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Factors Affecting the Governance of Innovation Commercialization: A Theoretical Model

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The ability to commercialize innovations is central to firm survival and success and despite research on parts of the process, there is no overarching framework. Successful commercialization can include retaining ownership of the innovation and bringing it to market, sharing it by licensing or developing it with partners, or by selling it. A firm-level model is constructed that goes from innovation sourcing, through assessment of viability, to selection of the optimum form of governance. External networks and absorptive capacity at the meso level, plus micro- and macro-level factors, as moderators affecting the strength of the relationship between viability and governance are identified. Propositions are generated on these relationships for empirical testing and further theoretical insight.

Would an author of today find a publisher for a book that advocated the conservation of our natural resources because "We can see our forests vanishing, our innovation is a complex notion and to truly see the inherent value in it in a corporate setting, one must see innovation manifested in outcomes such as commercialized products" (Schendel & Hill, 2007). In 2008, Nokia and Sony-Ericsson each successfully introduced over seventy models of cellular phones, thus penetrating many market niches. That pace of commercialization allowed the innovators to be successful

with introduced products, and it raised barriers for potential competitors. Successful commercialization of innovations is not only of strategic importance to firms (Nerkar & Shane, 2007), but it is also a key driver of economic growth (Cohen & Levinthal, 1990; Eisenhardt & Martin, 2000; Sorensen & Stuart, 2000; Zahra & Nielsen, 2002). Schendel and Hitt (2007) argued that economic growth is related to entrepreneurial activities. Entrepreneurial activities such as selection of partners, forming alliances, and creating subsidiaries and spinouts are often centered around the commercial potential of innovations and assessments of the related capabilities of firms. The ability to commercialize innovations can help firms penetrate existing markets or create new markets, which contributes to the attainment of sustained leadership and firm longevity, which, in turn, positively impacts the health of the economy (Salamenkaita & Salo, 2002; Wallsten, 2000).

It is therefore no surprise that governments at nearly all levels attempt to mitigate market and other systemic failures that act as a barrier to innovation and subsequent commercialization. A better understanding of the process of innovation commercialization is therefore important at multiple levels. It has become generally accepted that, on average, it takes about three thousand raw ideas to result in a commercially successful product (Stevens & Burley, 1997). That statistic is far worse in some industries such as pharmaceuticals where only one out of 10,000 compounds succeeds as a new product, with an overall time from discovery to market of over a decade and a total cost approaching $1 billion. Even worse, those statistics hide the fact that more products could be successful but fail because of flaws in the process of commercialization. Despite such a low probability to success, firms have to bring new products to market because the alternative is the demise of the firm.

Firms typically depend on products developed three to five years ago for large portions of their current sales, which means that they are aiming three to five years in the future at a target that is both elusive and competitive in nature. Additionally, globalization of markets has put more pressure on firms to commercialize innovations in order to fend off global competition, to expand into global markets, or both (Collin & Porras, 1997; Hamel & Getz, 2004 ; Hamel & Prahalad, 2002; Huber & Glick, 1993; Huygens et al., 2001; March, 1991). As the global environment continues to grow at a faster pace, innovation is a requirement for ongoing organizational survival and continuing success (Schendel & Hill, 2007). In addition to these global stimuli, there are other environmental factors, such as rapid technological development, which simultaneously enhance and exacerbate the need for successful commercialization. Advances in information technology, and greater ease of use of these technologies, have led to shorter cycle times in developing new technology applications. These changes have resulted in greater process improvements and more efficient generation of new products and product changes (Brynjolfsson & Mendelson, 1993; Gulati, Sawhney & Paoni, 2002), which has further increased the speed with which firms and their competitors need to innovate and commercialize. Clearly, innovation and subsequent commercialization both are important, but where the former has received substantial attention in the literature (Damanpour, 1991; Dougerty & Hardy, 1996; McGrath et al., 1996; Pennings & Harianto, 1992; Teece, Pisano & Shuen, 1997), the latter has not, some seminal pieces notwithstanding (Andrew & Sirkin, 2003; Kelm, Narayanan &

Pinches, 1995; Kwak, 2002; Narayanan et al., 2000; Nerkar & Shane, 2007). Thus, the research question is posed: *What are the determinants of success in commercialization of innovations?* In order to address this question, we explore the related questions of a) *what resources and capabilities are necessary to innovate and commercialize,* and b) *what forms of governance help to maximize returns from innovation commercialization?*

To answer these questions, a review of the literature on innovation and commercialization is made. Then a baseline model of the innovation-commercialization process that starts with sourcing of innovations is built, followed by an assessment of viability, and finish with selection of the best governance form. The foundation for this baseline model came from Schendel and Hitt's (2007) contention that sources of innovation are complex and multiple, and the value potential is difficult to assess. It can be assusmed that the firm has the necessary motivation to innovate. The study also adopts the view that innovation is a necessary, but not sufficient, condition for successful commercialization. Having innovated and found it to be viable not only legally, but also in terms of profitability and access to the necessary capabilities for commercialization, we then address the thesis that success in the ability to commercialize is contained within selection of one of three forms of governance: own, partner, or sell. The strength of the relationship between viability and governance is affected by four moderators, two of which are firm level (external networks and absorptive capacity), one of which is a micro-level factor (previous managerial experience), and one of which is a macro-level factor (dynamism, munificence, and complexity in the operating environment). To ease the process of identifying these main and moderating effects, this paper assumes that there is demand for the innovation. It is also assumed that success in commercialization arises from a rational and managed process, and that luck is not counted upon as a factor input. Finally, the discussion is bound by limiting ourselves to established firms that have cash flows or access to any needed capital that allows them to make the expenditures that are necessary for commercialization.

