others to find successful commercialization opportunities (Granstrand & Sjölander, 1990; Rothaermel, 2001). Other research has explored the free revealing of innovations by firms (de Jong & von Hippel, 2009; Harhoff et al., 2003).

Creation. Creation of innovation within the Outbound mode essentially relies on a strong R&D capability on the level of the firm, although there may be varying motivations for a focal firm to create an innovation that is ultimately commercialized externally. In some cases, a firm creates an innovation for its own use — typically as a part of their value adding activities (de Jong & von Hippel, 2009) or new offerings to their customers (Chesbrough, 2003a) — that may also find its way to other firms, whether intentionally or otherwise. In

other cases, the innovation may be created but not used internally, whether because R&D is intended to support external commercialization or because it produces innovations that are not aligned to the firm's actual business model (Chesbrough & Rosenbloom, 2002; Chesbrough, 2006b).

Commercialization. A dominant strategy within Outbound innovation is the use of IP protection to market innovations for commercialization by others (cf. Arrow, 1962; Teece, 1986). Licensing out the right to use the relevant IP is therefore a common process for allowing external partners — even competitors — to commercialize a focal firm's innovation (Arora, 1997; Chesbrough, 2003a). External complementary assets may also be accessed through divestment — as when Xerox allowed spin-offs, including Documentum, Komag and SynOptics, to commercialize its PARC discoveries (Chesbrough, 2003a) — or through collaborative efforts such as joint ventures and strategic alliances (Granstrand & Sjölander, 1990; van de Vrande et al., 2009).

The motive for firms to pursue the Outbound mode is usually assumed to be monetary incentives on the innovation or firm level such as royalties or external venture capital (Chesbrough, 2003b, 2003c). However, a focal firm may also disseminate its internal innovation to the outside based on nonpecuniary motivations (Dahlander & Gann, 2010). For example, free sharing among firms was documented by Henkel (2006) in his study of embedded Linux and by de Jong and von Hippel (2009) in their study of Dutch high-tech SMEs. Moreover, depending on the environmental conditions, such as the appropriability regime, a firm's innovations may be disseminated through involuntary spillovers as in Allen's (1983) study of collective invention in 19th century blast furnace development.

Interaction Between Creation and Commercialization. Given that common rationales for finding external commercialization opportunities include decreasing lead times or reaching new markets (Enkel et al., 2009), the success of such a strategy will depend on the relevant

capabilities of the external partners — as predicted by Teece (1986). Finding the right creator-commercializer tie is facilitated by codifiability of the innovation and a functioning market for technology more generally (Arora et al., 2001; Arora & Gambardella, 1994).

Nevertheless, the rivalry between the creator and commercializer, which may often be competitors, may hamper an efficient market exchange. While Chesbrough (2003a) hints at rare examples — as when IBM licensed hard disc drives to competing laptop makers³ — the relative scarcity of such examples suggests the difficulty of aligning such competing interests, even in an era of open innovation. The shift over decades towards such outbound licensing in an industry is highly dependent on scale economies, suggesting a fairly narrow range of conditions under which such licensing occurs (e.g. Arora, 1997; Lieberman, 1989).

3.3 Inbound Innovation: Created Externally, Commercialized Internally

The Inbound mode considers how firms commercialize innovations that are created outside the firm. This is the focus of a subset of the research on user-created innovations (Bogers et al., 2010; von Hippel, 1988). It also corresponds to the “outside-in” modes of open innovation (Enkel et al., 2009), which is the largest area of research in open innovation (West & Bogers, 2013). It additionally shows up in other literatures, including technology sourcing (Rothaermel & Alexandre, 2009) and the special case of user entrepreneurship (e.g. Shah & Tripsas, 2007) in which an organization is created to commercialize such innovations.

Creation. Researchers have identified both pecuniary and nonpecuniary motives for creating those external innovations that are later commercialized by firms (Dahlander & Gann, 2010). While pecuniary motives feature more prominently in firm-centric innovation models, the importance of nonpecuniary motives for sharing innovation is particularly well studied for users as sources of innovation (Harhoff et al., 2003; von Hippel, 2005). In addition to users, researchers have also identified suppliers (Schiele, 2010), competitors (Lim

³ In 2002, IBM sold its global disk drive operations to Hitachi, which does not compete with laptop makers.

et al., 2010) and universities (Perkmann & Walsh, 2007) as important innovation creators; some earlier evidence in this domain dates back to studies such as Myers and Marquis (1969) and the SAPPHO studies (Rothwell et al., 1974).

