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Inbound open innovation for enhanced performance: Enablers and opportunities

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ABSTRACT

Open innovation, defined as a firm's purposive pursuit and integration of external inputs for new product development, offers an alternative perspective on innovation. Drawing on resource-based and capability theories, this study identifies key factors that enable inbound open innovation and increase its efficacy in a business-to-business context. Because open innovation relies on external connections, relational capability—that is, the firm's ability to make and manage relationships with other firms—should enhance the effects of inbound open innovation on firm performance. Two key resources may further enhance the moderating effects of relational capability: network spillovers that indicate knowledge-rich surroundings, and flexibility that allows for responsiveness and adaptability. The authors test these relationships with data from managers in 204 business-to-business high-tech firms, as well as secondary data pertaining to firm performance and flexibility. The results support the expectations that the ability to build interfirm relationships in a knowledge-rich environment increase the efficacy of inbound open innovation for gaining superior financial performance. Interestingly, additional analyses suggest an unexpected nonlinear interaction effect with flexibility. When firms possess strong relational capabilities and adopt an open innovation approach, they achieve higher financial performance if they have a low or a high level of flexibility. The theoretical and managerial implications of these findings are discussed.

1. Introduction

Innovation underpins the process of bringing novel products and services to market and is critical to a firm's viability and performance (e.g., Hauser, Tellis, & Griffin, 2006). This is especially true in high tech business markets where pressures to innovate dominate the competitive culture. Although, the ability to innovate no doubt will remain critical, the approach that firms take to innovation is evolving. For example, industrial titans such as IBM, Motorola, and Xerox tend to invest heavily in research and development to develop new products, while others such as Intel, Microsoft, Cisco, and Nokia conduct little basic research yet consistently turn out products that contain cutting edge innovation (Chesbrough, 2003). Likewise, ESRI, the world leader in geographic information systems, integrates technologies from a variety of sources to deliver solutions for customers such as Nike, PETCO, and FedEx. ESRI, Intel, Microsoft, Cisco, Nokia, and a host of many others have come to realize the merits of what is known as open innovation where inputs (e.g., ideas, knowledge, intellectual property, technologies) for innovation are sought and acquired from sources external to the firm and then integrated into the firm's existing new product development programs.

The process of leveraging external sources to support new product development (NPD), which Procter & Gamble calls its Connect and Develop strategy, implies an open innovation approach. Open innovation generally consists of two key elements (Chesbrough & Crowther, 2006): the outbound element refers to a firm taking its technologies to market through nontraditional forms, such as spinning off startups or licensing. In this research, we focus specifically on the inbound open innovation element which involves the acquisition and leveraging of external inputs for new product development, that is, the systematic practice of integrating external inputs into a firm's extant new product technologies. For simplicity, we refer to inbound open innovation as “open innovation” in the remainder of this manuscript.

The success of Genentech, Intel, Microsoft, Oracle, and others hints at the potential advantages of open innovation in a business market (Chesbrough, 2003). Open innovation may indeed be particularly suited to accommodate the demanding competitive landscape in high tech business markets; however, little is understood about it. For example, despite its appeal and promise, there is little or no systematic evidence that open innovation has any impact, positive or negative, on firm performance. Importantly, there is a particular dearth of evidence for business-to-business firms as the limited existing anecdotal evidence often relates to consumer firms such as Procter & Gamble (Huston & Sakkab, 2006). Does open innovation lead to performance gains? Losses in business markets? Further, among the success stories, reports of

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assimilation difficulties and failures have also begun to emerge (e.g., Chesbrough, 2006), indicating that open innovation may not be a cure-all (e.g., Faems, de Visser, Andries, & Van Looy, 2010). Importantly, these reports also point to the existence of important firm and context factors that impact whether or not open innovation can garner performance gains for a firm. How do firm and context characteristics work to enable and facilitate gains from open innovation?