Prior Research

The innovation process is defined as the combined activities leading to new, marketable products and services, or new product-delivery systems (Burgelman, Christensen & Wheelright, 2006), and a firm's ability to innovate is dependent upon its capabilities (Damanpour, 1991; Dougerty & Hardy, 1996; McGrath et al., 1996; Pennings & Harianto, 1992; Teece et al., 1997), its human resource practices (Nerkar, McGrath & MacMillan, 1996; Scott & Bruce, 1994), the nature of the top management team (Bantel & Jackson, 1989; Howell & Higgins, 1990), and the external environment within which the firm operates (Abrahamson & Rosenkopf, 1993; Keats & Hitt, 1988; Milliken, 1987; Wade, 1996). Other seminal work on innovation has concentrated on the types of innovations: product versus process innovations (Burgelman et al., 2006; Cooper, 1985; Cooper & Kleinschmidt, 1986; Danneels, 2002; Dougerty & Hardy, 1996; Herstatt & Von Hippel, 1992; Schilling, 2006); radical versus incremental innovations (Burgelman et al., 2006; Dahlin & Behrens, 2005; Golder, Shacham & Mitra, 2008; Majchrzak, Cooper & Neece, 2004; Schilling, 2006); competence enhancing versus competence destroying innovations (Burgelman et al., 2006; Schilling, 2006);

architectural versus component innovations (Christensen, 1992a; Christensen, 1992b; Christensen & Bower, 1996; Henderson & Clark, 1990; Wade, 1996).

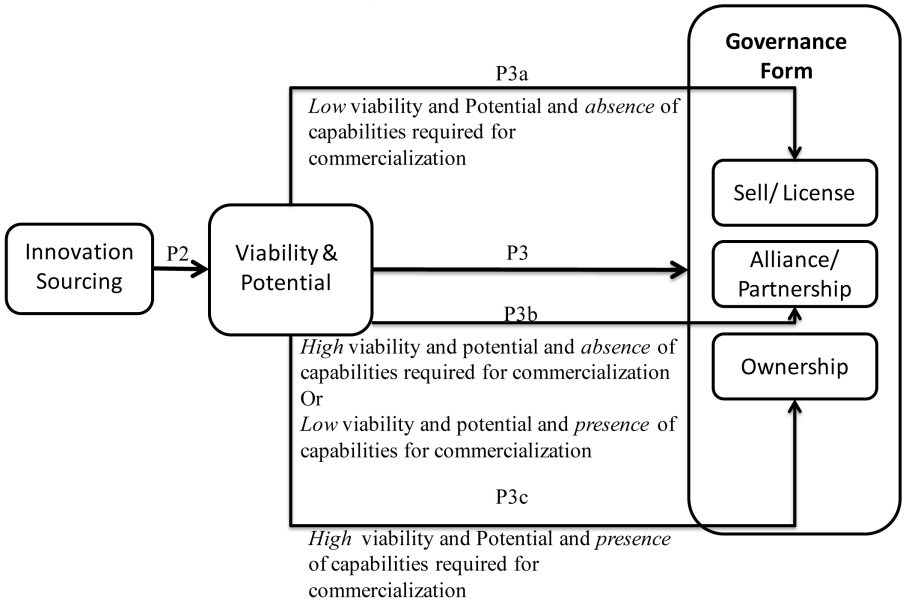
Much of the literature just cited however, has treated innovation and its commercialization as the same construct. In fact, commercialization in many cases was assumed. While innovation characteristics are a necessary component of future market success, innovation itself is not sufficient enough to ensure that success. Instead, innovations generally lead to market success through the process of commercialization (Drucker, 1985). While this growing body of work undoubtedly contributes to our understanding of successful commercialization, it remains that a dedicated model of the factors affecting commercialization is needed. That being said, a few scholars have kept innovation and commercialization as separate and distinct constructs. Commercialization of innovation has been defined as the act or activities required for introducing an innovation to market (Andrew & Sirkin, 2003; Kelm et al., 1995; Kwak, 2002; Narayanan et al., 2000; Nerkar & Shane, 2007). Nerkar & Shane (2007) operationalized commercialization as the first sale of a given product or service. However, when an innovation is introduced in the market, only technology enthusiasts adopt it initially, and such enthusiasts comprise less than three percent of the market (Moore, 1991, 2000). The larger mainstream market is comprised of pragmatists and conservatives, so it can be argued that a successful commercialization is one that also captures this mainstream market. Fully capturing the mainstream market is difficult, therefore the threshold for 'successful' commercialization of an innovation will lie somewhere between these two extremes—a single sale on the one hand and saturating the mainstream of a market on the other (Moore, 1991, 2000).

New Product Development (NPD) has emerged in the literature as a complementary dimension of commercialization of innovations and includes the selection of projects for new product development (Cooper, 1985; Hansen, 1999; Herstatt & Von Hippel, 1992). The extant literature includes investigation into processes of NPD (Cooper & Kleinschmidt, 1986; Hansen, 1999; Herstatt & Von Hippel, 1992; Johne & Snelson, 1989; Spivey, Munson & Wolcottl, 1997; Zirger & Maidique, 1990), the effects of path dependency and leveraging of primary and second-order competencies (Danneels, 2002), identifying suppliers for NPD (Ragatz, Handfield & Scannell, 1997), predicting success of NPD based on the type of idea and the circumstances of its emergence (Goldenberg, Lehmann & Mazursky, 2001), and the role of network alliances in information acquisition and its lagged effect on the new-product performance of the firm (Soh, 2003). As a body of work, this research assumes, either explicitly or implicitly, that the developed product does not violate existing intellectual property rights, it will serve a viable market, and that the firm has the wherewithal to bring the product to market either by itself (hierarchy) or with partners (alliances). Here, those assumptions make explicit in a baseline model which then becomes the vehicle for identifying the effect of other moderating factors that contribute to success in commercialization.

Baseline Model

The baseline model is comprised of three constructs: *innovation sourcing, viability and potential,* and *governance form*. Sources of innovation can be internal or external to the firm, and strategies to manage those sources are deliberate and emergent. Viability and potential looks at the legal feasibility and profit potential of the innovation. Viability and potential are linked with three forms governance: own, partner, or sell. Figure 1 depicts the constructs are linked and their relationships.

Figure 1: *Baseline Model*



Innovation Sourcing

Whereas the innovation process is defined as the combined activities that lead to new, marketable products (Burgleman et al., 2006), innovation itself is defined as the practical implementation of an *idea* into a new product (Markham, 2000; Schilling, 2006). As such, innovation sourcing means being aware of the disparate sources of ideas and being willing and able to use them.