Whether external creators are individuals (Jeppesen & Lakhani, 2010) or communities (Dahlander & Wallin, 2006; West & Lakhani, 2008), their innovative potential is increasingly being facilitated by the increasing mobility of skilled labor (Chesbrough, 2003a; Fleming & Marx, 2006) and the growing availability and effectiveness of the Internet, ICTs and toolkits more generally (Afuah & Tucci, 2012; Dodgson et al., 2006; Franke & von Hippel, 2003).

Commercialization. Typical approaches to commercialize externally created innovation include sourcing external innovations (Laursen & Salter, 2006; Rothaermel & Alexandre, 2009), combined with internal processes for integrating external innovation, often relating to “not-invented-here” (Katz & Allen, 1982) and absorptive capacity (Cohen & Levinthal, 1990). An implicit assumption is that a firm that brings Inbound external sources of innovation would be expected to have successful internal processes for commercializing innovations, although actual research seems to be mostly mum on this topic (West & Bogers, 2013).

Interaction Between Creation and Commercialization. The mechanisms of getting external innovations into the firm consist of processes such as searching, enabling and filtering such externally sourced innovations (West & Bogers, 2013). Conditions that affect this process typically include firm-level characteristics of the focal firm and the external source, such as R&D capabilities and complementary assets (Ceccagnoli et al., 2010; Teirlinck et al., 2010). Environmental conditions such as the appropriability regime will also influence the effectiveness of Inbound innovation processes (e.g. Arora et al., 2001; Chesbrough, 2003a; Laursen & Salter, 2006).

3.4 Outside Innovation: Created Externally, Commercialized Externally

In the Outside innovation mode, both the creation and commercialization of the innovation takes place without (or despite) the firm's lack of involvement. Perhaps the most often researched example is the community-based innovation model that excludes the focal firm; another example would be third-party complements that are developed independently of the focal firm.⁴ The former typically differs from other modes in being primarily motivated by nonpecuniary factors.

Creation. Innovations may be created at other firms, at non-commercial organizations such as universities, or by individuals. Examples of the latter research within user innovation include open source software (Lakhani & von Hippel, 2003; von Hippel & von Krogh, 2003) and sport-related industries (Franke & Shah, 2003). In such cases, innovation is often created in communities or networks of individuals, facilitated by a need and capability to innovate as well as conditions favorable for sharing the innovation (von Hippel, 2007).

Commercialization. Commercialization of an innovation outside the boundaries of a focal firm requires production and distribution capabilities (von Hippel, 2007), while the appropriability regime should facilitate (easy and low-cost) diffusion beyond firm boundaries. The dissemination of innovations outside firms has become more feasible due to decreased communication and transaction costs, as in the case of collaborative innovation within user communities (Baldwin & von Hippel, 2011). Transaction costs can remain low in such cases especially when the innovators are not driven by pecuniary motivations but rather want to solve a particular need, which is best served by freely revealing the innovation instead of monitoring and enforcing its IP (Harhoff et al., 2006).

⁴ During the mainframe and PC era, third-party complements for computing platforms were often developed without direct involvement of the focal firm (an Outside approach). However, videogame makers have long required cooperation and licensing from the platform owner (an Outbound mode), and today mobile phone software is increasingly distributed through the platform owner's application store (Inbound).

Interaction Between Creation and Commercialization. The interaction between creators and commercializers in the case of Outside innovation may involve a variety of stakeholders, both firms and individuals (Henkel, 2009; Jeppesen & Frederiksen, 2006). In many cases, these interactions are between individuals within communities, whose motivations may vary depending on whether the individual acts on his/her own personal behalf or represents employer interests (West & Lakhani, 2008).

Of particular note is the body of cumulative innovation research that documents persistent patterns of external creation and commercialization within a given industry or segment. In such cases, firms or individuals freely build upon each others' innovations as they pursue their own interests in creating and commercializing innovations, whether for nonpecuniary (such as recognition) or pecuniary motives. There are two distinct patterns on such sharing — a collaborative approach enabled through voluntary spillovers, and competitive rivalry driven by the infeasibility of blocking spillovers due to weak appropriability (Allen, 1983; Meyer, 2006; Murray & O'Mahony, 2006; Bogers & West, 2012).

4 Combining Innovation Modes

Chesbrough (2003, 2006a) argues that in open innovation, firms can use Inbound and Outbound innovation strategies to supplement their traditional (Integrated) strategy. However, researchers have tended to focus on only one innovation mode (West & Bogers, 2013).