Drawing on capabilities theory (e.g., Eisenhardt & Martin, 2000; Molina-Castillo, Jimenez-Jimenez, & Munuera-Aleman, 2011), strategy theory (e.g., Lorenzoni & Lipparini, 1999; Porter, 1980), and the resource-based view (e.g., Barney, 1991; Wernerfelt, 1984), we aim to explore these questions. Because open innovation depends on external connections, we argue that relational capability, or the firm's ability to make and manage relationships with other organizations (e.g., Dyer & Singh, 1998; Johnson, Sohi, & Grewal, 2004; Lorenzoni & Lipparini, 1999), substantially enhances the potential performance gains attained through open innovation. In particular, we posit that because relational capability gives the firm greater access to its surroundings, and thus provides a viable and effective mechanism to enact open innovation, it enhances the impact on performance.

Other key factors, both external and internal to the firm, also should interact with relational capability to affect the performance gains from open innovation. First, a critical external firm factor is the industry context (e.g., McGahan & Porter, 1997) because some industries provide relatively more ample opportunities for competitive advantage. Such industries are characterized in part by knowledge richness (e.g., Porter, 1980) which manifests largely as network spillovers (Meagher & Rogers, 2004). Network spillovers involve the leakage or transmission of knowledge from firms such that it can be accessed by other firms in the network. We reason that relating to others outside the firm (i.e., relational capability) amplifies the performance outcomes of open innovation even further in the presence of abundant network spillovers. These spillovers involve a flow of and accessibility to information, knowledge, and technology in the firm's industry network (Owen-Smith & Powell, 2004; Wiewel & Hunter, 1985), so they offer an opportunity for the firm's relational capabilities to enact open innovation.

Second, we investigate flexibility as a critical factor in the firm. Flexibility, particularly in the form of resource slack, engenders agility and responsiveness (George, 2005; Lee & Grewal, 2004). The performance benefits attained through a relational capability should increase further with a flexible resource base that allows for responsiveness and adaptability. In essence, resource slack provides an opportunity for relational capability to actualize open innovation, leading to further performance enhancements. We depict these relationships in Fig. 1.

Extant research acknowledges the importance of networks (e.g., Rampersad, Quester, & Troshani, 2010; Story, O'Malley, & Hart, 2011) and inter-firm relationships (e.g., Perks, 2000; Sivadas & Dwyer, 2000; Wong, Tjosvold, & Zhang, 2005) in innovation. However, open innovation encompasses more. It is an overall approach to innovation; some have even argued that it is a business model (Chesbrough, 2003). Based on the largely anecdotal extant research, we have some general understanding of the concept, yet little systematic research exists on open innovation's role in business markets. Thus, based on both the extant literature and in-depth field interviews with executives, we offer a treatment of open innovation that is consistent with its broader foundations and we provide a systematic empirical investigation that advances our understanding of its role for firms competing in business markets.

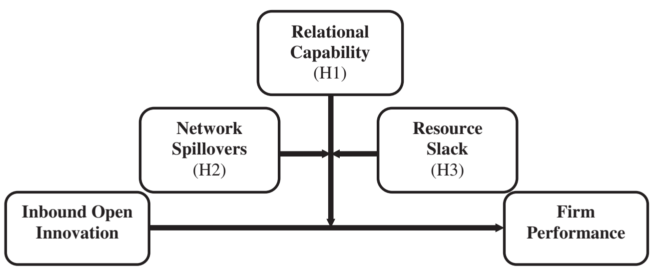

Fig. 1. Moderation of the inbound open innovation–firm performance link.

In the next section, we offer a conceptualization of open innovation and its performance implications, followed by an articulation of the key contextual factors that might enable performance gains from open innovation. Based on our discussion of the resources and capabilities that facilitate and enable open innovation performance gains, we specify several hypotheses. We then perform a series of field interviews, and test our hypotheses on a multi-industry sample of 204 firms in high tech business markets that includes survey and secondary data. The results suggest that firms must be able to connect and gain access to a knowledge-rich context or flexible resource base to benefit from open innovation. We conclude with a discussion of the results, implications, and directions for further research into open innovation.