Sources of ideas for innovations can be internal or external to the firm. The internal generation of ideas arises from organizational creativity, which can range from being a one-off organizational aberration, to a formalized process that is embedded in the culture or supported as a separate R&D function. The creativity of the organization is a function of the creativity of individuals, social processes, and contextual factors that shape the way individuals interact and behave (Woodman, Sawyer & Griffin, 1993). Firm R&D intensity has been shown to have a positive correlation with sales from new products, sales growth rate, and profitability (Roberts, 2001; Schilling, 2006). Thus,

as a source of ideas for innovation, the R&D function, whether internally funded or externally contracted, is key (Acs & Audretsch, 1988; Cassiman & Veugelers, 2002; Hagedoorn, 2002; Iwasa & Odagiri, 2004; Katila, 2002; Kelm et al., 1995; Kortum & Lerner, 2000; Lane & Lubatkin, 1998; Levin, 1988; Penner-Hahn & Shaver, 2005; Veugelers, 1997; Wallsten, 2000). It also is a readily apparent source and, as such, does not need further elaboration aside from noting that it is the norm to have processes in place for moving ideas forward for assessment for commercialization.

Discovery of entrepreneurial opportunities is somewhat probabilistic in nature, as opposed to the result of a systematic search effort (Kirzner, 1997). Entrepreneurs seem best able to "discover" opportunities for commercialization that directly relate to their previous knowledge of markets, knowledge of how to serve those markets, and knowledge of specific customer problems (Shane, 2000). This knowledge is not equally distributed across all entrepreneurs and therefore, is necessarily a function of their relationships with innovators, and funders (Anderson, 2008). Thus, recognition of an opportunity to commercialize an innovation is more likely to happen within a network of these entities (Seppanen & Skates, 2001) through knowledge sharing and transfer.

Networks with customers, suppliers, complementors, and competitors also are valuable sources of new product ideas (Cooper & Kleinschmidt, 1986; Yoon & Lilien, 1988). External sources of information also complement in-house R&D by increasing a firm's absorptive capacity (Chen, 2004; Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Zahra & George, 2002). These sources include new ventures, licensing arrangements, sourcing agreements, research associations, and government-sponsored, joint research programs for technical and scientific interchange, as well as informal networks (Ahuja & Lampert, 2001; Allen, 1977; Burt, 1992; Freeman, 1991; Hargadon & Sutton, 1997, 2000). Such networks are especially important in high-technology sectors where it is unlikely that an individual firm will possess all the capabilities necessary to develop a significant innovation (Hagedoorn, 2002). Additionally, technology spillovers, which are defined as a positive externality from R&D resulting from the spread of knowledge across organization and regional boundaries (Cohen & Levinthal, 1990; Schilling, 2006), also provide ideas for innovation. Technology spillovers not only have a significant influence on innovation activities (Henderson, Jaffe & Trajtenberg, 1998; Jaffe, 1986; Jaffe, Trajtenberg & Henderson, 1993), they also increase a firm's absorptive capacity (Cohen & Levinthal, 1990).

Strategies to Manage Sources of Ideas: Deliberate and Emergent

Strategy has been distinguished as deliberate and emergent (Bodwell & Chermack, 2009; Fuller-Love & Cooper, 2000; Mintzberg, 1978; Mintzberg, Ahlstrand & Lampel, 1998; Mintzberg & Waters, 1985). While deliberate strategies tend to emphasize central direction and hierarchy, emergent ones open the way for collective action and convergent behavior (Bodwell & Chermack, 2009; Mintzberg & Waters, 1985). Deliberate strategy is the specification of intended actions the firm plans to take to achieve its goals, whereas emergent strategy happens when companies engage in actions that evolve unplanned from past patterns or newly recognized patterns in the business environment (Bodwell & Chermack, 2009). Few strategies are purely deliberate or

purely emergent (Mintzberg et al., 1998). One means no learning, the other means no control. As Mintzberg et al. (1998) argued, all real-world strategies need to mix these in some way, which means exercising control while fostering learning. That means being willing to use (or combine) ideas from R&D (deliberate) along with those that arise from other sources of organizational creativity (emergent), or those from collaborations (deliberate), along with those from networks and spillovers (emergent). Thus,

> *Proposition 1: Firms that have processes in place for monitoring both internal and external sources and deliberate and emergent sources of ideas for innovation will capture more ideas than those that rely on single sources.*

Viability

The viability and potential of an innovation for development and commercialization is determined through a series of legal searches and business decisions. A legal search is required to determine whether or not the innovation infringes upon existing patents and if so, whether or not those patents can be challenged. The business part of the process is a series of decisions ranging from the tactical, such as whether to kill an innovation project or support it, to the strategic, with the latter depending on assessments of the potential market, barriers to entry into that market, fit with existing products and service platforms, trends in the industry, externalities and installed base, and the availability of complements. These issues are well described by Schilling (1998) and do not need further discussion here. Instead, we simply assume that the strategy of commercialization is viable and that the firm can profit in one way or another from that commercialization.

It was Schumpeter (1934) who originally noted that because innovations can be protected from imitation, they can provide superior returns. Those superior returns generally are considered in terms of economic rents (Schumpeter, 1934). They can occur in the form of monopoly rents, which arise from barriers to competition and barriers to entry that prohibit existing and potential competitors from satisfying excess demand. They can occur in the form of Ricardian rents, which arise from owning scarce resources that permit development of the innovation. They can also occur in the form of entrepreneurial rents, which are received by bringing to market a new product or service. The latter are naturally self-destructive because, with patenting or bringing to market a new product or service, the underlying knowledge is revealed (Mahoney & Pandian, 1992).

Instead of earning rents from commercialization, there may be private benefits from bringing an innovation to market, such as when it is a complementary product or service that supports other existing activities. Thus, an innovation may be commercialized even if it loses money, as long as the combined public and private returns are positive. Any discussion of rents implies supernormal profits, but it long has been argued that all that is needed to induce an entrepreneur to bring an innovation to market is the guarantee of an irreducible minimum amount of profit (Marshall, 1967), such as that which can be found be investing in zero-risk government securities. Extending that thinking to managers in firms,

Proposition 2: In the absence of the potential for economic rents or private benefits, firms will still be willing to commercialize innovations that have positive but low levels of return.

Governance

Governance deals with the form of structure required for commercialization. Essentially, it is a choice among three options: ownership of the technology with its development and commercialization being in-house, commercializing the innovation with others either through an alliance or via licensing, or selling it for others to commercialize. Usually, commercialization is thought of in terms of the first two forms, but electing to sell an innovation also allows the firm to secure a return and arguably is also a form of commercialization. The choice of which form to adopt is governed by: (a) the amount of profit available from commercialization, and (b) the distance between a firm's existing capabilities and those required for it to be able to commercialize the innovation. In the following discussion, we build on Teece's (1986) contention that regimes of appropriability must be in place and on the thesis that economic gain rests critically upon a firm's ability to create and transfer technology more quickly than it is imitated in the market.