Here we highlight examples of how firms can and do combine innovation modes, both for a given innovation and within the firm (or business unit) more broadly. Such combination may occur simultaneously, as when firms combine Inbound and Outbound processes in the coupled approach to open innovation (Gassmann & Enkel, 2004). Or it may occur sequentially, as when knowledge discussed within an Outside community of users is used to

create a new Integrated firm through the process of user entrepreneurship (Shah & Tripsas, 2007).

The examples below are based on established combinations as addressed in earlier studies, although they may not always be framed as such. While these examples do not provide a complete overview of all possible combinations of modes, they highlight the relevance of considering open innovation as a combination of innovation modes. And while our framework does theoretically imply various combinations (cf. Figure 1), the examples below illustrate what is known and thereby what is not known about such combinations. The distinction between combinations on the firm/business unit level and the innovation/project level moreover further illustrated to value and importance of applying multiple levels of analysis when considering innovation strategies (cf. Table 1).

4.1 Combinations by the Firm or Business Unit

Inbound and Integrated. Chesbrough's (2006a: 1) definition of open innovation as including "the use of purposive inflows... of knowledge to accelerate internal innovation" suggests a firm strategy that uses Inbound mode to supplement its Integrated mode. An important early example of this in practice has come with Procter & Gamble's Connect+Develop program. The company had traditionally relied on strong internal R&D capabilities to create new products and fuel revenue growth, but in 2001 launched the new program to identify new technologies and product concepts that could be commercialized via the company's consumer products distribution channels (Dodgson et al., 2006).

Integrated and Outbound. For first and (especially) second generation mobile telephones, manufacturers used patented inventions to support their own Integrated product strategies and to deter entry by potential competitors (Bekkers et al., 2002). However, with 3rd generation mobile phones, handset manufacturers Nokia and Ericsson created patents essential to

conform to the 3G standard, both to protect their own product innovations (Integrated) and extract revenues (Outbound) from competing manufacturers (Bekkers & West, 2009).

Inbound and Outbound. Despite the original exemplar of IBM recounted by Chesbrough (2003), few researchers have examined the use of Inbound and Outbound modes in the same firm. One exception is an in-depth exploratory analysis by Bianchi et al. (2011) on how bio-pharmaceutical firms have used different mechanisms and relationships acquire and commercially exploit technologies. Also the recent findings of Burcharth et al. (2014) that there are differing predictors of Inbound and Outbound activities in a sample of small and medium sized Danish manufacturers combine these two modes in the same study, although not directly linking them.

Inbound, Outbound and Outside. Firms such as IBM choose to engage in ongoing collaborations with external communities of innovators, particularly in open source software. By doing so, the firms may share their technologies for external use (Outbound), have those technologies extended and improved by the external community (Outside), and then utilize these external inventions (Inbound) to support their own products (Dahlander & Wallin, 2006; West & Gallagher, 2006). Another example is in industries where competitors cross-license each others' technology — both providing to and receiving from competitors access to patents — as found in the semiconductor industry (see Galasso, 2012).

4.2 Combinations for a Given Innovation or Product

As discussed earlier, the choice of an innovation mode may not only vary by firm, but may also vary between technologies or products being produced by the same firm. Here we consider those cases where a firm might choose to combine modes for a single innovation or project. We thereby provide examples of the building blocks that are required to go beyond the level of the firm when considering a firm's choice of innovation mode. This implies that

it is not just firm-level attributes but also the nature of the technology and how it aligns to these attributes that determine the optimal innovation strategy.

Integrated and Inbound. Chesbrough's (2006a: 13) innovation funnel anticipates that bringing a product to market often requires a combination of internal and external technologies — whether the latter provide core science that enables the product, is acquired through a company acquisition, or comes in the form of manufacturing, packaging or other ancillary technologies necessary to commercialize an internal innovation. An example of the latter is when Pfizer had strong scientific expertise in diabetes treatment but not in drug delivery, and so partnered to develop an inhalable insulin (Chesbrough & Schwartz, 2007).

Outbound and Outside. Well known are examples of companies that (correctly or otherwise) decide to out-license a technology that does not fit its business model, as with Xerox's Palo Alto Research Center (Chesbrough & Rosenbloom, 2002). In some cases, this leads to an ongoing process of innovation creation outside the firm, as when IBM spun out a Java programming tool to create an open source community (West & Gallagher, 2006).