2. Theory and hypotheses

2.1. Conceptualizing open innovation

With open innovation, firms use internal and external paths to market as they advance their technologies (Chesbrough, 2003). It involves the purposive use of inflows and outflows of knowledge to accelerate innovation and expand markets for it (Chesbrough, 2006). Here, we focus specifically on inbound open innovation, or the integration of external inputs into the firm's NPD (Chesbrough & Crowther, 2006) because it tends to focus on the firm's core new product technologies (Chesbrough & Garman, 2009). Given that the strategy literature points to new products as central to a firm's viability and sustainable advantage (e.g., Calantone, Cavusgil, & Zhao, 2002; Leonard-Barton, 1995; Tellis, 2008), this inbound aspect of open innovation is particularly important.

Strategy theory (e.g., Liebeskind, 1996) and resource-based views (e.g., Barney, 1991; King & Zeithaml, 2001) also point to the hazards of knowledge loss and the advantage of inimitable resources suggesting fairly compelling logic for safeguarding intellectual property (IP) and the knowledge that is key to the firm's core technologies. Thus, the tendency and preference to keep NPD technology safely contained within firm boundaries is understandable. Regardless of this logic, the search for external inputs for NPD has become increasingly common, as has the acknowledgement of its effectiveness for NPD (e.g., Gassmann, Enkel, & Chesbrough, 2010; Laursen & Salter, 2006; Perks, 2000; Story et al., 2011). However, most analyses in prior literature involve discrete external inputs, integrated for specific projects or specific technologies (e.g., Narasimhan, Rajiv, & Dutta, 2006). In contrast, the notion of open innovation extends beyond this specificity and involves the use and integration of external inputs as a deliberate and systematic approach to NPD (Chesbrough, 2003, 2006).

Open innovation is the sustained and systematic practice of engaging in the search for and then integrating new product inputs from sources that cross firm boundaries and, often, technology boundaries. This explicit and purposive approach to NPD contrasts with an incidental or occasional use of external knowledge; in essence, it implies a pervasive, persistent, firm-level orientation toward NPD. Because it involves a deliberate programmatic approach, underpinned by complex routines (Nelson & Winter, 1982) that have been built to seek, access, combine, and deploy external sources of ideas, knowledge, and technologies, we characterize open innovation as a dynamic capability (e.g., Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997).

Open innovation can result in substantial gains for a firm for several reasons. First, open innovation casts a wider net for the generation of IP and the development of new products, so it allows for quicker, more sustained NPD possibly with more substantive new product advances. Because open innovation increases the options for NPD inputs, it also boosts innovation and serves as an opportunity to learn and further advance the evolution of effective new product processes (e.g., Calantone et al., 2002; Narasimhan et al., 2006). As the firm imports various inputs, IP, and ideas identified through its external search, its development cycles become more compressed, it resolves problems sooner and more effectively, and it can bypass early NPD steps to reach the implementation phase more quickly. These factors should translate to superior economic rewards for the firm.

Second, greater efficiency and cost benefits should arise when a firm combines extant IP and new product resources with inputs gathered from an external search (e.g., Dittrich & Duysters, 2007). This combination boosts the power and efficacy of the firm's new product resource bases, which diminishes or perhaps even eliminates the need to maintain large, costly internal R&D programs to generate new products (Chesbrough, 2003). In addition, open innovation encourages more efficient uses of underutilized resources, thus improving performance. As Cisco's success shows (e.g., Chesbrough, 2003), firms that adopt open innovation can improve their financial performance through the efficient use of firm resources and decreased R&D activity.