When the returns from an innovation are high and the firm already has the requisite capabilities to build the assets that are required for commercialization then, logically, development will be through hierarchy (in-house). If the capabilities are not available internally, then sourcing them externally will reduce the firm's ability to earn rents from the innovation because suppliers of those resources will bid up prices, or they may turn into potential competitors. An alternative is to develop the capabilities internally. That requires an assessment of the effects on the current stock of knowledge and capabilities (Kogut & Zander, 1992, 1996) because long-term strategies of building new capabilities can require a tradeoff between current and future profitability. Such a choice is viable only when the firm's survival is not at stake and it has the necessary short-term cash flows to undertake learning initiatives and bear the associated risks (Decarolis & Deeds, 1999; Kogut & Zander, 1992, 1996). Conversely, too much reliance on exploiting current profitability may deter a firm from developing capabilities for the future (Kogut & Zander, 1992; Stiglitz, 1987). The decision of maintaining and developing some capabilities over others is influenced by the current knowledge of the firm and expectations from economic gain by exploring newer technologies and organizing principles into future market developments (Kogut & Zander, 1992). Thus, the promise of economic rents is usually sufficient to convince firms that developing new capabilities is a worthwhile activity (Decarolis & Deeds, 1999; Kogut & Zander, 1992, 1996). The most significant determinant of 'make' or 'buy' and 'within firm' or 'with suppliers' has been found to be the transaction costs associated with relying on outside suppliers (Kogut & Zander, 1992; Monteverde & Teece, 1982; Walker & Weber, 1984). It has been shown that volume and technological uncertainties, and the production capability of the buyer, reduce the advantage of buy over make, while supplier production cost advantage, competitiveness of a supplier market, and the size of supplier market increases the advantage of 'buy' over 'make' (Walker & Weber, 1984). While boundaries of firms are

influenced by transaction costs (Williamson, 1981, 1991, 2000), performance relies mostly on owned capabilities (Kogut & Zander, 1992).

An innovation can be contracted, licensed, or developed with alliances when the firm does not have the necessary capabilities required to bring it to market, when there are uncertain cash flows, and when imitators and competitors are better positioned (Teece, 1986). Specifically, when an innovation has the potential to earn high returns, but the firm does not have the capabilities to develop the assets necessary for bringing the innovation to market, the available options are to develop the innovation with partners or license it out (Friedman, 2006). It also means that when the firm has the requisite capabilities to develop the assets that are critical for commercialization but the innovation only has the potential for low returns, commercialization via partnership is also preferable. Choosing between alliances for joint development or licensing depends upon several factors beyond profit potential and capabilities. For example, the short-term profitability needs of the firm and high investment costs (Kalaignanam, Shankar & Varadarajan, 2007; Makadok & Walker, 2000; Zahra, 1996), along with the existence of steep learning curves (Malerba, 1992), make a strong case for licensing. Additionally, licensing an innovation is an option when the licensor has superior, tacit knowledge that protects the ability to secure rents, when capabilities required for commercialization are beyond those possessed by the firm, or there is pressure for immediate survival. In the case of the lack of capabilities, if the innovating firm does not license its new technology, competitors may quickly develop their own, possibly better, versions of the technology. By licensing the technology, the innovating firm may ensure that its version of the technology becomes the dominant design in an industry advantage (Hill, 1992; Schilling, 1998; Schilling & Phelps, 2007). Advantages of partnerships include sharing costs and risks of development, combining complementary skills and resources (Ahuja, 2000b; Ahuja & Katila, 2001; Brass, Galaskiewicz & Greve, 2004; Freeman, 1991; Powell, Koput & Smith-Doerr, 1996; Provan, Fish & Sydow, 2007), enabling transfer of knowledge between firms (Cowan & Jonard, 2004; Freeman, 1991; Gulati, Nohria & Zaheer, 2000), and facilitation of creation of shared standards (Brass et al., 2004; Gulati, 1995, 1998; Gulati & Gargiulo, 1999; Powell et al., 1996; Provan et al., 2007). A clear example of these advantages is in the commercialization of Microsoft's Windows software. Developing complementary assets needed for commercialization of the software required sets of capabilities that were distant from what Microsoft possessed, but the partnership with Intel resulted in the emergence of the industry standard Wintel and a success for both firms.

Going back to the transaction-cost economics (Williamson, 1981, 1983, 1991, 1994, 1998), contracts with partners in developing an innovation may lead to a reduction of uncertainty at the cost of opportunism. Such behavior occurs when an innovation, albeit novel, has uncertain market potential, or requires capabilities beyond those of the firm. A governance structure that leads to reduction of uncertainty in this scenario is more important than a partner being opportunistic. Mutual gains from contracts and alliances will be a less risky form of governance than in-house development. Such was the case for Microsoft.

Lastly, when the potential to earn profits is low and the capabilities needed to develop assets required to commercialize the innovation are not available internally or

through partnerships, the most logical option is to sell the innovation to another firm. Given this low-returns scenario, this would be the least risky option. That, of course, assumes that the sale would not result in the buyer becoming a future competitor. Thus,

Proposition 3a: An innovation with low profit potential, combined with the lack of capabilities necessary for developing the assets required for commercialization, will result in selling the innovation.

Proposition 3b: Firms will mitigate the risk of commercialization via alliances or licensing when an innovation has low profit-potential even though the capabilities for commercialization are present, or when the innovation has high profit-potential but the capabilities are not present.

Proposition 3c: An innovation with high profit potential, combined with the capabilities necessary for developing the assets required for commercialization, will result in retained ownership of the innovation and in-house commercialization.

The base line model along with the moderators was depicted in Figure 1.

Moderators

The effect of the moderators on Proposition 3 is depicted in Figure 2 and Figure 3.