Integrated and Outbound. Why would a company license a technology to competitors when it is also trying to commercialize it? One reason is when the technology is cross-licensed between direct competitors, as with the mobile phone and semiconductor industries mentioned earlier. Another reason is when the firm can partition the rights (and thus the value created) for a given innovation between multiple applications.

5 Discussion

This paper makes two main contributions. First, it offers an integrated taxonomy of four possible combinations of closed and open strategies for innovation creation and commercialization. Second, it examines the environment-, firm- and innovation-level factors that cause firms to choose each strategy and how these strategies can be combined within a

given firm, technology or product. Together, these suggest new opportunities for considering the relationship between firm capabilities and their open innovation strategies.

5.1 An Integrated View of Commercialization Modes

This paper identifies and contrasts four distinct innovation modes that represent distinct paths of innovation creation and commercialization: Integrated, Outbound, Inbound, and Outside. It extends and complements existing frameworks (e.g. Chesbrough, 2006a; Dahlander & Gann, 2010; West & Bogers, 2013) by developing a complete list of innovation modes by jointly considering both the creator and commercializer of the innovation. It develops the dyadic perspective of the boundary-crossing innovation process (as proposed by West et al., 2006) and identifies the interactions between the choices of the individual participants for each mode. It also suggests the opportunity for linking open, user and cumulative innovation processes — along with the pecuniary and nonpecuniary innovation flows identified by Dahlander and Gann (2010) — into a unified innovation framework. At the same time, a consideration of the interaction between the creator/creation and commercializer/commercialization helps to better understand under which conditions successful dissemination breaks down — when innovation fails.

5.2 Changing the Level of Analysis

The paper moreover shows how open innovation research should move beyond considering openness strategies (external creation or commercialization) as a firm-wide choice towards one made on an innovation-by-innovation basis. It suggests how choices of openness for a given innovation are constrained and influenced by specific conditions of the economy, industry or firm, as well as the nature of the innovation itself. Such greater theoretical precision would support calls (e.g. Bogers et al., 2010; Dahlander & Gann, 2010) for an increased focus on the conditions and causal relationships that enable innovation creation and commercialization across the modes. Moreover, the innovation-centric approach

to openness opens opportunities to consider how the selection and combination of innovation modes can lead to superior performance for specific innovations and firms at large.

The framework presented here offers a platform for future researchers to further examine innovation-level conditions under which firms are likely to utilize a particular innovation commercialization mode — i.e. Integrated, Outbound, Inbound or Outside. Various perspective and literature streams could be used to build on our taxonomy and extend our understanding of the strategic choices of open innovation modes. A possible way to investigate the determinants of internal vs. external modes of innovation creation and commercialization is to consider the complementary nature of the innovation relative to the creator-commercializer tie — is external innovation creation and commercialization more likely if external assets are complementary the focal firm's internal ones (cf. Boudreau, 2010; Cassiman & Veugelers, 2006; Miotti & Sachwald, 2003)? Moreover, how does the optimal innovation mode depend of the incremental vs. radical nature of the innovation (cf. Henderson & Clark, 1990; Hill & Rothaermel, 2003; Tripsas, 1997)? Or, how does the modular nature of the innovation problem — or the separation or integration of the creator and the commercializer of an innovation — affect the strategic choice of which innovation mode to select (cf. Baldwin & Clark, 2000; Langlois & Garzarelli, 2008; Schilling, 2000)?

If researchers consider the openness decision at the level of the innovation, then that allows examining the linkages between innovation-, firm- and environment-level conditions for the locus of innovation creation and commercialization as well as associated open innovation strategies. For example, do these different levels act as independent determinants or are they in some way correlated, whether through moderating or mediating relationships? Also, how do environmental factors and policies as well as firm-level strategies and business models affect focal firms' choice of innovation modes in the face of innovation-level changes of such conditions? This can also be linked back to the ambidexterity literature, where

different analysis levels have been considered, with most attention going to organizational level and less to individual ambidexterity (Raisch et al., 2009). Applying ambidexterity to open innovation also suggests the potential of studying the interdependence of different levels or types of ambidexterity — as in Rosenkopf and Nerkar’s (2001) study of boundary spanning across organizational and technological boundaries.

5.3 Capabilities for Ambidextrous Combinations of Modes

If firms can pick and choose the different innovation modes for a given innovation — or combine them within the same innovation — then this implies additional activities beyond those required for each mode individually. Selecting the appropriate modes is one such activity; another is managing the conflicts between internal and external choices in the same division or technology, whether that be “not invented here” (internal vs. external creation) or the threat of cannibalization via out-licensing (internal vs. external commercialization). We suggest such processes (and the associated capabilities) may be called “ambidextrous⁵ open innovation.”