Although open innovation can provide these efficiency and cost benefits, it is not a panacea and in fact has some fairly serious downsides, introducing a number of problems for a firm that constitute real disadvantage. First, open innovation can introduce potential for knowledge leakage (e.g., Harmancioglu, 2009). As more players become involved in a firm's innovation processes, technologies and proprietary knowledge becomes more exposed to more outsiders, introducing knowledge appropriation risk (Lee & Johnson, 2010) for key strategically central resources (e.g., Barney, 1991). Second, when a firm comes to rely more on external search and inputs, its search and partnering costs also may increase (e.g., Faems et al., 2010). Investments in search for partners, management of increasing numbers of partner relationships, and the building of a common ground to aid in knowledge transfer (e.g., Tortoriello & Krackhardt, 2010; Wong et al., 2005), all increase partnering costs. Third, a firm's ability to garner performance advantages from its technologies may be inhibited by open innovation because of external players (other firms) involvement. Some research (e.g., Almirall & Casadesus-Masanell, 2010) suggests that the introduction of external players devolves firm control over technology trajectories such that gains from the technologies never materialize. Finally, open innovation may weaken the firm's internal R&D capabilities (Almirall & Casadesus-Masanell, 2010). If the focus is on external inputs, the firm's own R&D capabilities can languish and deteriorate.

Despite these potential hazards, we argue that in the right conditions, open innovation should provide substantial advantage and result in superior firm performance. While firm performance is conceived of from various perspectives in the literature ranging from managerial assessments of market positions (Calantone et al., 2002) or relative market positions (Chen, Lin, & Chang, 2009) to financial performance in terms of ROI, ROA, etc. (Krasnikov, Mishra, & Orozco, 2009; Narayanan, Desiraju, & Chintagunta, 2004), here we assess firm performance as Tobin's q. Tobin's q, the ratio of a firm's market value to replacement cost of its assets, captures increases in a firm's market value deriving from unmeasured intangible assets (Bharadwaj, Bharadwaj, & Konsynski, 1999). Scholars consider it a forward-looking indicator of firm performance because it depicts investor expectations of future firm cash flows adjusted for risk (Lewellen & Badrinath, 1997). For these reasons, Tobin's q recently has been favored by researchers (e.g., Erickson & Rotheberg, 2009; Fang, Palmatier, & Steenkamp, 2008; Lee & Kim, 2010). However, it is particularly appropriate for examining the performance effects of open innovation because the gains will unfold relatively slowly and, thus will be reflected more accurately in a forward-looking measure. Also, much of the gains from open innovation derive from factors that are intangible and directly unobservable.

Importantly, consistent with research indicating that performance hinges on appropriate bundles of resources and capabilities (e.g., Molina-Castillo et al., 2011; O'Cass & Ngo, 2012), as well as strategy research that suggests that effective firm action derives from intent, ability, and opportunity (e.g., Chen & Miller, 1994), we argue that open innovation alone is not sufficient. Its efficacy for generating performance gains depends on the presence of relational capability, a key factor that enables the firm to realize the benefits of open innovation. Furthermore, we argue that open innovation, as enabled by relational capability, generates particularly enhanced performance when it occurs in a rich industry network and when the firm is sufficiently flexible. Both strategy theory (Porter, 1980, 1996) and the resource-based view (Barney, 1991; Wernerfelt, 1984) suggest two alternative explanations of the development of sustainable advantage: (1) the firm's industry network provides access to knowledge, ideas, and technologies through spillovers, and (2) flexibility, in the form of financial resource slack, provides responsiveness and agility (e.g., Fang et al., 2008; Lee & Grewal, 2004). Below, we explicate how these factors work in tandem to empower open innovation for enhanced performance.

2.2. Relational capability as an enabler of open innovation

Open innovation demands a connection to external sources of NPD inputs (e.g., Rampersad et al., 2010). Such a connection in turn requires boundary-spanning activities by the firm (Wuyts, Dutta, & Stremersch, 2004). Boundary spanning might involve a firm's informal relationships and interactions with other firms that operate in similar or complementary industries and technologies, or even with competitors (e.g., Luo, Rindfleisch, & Tse, 2007). It also can involve associations and research collaborations with universities or research consortia. Likewise, boundary spanning might pertain to outsourcing relationships, strategic alliances, and deep partner-style relationships with upstream suppliers or downstream customers, or even arm's-length relationships with suppliers or customers. Whatever its form, boundary spanning generally entails interfirm relationships.