Figure 2: *Model of Factors Affecting Governance of Innovation Commercialization*

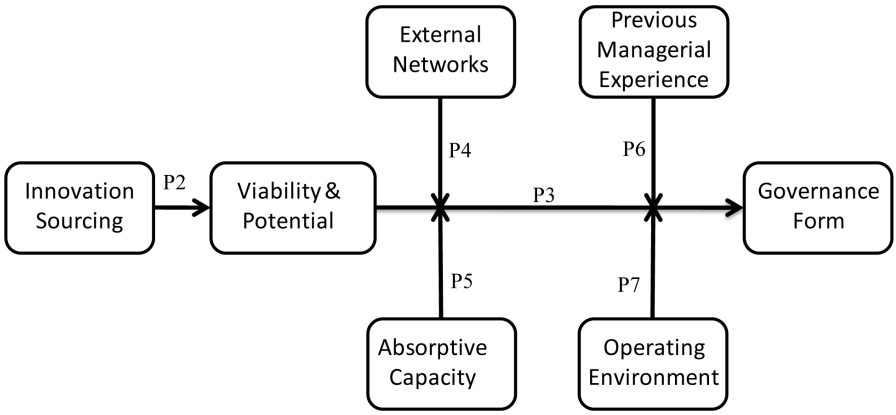
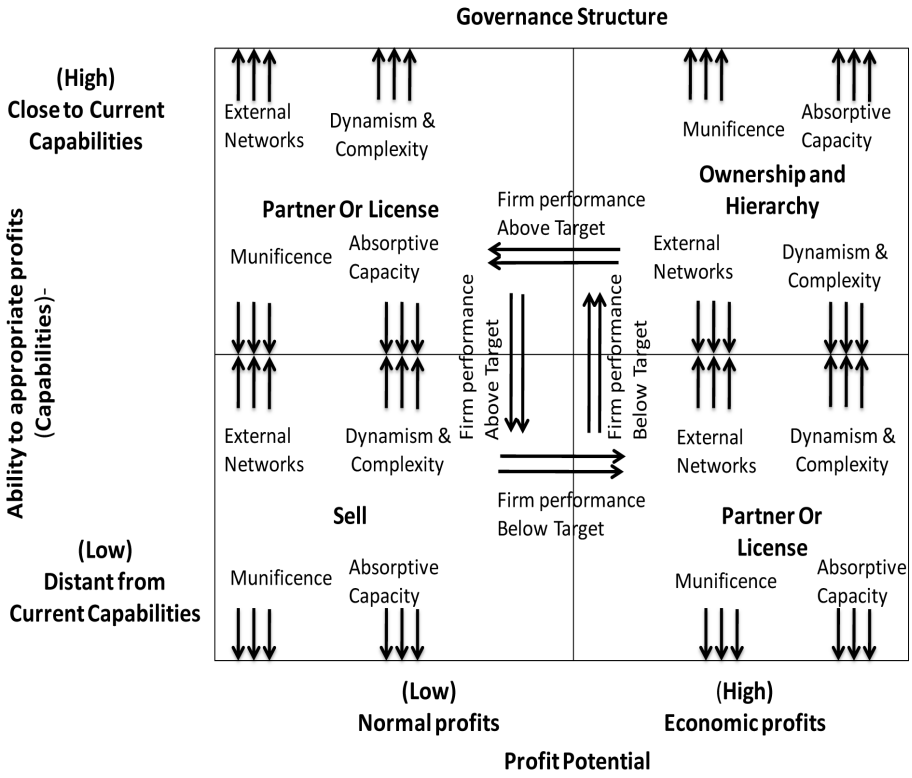


Figure 3: *Effect of moderators on Governance*



Firm-level Moderators

Networks. Social, external, and internal networks are considered three different network types that focus on different levels of analysis, use different theoretical constructs, and explain different outcomes (Van Wijk, 2003). For the purpose of discussion, networks external to the firm and those which extend its boundaries will be the focus. External network research focuses on networks as a governance mode intermediating markets and hierarchies—e.g., joint-ventures and strategic alliances. It highlights the competitive dimension of networks and, therefore, focuses particularly on performance issues (Dyer & Singh, 1998). The terms 'external' or 'interorganizational' network are used interchangeably with strategic alliances, coalitions, and cooperative arrangements (Provan et al., 2007), and have been tied to resource dependence theory (Pfeffer & Salancik, 1978), transaction cost economics (Williamson, 1991), and interorganizational contracts (Ariño & Reuer, 2006). Despite these differences, all definitions of external networks refer to common themes including social interaction, relationships, connectedness, collaboration, collective action, trust, and cooperation (Provan et al., 2007).

Organizations enter alliances with each other to access critical resources,

knowledge, and capabilities, but they rely on information from the network of prior alliances to determine with whom to cooperate (Gulati & Gargiulo, 1999). These new alliances modify the existing network, prompting an endogenous dynamic between organizational action and network structure that drives the emergence of external networks. While networks are formed to access and share resources (Dyer & Singh, 1998; Gnyawali, He & Madhvan, 2006; Gulati, 1998; Gulati & Kletter, 2005; Gulati et al., 2000; Klein, Rai & Straub, 2007b; Pfeffer & Salancik, 1978), they themselves become valuable resources, enabling a firm to access and possibly increase its stock of knowledge and capabilities beyond its boundaries (Barney, 1991; Mata, Fuerst & Barney, 1995; Melville, Kraemer & Gurbaxani, 2004; Porter, 1980; Ray, Muhanna & Barney, 2005). The characteristics of an organization's network of external relations are relevant to a firm's ability to commercialize innovations (Nohria, 1992; Nohria & Eccles, 1992). Networks can be defined as the collective of structures and collaborations between organizations. From an external-network standpoint, this includes social networks, business clusters, partnerships, business ecosystems, and relationships with innovation engines. To better understand the impact of networks on the commercialization process, the concepts of centrality and multiplexity in networks need to be considered.

Centrality determines the relative importance of an entity or a node within a network. While some organizations will struggle to reach the central position on any network to maintain competitive advantage and control key resources and capabilities, others may instead link themselves to the central node (Dyer & Singh, 1998; Gnyawali et al., 2006; Gulati, 1995, 1998; Gulati & Gargiulo, 1999; Gulati & Kletter, 2005; Gulati et al., 2000; Klein, Rai & Straub, 2007a). Being in a central position or having a direct link to the central node within an external network, firms are better able to access resources and capabilities, such as finance, manufacturing facilities, or distribution channels that help in the commercialization of innovations (Gnyawali et al., 2006; Klein et al., 2007a).

Multiplexity deals with the strength of the relationship an organization maintains with network partners, based on the number of types of links (e.g., research ties, joint programs, referrals, and shared personnel) connecting them (Provan et al., 2007). Multiplexity is also referred to as a heterogeneity of networks (Newman, 2001). Multiplex ties are thought to be an indicator of the strength and durability of an organization's links because they enable the connection between an organization and its linkage partner to be sustained even if one type of link dissolves (Provan et al., 2007). Two entities that have collaborated in multiple arrangements such as manufacturing and marketing or the exchange of unique information, are likely to know each other better, on average, than those that have had fewer such collaborations. These interactions add value to the network, enabling the exchange of knowledge and capabilities required to succeed in the commercialization of innovations.