Moreover, such ambidexterity in open innovation may be a firm-level dynamic capability that parallels other previously identified forms of organizational ambidexterity — whether between radical and incremental change or exploration and exploitation (O’Reilly & Tushman, 2008; Raisch et al., 2009). In fact, Helfat (1997) notes that dynamic capabilities related to R&D include the ability to acquire both innovation creation and commercialization capabilities. In this case, ambidexterity means that a firm can obtain the innovation creation and commercialization assets necessary for a given innovation, whether by developing them internally, acquiring them and bringing them into the firm⁶, or by partnering with those who

⁵ We use the term by analogy to Tushman and O’Reilly (1996), although their two organizational change processes are more likely to be sequential, while our open innovation modes are often used simultaneously.

⁶ An important unresolved issue in open innovation is whether acquiring external technology (such as by acquiring a firm) is properly an open or closed innovation

hold the necessary capabilities external to the firm. Future research on open innovation should therefore consider how firms can create, adapt, acquire or contract for the innovation creation capabilities necessary to complete a given product or project, and similarly make or buy commercialization channels (including new business models) for such products or services.

Considering open innovation ambidexterity as a dynamic capability would allow studying linkages between firm-level capabilities and environmental change (cf. Eisenhardt & Martin, 2000; Teece et al., 1997). Future research could also explore the path-dependent legacy of how many of the identified innovation strategies have emerged over time. We would expect that the interaction between creation and commercialization will cause each process to be optimized for a particular mode, but that prediction has yet to be empirically verified. Finally, our static model of innovation modes does not allow for sequences or other changes over time, so a dynamic model could examine the relationship between innovation creation or commercialization choices over time, within a firm, product line, specific product or technology (cf. Aylen, 2010; Christensen et al., 2005; Pattit et al., 2012).

5.4 Considering Non-Commercialized Innovations

A final consideration is that there is a significant lack of studies of “failure” cases in open innovation — whether this is due to economic rationales, Type II (false negative) errors, or a misfit with the firm’s business model (Chesbrough, 2006c; Chesbrough & Rosenbloom, 2002). While extant literature describes various aspects on innovation creation and commercialization for the four identified innovation modes, it is sampling on the dependent variable if we ignore those important cases when some innovations are not commercialized. The internal/external framework namely implies two distinct modes of non-

strategy. Such strategies require many of the same search and contracting competencies of the Inbound mode (cf. West & Bogers, 2013) but provide the same control and ongoing closedness as the Integrated mode.

commercialization. Considering non-commercialized (or non-diffused) innovation — whether created internal or external to the firm — could thereby extend our framework in Figure 1 by adding a third column of non-commercialized innovations.

First, a firm may decide not to commercialize internally developed innovations, which we term the Orphan mode. This decision may happen early on, when the firm concludes (correctly or otherwise) that the innovation does not hold sizable commercial promise, or it might happen later when a planned product introduction is cancelled due to budget cuts. Firms may also decide that it is in their best interest to (temporarily) leave an innovation on the shelf when the new product would cannibalize existing revenue streams (Chesbrough, 2003a, 2006b; Chesbrough & Rosenbloom, 2002).

Second, there are cases in which an innovation is created outside of the firm but is not disseminated in any way. This Egocentric mode typically corresponds to individual or organizational user-innovators meeting their own needs and is more likely in cases of highly heterogeneous demand or low costs of innovation, as when enabled by user innovation toolkits (Baldwin & von Hippel, 2011; Franke & Piller, 2004). The non-dissemination decision may also occur where the innovator lacks both the internal commercialization competencies and external appropriability mechanisms and markets — and thus rationally concludes that commercialization would be unprofitable.

This extended framework thus proposes two distinct modes of non-commercialized innovation, whether by firms (Orphan) or by a user (Egocentric). Future research could examine the conditions on different levels — related to creation, commercialization, and the creator-commercializer tie — under which innovations become commercial failures as well as how firms can modify their innovation strategies to strengthen the creation-commercialization tie.