Considering the importance of boundary spanning through interfirm relationships for our conceptualization of open innovation, we argue that the ability to create and manage such relationships is vital for realizing the potential rewards of open innovations. This ability, which constitutes the firm's relational capability (e.g., Dyer & Singh, 1998; Johnson et al., 2004; Sivadas & Dwyer, 2000), features learned behaviors, including interfirm procedures, interaction patterns, and operational issues (e.g., Fang, Fang, Chou, Yang, & Tsai, 2011). Relational capability derives from knowledge stores that comprise socially complex and deeply embedded routines, culminating from insights, beliefs, observations, and experiences with building and managing interfirm relationships. As such, consistent with capabilities theory (e.g., Leonard-Barton, 1995; Nelson & Winter, 1982), we conceptualize relational capability in terms of relevant interfirm knowledge, which consists of interactional and functional knowledge stores (Johnson et al., 2004). Interactional knowledge stores feature knowledge about communication patterns, negotiation, conflict management, and the development and implementation of cooperative programs. Functional knowledge stores pertain to an understanding of how to work with suppliers, as well as knowledge about logistics, delivery and inventory management, production, and cost reductions (Johnson et al., 2004).

Theory (Dwyer, Schurr, & Oh, 1987; Jap & Ganesan, 2000) points to the importance of the initiating stages of an interfirm relationship where a firm sorts out the compatibility and complementarity of factors such as beliefs, values, culture, resources, information, services, legitimacy and status, with another firm. These compatibility assessments form the favorable impressions of a potential partner firm with regard to the benefits or burdens of a possible relationship. Importantly, in field interviews conducted to support this research effort, managers repeatedly emphasized the importance of partnering with the "right" firm. Thus, based on theory and executive interviews, we identified an additional relevant knowledge component in relational capability, the initiation knowledge store. This knowledge store involves a firm's understanding of the match with potential partners, the identification, qualification, and selection of interfirm partners for productive relationships.

Ultimately, we argue that relational capability—cast as the amalgam of a firm's interactional, functional, and initiation interfirm knowledge stores—moderates the impact of open innovation on firm performance (see Fig. 1). Specifically, relational capability should enable open innovation to generate performance gains because it increases the firm's ability to engage in effective external search and connect with external sources of NPD inputs. This more effective engagement of the environment should expose firms to a broader array of NPD external inputs yielding lower costs due to increased NPD effectiveness and decreasing NPD cycle time. Further, with the enhanced access that strong relational capabilities bring, the resulting increased role of external inputs to NPD can help drive down R&D costs and increase gains. Likewise, the more effective interfirm engagement that relational capability brings can help the firm identify and select viable and productive external sources to incorporate into new products, and importantly, it can facilitate evaluation of the quality, worth, and merit of these resources from external partners, again driving down costs and increasing NPD outcomes, ultimately for bottom line gains. Finally, relational capability with its enhanced interfirm engagement should improve knowledge access and transfer between a firm and its external NPD input sources (e.g., Fang et al., 2011; Lorenzoni & Lipparini, 1999) allowing for more gains from the external NPD inputs that interfirm partnerships provide, and ultimately enhancing performance. For these reasons, firms with greater relational capability are better equipped to leverage boundary-spanning and interfirm connections for the empowerment of open innovation and greater performance gains. Thus, we posit:

H1. Relational capability moderates the effect of open innovation on firm financial performance, such that in the presence of high relational capability, the performance gains from open innovation are greater.

2.3. Network spillovers and flexibility for open innovation performance gains

We reason that the enabling effect of relational capability for open innovation performance gains should be enhanced further in the presence of a knowledge-rich industry network because performance gains also depend on the characteristics of a firm's industry (e.g., Porter, 1980). If a firm assembles and develops a network that provides a rich source of potential inputs (i.e., knowledge, IP, and technologies), it should combine with the firm's relational capability to generate even greater performance gains from open innovation. That is, the moderating effect of relational capability in the link between open innovation and performance should be boosted by a rich network that is high in network spillovers (Fig. 1).