External networks can also include ties with universities, national research laboratories, and other research institutes that conduct basic research and are regarded as engines of innovation (Agarwal, 2006; Chataway & Wield, 2000; Colyvas et al., 2002; Henderson & Cockburn, 1996; Henderson et al., 1998; Henderson & Clark, 1990; Jaffe et al., 1993; Numprasertchai & Igel, 2005). It constitutes a type

of multiplex tie that we mentioned earlier. Knowledge exchange between firms and innovation engines occurs through formal and informal mechanisms such as scientific meetings, licenses, joint ventures, research contracts, consulting, personal networks, research grants, recruitment of students, email, shared databases, workshops, and communities of practice (Cohen, Kamienski & Espino, 1998; Cohen et al., 1998; Cohen & Levinthal, 1990; Cohen, Nelson & Walsh, 2002; Hoegl & Schulze, 2005; Oliver, 2004; Powell, 1998; Rothaermel & Thursby, 2005; Salman & Saives, 2005; Van den Bosch, Volberda & Boer, 1999). Through contracted and funded research, both the innovator and the commercializer benefit and the innovation/commercialization cycle appears to crystallize faster and more effectively (Birkinshaw & Gibson, 2004). Such relationships help shorten the innovation cycle and promote faster commercialization, giving the innovator access to the firm's capabilities and also leading to the firm gaining knowledge about a new technology or innovation.

In our previous section on governance, it was already mentioned that advantages of partnerships include sharing costs and risks of development, combining complementary skills and resources, enabling transfer of knowledge between firms, and the creation of shared standards. Further, choosing between alliances for joint development or licensing depends upon several factors including profit potential and capabilities. The decision to collaborate with networks to bring an innovation to market is therefore multidimensional. The factors include: (a) whether the firm or the collaborator has the required capabilities, (b) the degree to which collaborations would make proprietary technologies vulnerable to expropriation by a potential competitor, (c) the importance a firm plays in controlling the development process for its innovations, and (d) the role of development projects in building the firm's own capabilities or permitting it to access another firm's capabilities (Ahuja, 2000a; Hagedoorn, 1993; Powell et al., 1996).

Centrality and multiplexity in external networks moderate the relationship between viability and governance by extending firm boundaries. Firstly, for innovations with low profit potential, networks facilitate easier disposition of the technology to potential buyers. Knowledge of network partners and their specific needs allows the disposing firm to more quickly find a customer for the technology. Additionally, that knowledge may lead to a better fit between the innovation and the customer's needs, which could, in turn, lead to increased funds from the sale. Networks thus have a positive effect on disposition as a form of governance. Secondly, and as discussed, networks aid in accessing capabilities that are essential for commercialization, such as those in manufacturing, or marketing and distribution. That access can come either in the form of licensing or alliances and as noted earlier, it depends upon the need to lock out competitors or to establish a dominant design. An additional potential benefit though is that by licensing or forming alliances to bring the innovation to market, firms that may have been natural competitors can effectively be removed from the equation.

When a firm has an innovation with high profit potential, plus the necessary capabilities for commercialization of the product, the concern is with protecting proprietary knowhow and controlling the development process to secure any available rents. Those requirements and that outcome are best achieved by keeping all activities in-house rather than working with partners. Networks, however, have a negative

impact on the selection of that form of governance. Firms centrally located in the networks will have access to resources from other firms and will therefore be more likely to develop innovations with partners. Being central in a network will enable the firm to have higher bargaining power which should not be compromised even when a critical capability required for commercialization is developed outside the firm boundary. Hence, centrality resists suppliers from becoming potential competitors so that firms can enjoy sourcing capabilities from other firms. Firms that are not central in the network will also tend to either license or codevelop innovations (with high profit potential) with partners, because being in the network will enable them to access critical resources, capabilities, and knowledge that would otherwise be expensive to develop. Overall, easier access to complementary resources offsets the advantages of in-house commercialization of innovations. Thus,

Proposition 4a: External network relationships have a positive moderating effect on decisions to sell an innovation.

Proposition 4b: External network relationships have a positive moderating effect on decisions to license or develop an innovation with partners.

Proposition 4c: External network relationships have a negative moderating effect on decisions to use in-house commercialization.

Absorptive capacity. According to Cohen and Levinthal (1990) and Jansen, Vanden Bosch and Volberda (2005), absorptive capacity is the limit to the quantity and rate at which a firm can absorb scientific or technological information. Conceptually, absorptive capacity is similar to information-processing capacity but at the firm level rather than at the individual level. Absorptive capacity enables firms to predict the commercial potential of technological advances more accurately (Cohen & Levinthal, 1990). It is inherent within a firm's knowledge capabilities by which it acquires, assimilates, transforms, and exploits knowledge resources to produce capabilities such as innovativeness (Zahra & George, 2002), and a firm's investment in prior experience can increase its rate of future learning by building its absorptive capacity (Cohen & Levinthal, 1990; Zahra & George, 2002).

Zahra and George (2002) deconstructed absorptive capacity into potential and realized absorptive capacities. *Potential absorptive capacity,* which includes knowledge acquisition and assimilation, captures efforts expended in identifying and acquiring new external knowledge and in assimilating knowledge obtained from external sources (Zahra & George, 2002). *Realized absorptive capacity,* which includes knowledge transformation and exploitation, encompasses deriving new insights and consequences from the combination of existing and newly acquired knowledge, and incorporating transformed knowledge into operations (Zahra & George, 2002). Realized absorptive capacity converts knowledge into products, services, and technologies (Jansen et al., 2005). Through the combination of potential and realized absorptive capacity, firms increase the distinctiveness of their innovations (Yli-Renko, Autio & Sapienza, 2001) and are able to develop new innovations that differ substantially from existing

products, services, and processes and, all else being equal, should have the potential for generating higher income. In turn, that means that absorptive capacity should therefore have a positive moderating effect on in-house commercialization and a negative effect on the other forms of governance.