6 References

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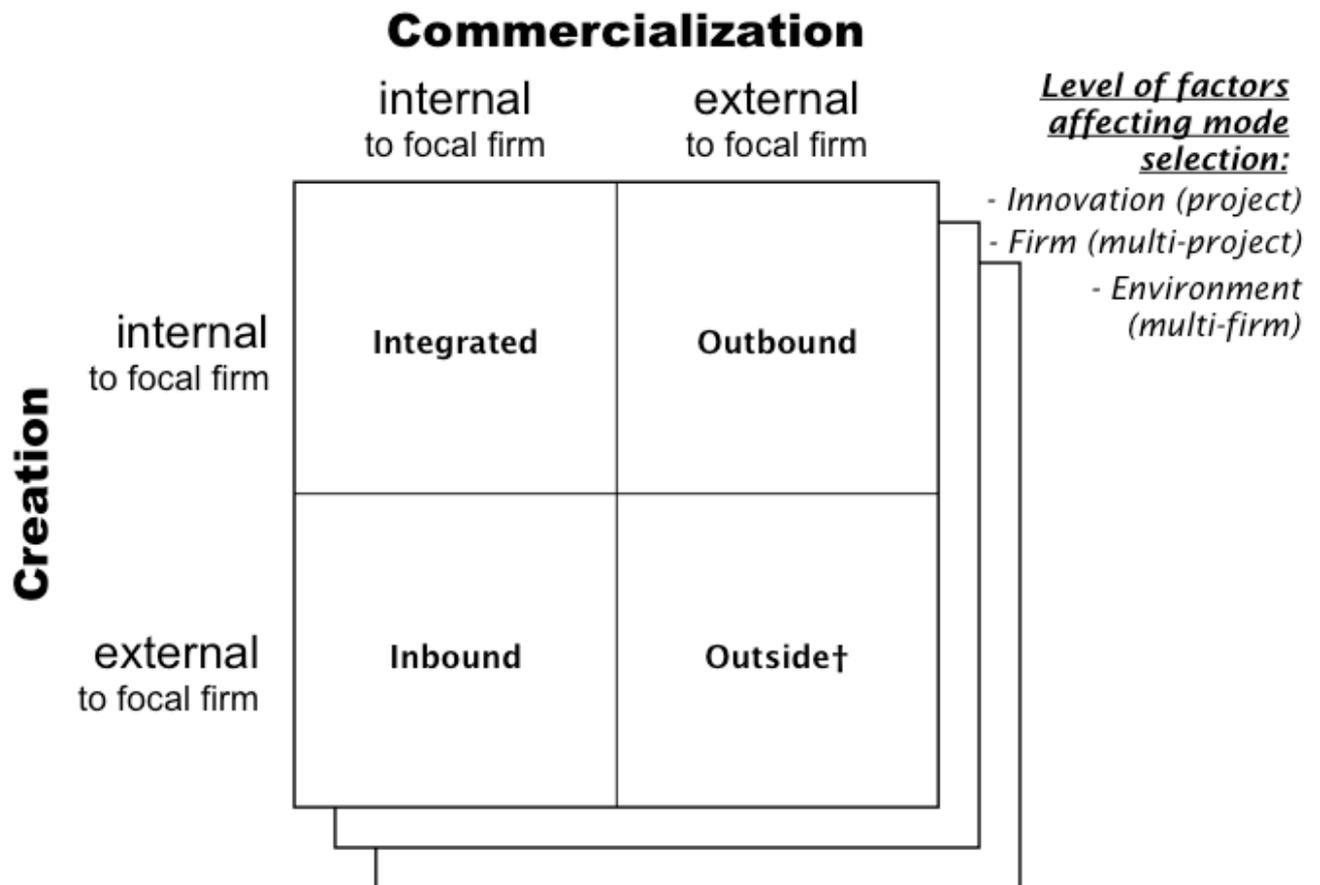
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7 Tables and Figures

Activity	Choice	Environment-level factors	Firm-level factors	Innovation-level factors
<i>Creation</i>	Internal to the firm	Lack of external markets for sourcing innovation Life cycle/dominant design	Strong R&D capabilities Scale economies of R&D	Innovation input (R&D, science) Innovation output (IP)
	External to the firm	Distributed nature of knowledge Geographical proximity	Lack of R&D resources Absorptive capacity	Lack of internal support (incentives) Spillover-inducing codification
<i>Commercialization</i>	Internal to the firm	Lack of external commercialization channels Industry structure (e.g. firm concentration)	Strong complementary assets Absorptive capacity to obtain required knowledge	Fit with business model To form barriers to imitation
	External to the firm	Strong appropriability regime Availability of technology markets	Openness of business model Corporate culture (“not sold here”)	Strategic importance Low distribution cost

Table 1: Key factors that influence firm strategies for innovation creation and commercialization



† Includes non-commercial diffusion of innovations

Figure 1: Locus of innovation creation and commercialization