Network spillovers refer to flows of information throughout a firm's extended network (e.g., Cassiman & Veugelers, 2002; Owen-Smith & Powell, 2004), which affect the firm's access to knowledge, IP, and technologies. They involve the transmission of knowledge through formal or informal association and contact among firms in a network. Such spillovers could result from exchanges and interactions with other firms, technology licensing, or similar interfirm activities (e.g., Bharadwaj, Clark, & Kulviwat, 2005). Some inputs may seem costless (e.g., Kaiser, 2002) because they originate in venues such as open source communities (e.g., Fleming & Waguespack, 2007), patent disclosures, the popular press, trade journals, information exchanges at conferences, employee migration, or conversations around the watercooler (e.g., Lee, Johnson, & Grewal, 2008; Los & Verspagen, 2000), while others are acquired at full or partial market value (Monjon & Waelbroeck, 2003). Whatever form they take, network spillovers play a crucial role in the evolution of technology, because they augment access to knowledge (Salter & Martin, 2001). For example, valuable spillovers could result if a firm grants network access to its underutilized R&D, which buttresses and supplements the R&D of others in the network (e.g., Bernstein & Nadiri, 1988; Henderson & Cockburn, 1996; Jaffe, 1986) and increases the rate of trial-and-error experimentation (Bharadwaj et al., 2005).

In a knowledge-rich network context, relational capability provides better means and routines for identifying, recognizing, and linking with these valuable spillovers, sometimes at minimal costs (e.g., Dyer & Nobeoka, 2000; Fleming & Waguespack, 2007). Relational capabilities imply that the firm conducts effective external searches and network spillovers provide a target-rich context for that search. Network spillovers offer high quality, high value NPD inputs for firms that know how to access them through relational capability. In combination, network spillovers and relational capability should make NPD and commercialization more effective and efficient, such that they should encourage the effect of open innovation on superior firm performance. Through greater R&D cost efficiencies derived from open innovation and the optimization of the firm's extant new product resources, performance gains for the firm should increase further. Thus, we hypothesize:

H2. Network spillovers enhance the moderating effect of relational capability in the open innovation–financial performance relationship, such that when high relational capability combines with high levels of network spillovers, the positive influence of open innovation on firm financial performance increases.

Another factor that couples with relational capability to enhance the performance gains from open innovation is flexibility. Flexibility is conceptualized from various perspectives in the extant literature (e.g., Johnson, Lee, Saini, & Grohmann, 2003); however, consistent with recent research (e.g., Fang et al., 2008; Lee & Grewal, 2004), here we focus on financial resource slack. From this perspective, flexibility results from the cushion of financial resources that enables a firm to adapt and respond to opportunities and the ebb and flow in the innovation process (Nohria & Gulati, 1996). Flexibility as financial slack or excess capacity means that resources may have multiple and discretionary uses, supporting dynamic deployment without stressing the firm's other activities or programs (e.g., Bourgeois, 1981). These discretionary resources give the firm room to engage in experimentation and aid in NPD (e.g., George, 2005; Tatikonda & Rosenthal, 2000). Thus, flexibility is the ability to deploy and redeploy resources readily toward adaptation and accommodation to changes in a firm's conditions or situations (e.g., Johnson et al., 2003), which derives directly from the firm's deliberate management of a resource portfolio to ensure the presence of slack.

Resource slack also provides a chance for the firm to take advantage of potential opportunities derived from its external search (see Fig. 1). That is, flexibility allows the firm to act on and perhaps even generate opportunities for incorporating external inputs into its NPD. Thus relational capability and flexibility together empower open innovation to increase the speed and sustainability of new product generation and introduction, thereby further improving firm performance. Likewise, flexibility facilitates the incorporation of external inputs into the firm's extant new product resources and processes. This inherent resource deployment agility should enhance the efficiency gains achieved by coupling a firm's extant R&D with external new product inputs, enhancing firm performance still further.