In addition to absorbing and capitalizing on external scientific and technological information, absorptive capacity also means being able to identify and build on internally generated information. In other words, learning from and capitalizing on prior experience, which in turn, shapes the ability to recognize the value of new information and use it effectively. A firm's experimentation with innovations increases its knowledge and experience with the technology, and also its understanding of market potential, which leads to better gauging of the profit potential of innovations. Additionally, it helps in developing new innovations, which can help firms stay ahead of competitors. In resource-based theory terms, previous experience is a valuable and difficult-to-imitate resource that provides firms with an advantage. Firms that don't build on such experience effectively are starting anew with the process of bringing each new innovation to market and thus, they are at the bottom of the learning curve and unable to capitalize on cost-reducing, experience-curve effects. Further, prior experience will lead firms to identify complementary innovations that will add value to the innovation to make it more attractive. Thus, absorptive capacity has a positive moderating effect on the relationship between viability and governance leading to ownership of innovations,

Proposition 5a: Absorptive capacity has a negative moderating effect on decisions to sell an innovation.

Proposition 5b: Absorptive capacity has a negative moderating effect on decisions to license or develop an innovation with partners.

Proposition 5c: Absorptive capacity has a positive moderating effect on decisions to use in-house commercialization.

Micro- and Macro-level Factors

Thus far, our arguments have focused on the role of the firm and firm-level factors in innovation commercialization. As such it is a meso-level model. There are, however, factors at both the micro and macro levels that affect success in commercialization and thus need addressing.

Micro level. At the micro level, the previous experience of managers in bringing an innovation to market will affect their actions with subsequent commercializations. Prospect theory, which explains decision making involving uncertainty in the context of psychology and economics (Kahneman & Tversky, 1979), provides a useful means of assessing the effect of this micro-level variable on the selection of form of governance for commercialization. The theory offers insights into why managers make non-optimizing decisions rather than strictly choosing those that are profit maximizing. The most distinctive implication of the theory is the effect that previous performance has on managerial attitudes towards risk. If previous firm performance is acceptable,

then managers will avoid risk-laden situations, even if the associated returns are high. However, if previous firm performance is below target, they will be more likely to accept more risk for higher returns. That relationship, however, is moderated by the framing that previous experience provides. If managers have been successful with such actions in the past, their assessment of the probability of failure will be artificially low. If they have failed in the past, it will be artificially high. Holding previous firm-performance constant, successful previous experience with a hierarchy solution to commercialization would again push them towards hierarchy. Similarly, if in the past a firm did not have the necessary capabilities to commercialize a product, but managers successfully developed them, they would be more likely to underestimate the risk of doing so again. A poor experience would push them away from hierarchy. The same logic applies to previous experiences with selling an innovation or partnering to bring it to market.

Obviously, Prospect theory is temporal in nature, whether previous performance has met target performance or not, and what managers do today is affected by what has happened in the past. Thus,

Proposition 6a: If firm performance is below target, then the probability of selling is reduced in favor of partnering or hierarchy, and the probability of partnering is reduced in favor of hierarchy.

Proposition 6b: If firm performance is above target, then the probability of hierarchy is reduced in favor of partnering (unless that form of governance has been successful in the past), and the probability of partnering is reduced in favor of selling (unless that form of governance has been successful in the past).

Macro level. For the macro-level, the established environmental constructs of dynamism, munificence, and complexity is drawn on. Environmental dynamism results in uncertainty and unpredictability in the external environment (Child, 1972; Dess & Beard, 1984). Firms faced with more stable environments tend to emphasize static efficiency at the expense of dynamic efficiency, and this process is reversed when firms find themselves in unstable environments (Ghemawat & Costa, 1993). In other words, a firm tends to be inward-looking during stable times and outward-looking during disruptions. In highly dynamic environments, there is rapid and discontinuous change in demand, competitors, technology, and regulations. As a result, information is often inaccurate, unavailable, or obsolete (Eisenhardt & Bourgeois, 1988; Simsek, 2009). Therefore, dynamic environments require that the organization develops adaptive responses quickly and expands the scope of information acquisition and gathering (Sidhu, Volberda & Commandeur, 2004; Simsek, 2009). In doing so, dynamism imposes a challenge to the organization by demanding flexibility and agile actions ranging from information scanning, selection, and processing to interpretation (Miller & Friesen, 1983; Simsek, 2009), and that strains an organization's information-processing capability (Simsek, 2009). Such problems can cripple an organization's ability to correctly assess the profit potential of an innovation. Therefore, environmental dynamism has a negative moderating effect on the relationship between viability and

governance such that there is a reduced tendency to use an in-house approach to commercialization. The corollary to that is that dynamism will positively affect the relationship between viability and governance that leads to selling an innovation and licensing or developing it with partnerships. Even if the firm currently posseses what it considers to be the capabilities required for successful commercialization, a dynamic environment may make them useless or irrelevant in the future. Thus, licensing or development with partners remains the lower-risk option. All else being equal, such as prospect theory considerations, then managers will likely choose to avoid, rather than incur risk.

An environment is said to be munificent to the extent that it supports a firm's continued and sustained growth, and thus refers to the extent to which critical resources exist in the environment (Dess & Beard, 1984). The degree of resource abundance in the firm's environment (i.e., munificence) has a significant impact on the firm's entrepreneurial orientation and subsequent growth (Castrogiovanni, 1991), as well as its ability to overcome capability weaknesses (Sirmon et al., 2010). Thus, in a munificent environment, a firm is more likely to take ownership of a venture (Tyebjee & Bruno, 1984). When the environment is munificent, that is, there are resources for growth, demand is present and the profit potential is high, not being able to own the technology and develop it in-house sacrifices income. When the environment offers opportunities and resources for growth, developing capabilities that may be distant from its current ones, but which are required for commercialization, becomes a more attractive option than in an environment that does not offer the same income opportunities. Thus, munificence has a positive moderating effect on the relationship between viability and governance leading to ownership, whereas the relationship leading to licensing or development with partnership or selling the innovation is affected negatively.