However, flexibility derived from financial resource slack apparently affects firm performance in complex ways. Extant literature indicates a nonlinear effect (e.g., George, 2005; Nohria & Gulati, 1996), and that some levels of resource slack clearly are beneficial. Too much slack may cost the firm in terms of inefficiencies, unrecoverable costs, or underutilized resources, while too little resource slack precludes response to opportunities. Thus some optimal but not excessive level of slack should effectively couple with relational capability to increase the performance gains from open innovation. However, considering the nascent stage of our understanding of open innovation and the complexity of coupling flexibility and relational capability, we do not advance a nonlinear moderated relationship. Instead, we predict:

H3. Flexibility enhances the moderating effect of relational capability in the open innovation–financial performance relationship, such that when high relational capability combines with high levels of flexibility, the positive influence of open innovation on firm financial performance increases.

3. Methods

This research is based on a mixed-method approach (qualitative and quantitative) that documents the phenomenon of interest: understanding the effects of open innovation on firm performance. First, we performed a series of interviews with executives to get a sense of the meaning of open innovation in practice, and to understand more fully the key enablers that increase the efficacy of open innovation. Second, we tested our hypotheses with a survey that linked the perceptions of managers with archival data on firm performance.

3.1. Field interviews

In 2007, we conducted field interviews with managers of eight high tech firms in the Pacific Northwest to learn more about the importance of open innovation in practice (see Table 1 for a description of the executives and their firms). As indicated by their job title in Table 1, most of these individuals were top level executives who were very familiar with the innovation process of their firms. Their background and experience were varied in terms of industries (communications, biotechnology, chemicals, etc.) and firm size (from 50 to 120,000 employees). Given the dynamic environment in which these firms operate, innovation is core to success (or failure) for all of them. All the interviewees were passionate about the innovation and new products of their firms. Overall, they provided substantial supporting information for this project.

The notion of open innovation—at least its inbound component—was intuitive for most managers, and they spoke of it with ease and verve. Importantly, managers seemed much more concerned about inbound open innovation and its potential effects, compared to outbound component. Indeed, their spontaneous focus was finding ways to improve innovation processes for the ultimate outcome of financial gains. Outbound open innovation, or the possibility of revenue gains by commercializing past technologies, did not get the same level of attention. The executives rarely referred to their outbound activities.

In the interviews, managers revealed that they could speed up product development and lower innovation costs through the discovery and use of different external inputs. The positive effects of open innovation on performance were well understood by managers. For instance, the Firm G manager noted it was important to constantly scan the external environment and to link internal R&D activities with external inputs. The importance of incorporating external ideas and inputs in their innovation process was viewed as a best practice, although managers did not formally label this as open innovation. Importantly, it was also clear that the simple use of external inputs was not a guarantee of success. The success and even the mere feasibility of open innovation seem conditional to the preexistence of external and internal factors. Many managers stressed that they were very careful about opening the borders of their firms to others, especially in matter of innovation. In particular, Firm A, B, and C managers indicated that they needed to be cautious when seeking partner firms when considering intellectual property critical to their firm. Thus it was important to identify firms that could be trusted (Firm B manager). The special collaboration implied by open innovation needed “perfect conditions in order to work out.”

In terms of key enablers of open innovation, many managers highlighted that the presence of “good” interfirm relationships was crucial to develop the ability to seek out inputs for innovation. Firms needed to capitalize on these relationships to scan their environment and discover new input opportunities. While it was important to manage existing relationships, it was also critical to develop new ones with upcoming firms—this comment directly speaks to the inclusion of initiation knowledge stores in our model. In sum, these comments synchronize with our examination of the moderating role of relational capability in our model.

The presence of useful inputs for their innovation processes was also viewed as a critical factor enabling open innovation. Indeed, managers noted the need to easily identify inputs that could be brought into their firms. The interviews indicated that in addition to the relationship making ability, firms also needed to operate in an environment with abundant external inputs. As one of the managers explained, “we need to capitalize on low hanging fruits, if those exist.” We represent these issues by the notion of network spillovers in our model.

Finally, in the interviews, managers mentioned the need for internal resources and to be in position to leverage the new input and use them in their current projects. The problem cannot always be expressed in term of finding the right inputs that could revolutionize innovations. Another challenge is: can the firm deploy the resources to take advantage of the new technologies. According to our discussions, many of the firms were often overcommitted to different projects, and they did not always have the resources to devote to the incorporation of new inputs, as interesting they could be. These concerns are captured by the concept of flexibility and resource slack in our model.