Environmental complexity is defined as the heterogeneity and concentration of environmental elements (Dess & Beard, 1984). A highly-complex environment is characterized by the level of heterogeneity of firms within the industry, a diverse range and high number of suppliers and customers, and a wide range of products being offered (Dess & Beard, 1984). A complex environment will be perceived as requiring more information processing than a simple environment and thus be less predictable (Dess & Beard, 1984; Simsek, 2009). Complex environments do not diminish an organization's ability to act, but make it difficult to identify what is most appropriate (Boisot & Child, 1999). Under this scenario, reduction of uncertainty becomes an important criterion, and that can be achieved either by licensing the innovation or developing it with partners. Similarly, the uncertainty created by complexity also will likely result in more selling of innovations. Thus, complexity has a positive moderating effect on the relationships between viability and governance leading to selling the innovation, licensing the innovation or developing with partners, and a negative moderating effect on in-house commercialization. Therefore,

Proposition 7a. Environmental dynamism has a negative moderating effect on the relationship between viability and governance leading to hierarchy, but a positive effect on partnering or selling the innovation.

Proposition 7b. Environmental munificence has a positive moderating effect on the relationship between viability and governance leading to hierarchy, but a negative effect on partnering or selling the innovation.

Proposition 7c. Environmental complexity has a negative moderating effect on the relationship between viability and governance leading to hierarchy, but a positive effect on partnering or selling the innovation.

Discussion

Commercialization of innovation is a critical entrepreneurial activity that leads to economic growth, but is not yet fully understood. A model has been constructed that explains how firms go from idea generation to innovation commercialization. When an idea emerges, then its viability has to be assessed before the process moves on to commercialization. This baseline framework constitutes a mid-level process model. Underpinning the core of the model is the argument that success in commercialization is derived from selecting the governance form that allows the firm to secure returns from an innovation while mitigating unnecessary risk. That is achieved by retaining ownership of the technology, licensing it to or developing it with partners, or selling it. Which of the three forms of governance should be selected is determined by the profit potential of the innovation and the current capabilities of the firm. Profit potential is part of the determination of the viability of an innovation and rests on the assumption that the technological and legal mechanisms that govern innovators' ability to earn rents from innovation are in place (Teece, 1986). An innovation is sold before developing it into a finished good when the profit potential from the innovation is low and ownership of or access to capabilities that are required for commercialization are distant. If one of the two main conditions of profit potential or capabilities is in place, the innovation is either licensed or developed with partners. If, however, the profit potential is high and the firm has the capabilities required to develop the innovation and take it to market, the firm will retain ownership of the innovation and governance will be hierarchical.

Four moderators were identified that affect the strength of the relationship between viability and governance. First of those moderators was external networks, which had a negative effect on the likelihood of a firm commercializing the innovation in-house, and a positive effect on selling the innovation or licensing or developing with partners. Absorptive capacity, our second moderator, had a positive effect on the relationship between viability and governance leading to in-house commercialization, and a negative effect on selling the innovation or licensing or developing with partners. At this point, the meso-level analysis was deviated from and included both micro and macro factors. The previous experience of managers in bringing innovations to market was our third moderator—a micro factor. Prospect theory was used to argue that if firm performance is above target, the probability of hierarchy is reduced in favor of partnering or selling, particularly if those forms of governance have been used successfully in the past. If firm performance is below target, then the probability of selling was reduced in favor of partnering or hierarchy, and the probability of partnering was reduced in favor of

hierarchy. The final moderators were at the macro level: environmental dynamism, munificence, and complexity. They have mixed effects on the relationship between viability and governance. Dynamism and complexity had a negative effect on the relationship between viability and governance leading to hierarchy and a positive effect on the on selling the innovation or licensing or developing with partners. Munificence, however, had a positive effect on the likelihood of a firm using hierarchy, and a negative effect on the use of licensing or developing with partners.

This work has made contributions to both theory and practice. For research, the framework recognized that successful commercialization is a process that has distinct stages and is as dependent on moderators to the process as it is on the direct effects. The paper offered insights into idea generation—interactions between source and type—that need exploring in more detail to determine under what conditions the output from those interactions is maximized, both in terms of quantity and quality. It also introduced the concept of viability assessment into the process of commercialization—something that is most notable by its absence from the theoretical literature on innovation management. A direct link between governance and success was also made, recognizing that not all innovations have to be developed in-house or with partners—they also can be sold, an outcome that is still commercialization. Addressing these questions should further our understanding in terms of what forms of governance should maximize returns from innovation. This work recognized that successful commercialization is a complex, multi-level process that requires input from extant theories as diverse as those explaining governance, networks, absorptive capacity, managerial behavior, and environmental factors. It opens up the potential for extending empirical research on commercialization. Additionally, the assumptions on which the model is based need to be empirically tested for validity. Before these or any other lessons can be acted upon with confidence, much research remains to be done. Surveys or secondary data sets can be used to conduct positivist research in order to test the propositions, while detailed case studies of firms in specific industries under given circumstances may aid in attaining an interpretivist understanding of commercialization of innovation that is deeper, richer, and more detailed.

In terms of practice, the baseline model revealed an interaction between internal and external sources of ideas for innovation, and whether or not they were deliberate or emergent. To be effective, those interactions need managing. Second, a careful assessment of the profit potential, vis-à-vis the firm's capabilities, helped force a separation between commitment to the newly developed technology and the ability to make money from it. Third, the model highlights the need for a firm to consider its network of partners and their capabilities before plunging into a decision. This permits risk reduction, it prevents a firm from disposing of a technology that could be developed with partners, it allows the firm to find better capabilities than those it possesses, and it allows the firm to hand-off development and commercialization, which then frees up time and resources for bringing other innovations to market. Fourth, it showed that firms need to question the effects of previous experiences on commercialization of innovations. For instance, if managers have been successful with such actions in the past, their assessment of the probability of failure will be artificially low. Lastly, an understanding of the macro-level environmental factors of dynamism,

munificence, and complexity is crucial in determining whether an innovation is best kept in-house, developed with partners, or simply disposed of.

All projects have certain inherent limitations. In this work, it was implicitly held constant the impact of networks within the firm as a potential moderator between viability and governance. Further, the paper did not discuss how the variables in the baseline model and the four moderators interact with each other. In determining the effects of each moderator, we implicitly held the other constructs constant. Future research extensions could be made on understanding the impact of these moderators, and internal networks, as a gestalt. Within that gestalt there also will be a feedback loop from commercialization to idea generation within innovation sourcing, an issue that was intentionally left beyond the scope of our discussions.

Some firms are good at innovation, but the fact remains that firms live and die by their ability to successfully bring innovations to market. This work has provided a theoretical model to address the question of what drives success in that process. While the thinking in this work is of relevance to practice, we have generated a model that should act as a catalyst for scholars to extend existing research on the commercialization process, and thus create an even deeper understanding of this crucial business activity.

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