Overall, these interviews were useful in four ways. 1) They validated our focus on inbound open innovation. 2) They confirmed the importance of studying the effects of open innovation on firm performance, especially if this later was expressed in terms of financial outcomes. 3) They highlighted the importance of incorporating initiation knowledge stores as a new component of relational capability. 4) These interviews were instrumental in the selection of the moderators of our model.

3.2. Survey procedure, sample characteristics and response rate

Upon completion of the field interviews in late 2007, we proceeded with gathering quantitative data. To examine our hypotheses, we required a context that is information rich and for which firms are under constant pressure to innovate and introduce new products (e.g., Narasimhan et al., 2006). Accordingly, we elected to collect data from business-to-business high-tech firms. Our sample included firms operating in advanced materials, biotechnology, computer software, medical, and pharmaceutical industries. Sample characteristics are shown in Table 2.

We obtained contact information for managers responsible for new product development and innovation at firms in these industries from the CorpTech Directory. We conducted a rigorous prescreening by contacting the potential participants by mail (i.e., postcards) and telephone. Through this initial contact, we verified the existence of the firm, its public nature, and the qualifications of the potential informants by asking them about their knowledgeability regarding new product innovation in their firm. We identified 532 managers as possible participants to whom we mailed survey packets that included a cover letter describing the project, the survey instrument, and two incentives ($5 cash and an offer of summary results).

Table 1
Qualitative interviews.

Firm	Job title	Industry	Employees (thousands)	Sales ($ millions)
A	President of strategic business unit	Communications	1.3	530
B	Manager of collaboration center	Semiconductor manufacturing	86	37,500
C	Director of corporate strategies and marketing	Information systems software	2.9	800
D	Director of open innovation	Chemicals	56.0	18,000
E	Director of IP	Electronics	120.0	34,000
F	Licensing director	Life & materials science	25.0	12,000
G	President	Biotechnology	.05	1.1
H	Vice president of strategic business unit	Electronics	12.2	56,000

Table 2
Sample statistics.

Sector classifications	Responses	Age[a]	Employees (thousands)[b]	Sales ($ millions)[b]
Pharmaceuticals, biotechnology, chemicals, advanced materials	82	31.08	5.51	920.51
Industrial machinery, computer equipment	24	38.12	14.75	3993.44
Electronic components, electric equipment	26	27.44	12.52	2716.08
Instruments and test, measurement	40	27.00	9.79	2030.35
Expert and professional services, computer software	32	26.09	5.44	929.05

[a] Data obtained from list provider.
[b] Data obtained from CRSP database.

We followed a mixed-mode method for this data collection using mail and electronic surveys. Dillman (2007) argues that mixed-mode surveys compensate for the weaknesses of individual methods. Thus, we took advantage of the ease of electronic surveys while the paper surveys served as a constant reminder (Manfreda, Bosnjak, Berzelak, Haas, & Vehovar, 2008). The t-tests comparing mail versus online survey responses did not show any differences in the variables in this study.

After the initial mailing and a follow-up, in early 2008 we received 216 surveys, for a response rate of 40.6%, which compares favorably with extant literature (e.g., Johnson et al., 2004). Accounting for missing responses and added archival data, we obtained a final sample of 204 usable responses yielding a final response rate of 38.3%. We assessed nonresponse bias by comparing early and late responders (Armstrong & Overton, 1977), as well as responding and nonresponding firms in terms of the number of employees, sales, resource slack, and financial performance. The t-tests indicated no differences between early and late responding firms or between responding and nonresponding firms.

Importantly, we verified the qualification of the key informants by asking them to indicate their positions, tenure with firm, and tenure in their position. We also asked them to complete a three-item scale on knowledge about the research topic. These checks indicated that 58.4% of the surveys came from NPD managers, 34.2% from senior executives, and the remaining 7.4% from product managers. The respondents had been with their firms for 12.8 years, and in their current positions for 6.4 years, on average. Finally, managers considered themselves highly qualified in the topics of interfirm relationships, R&D activities, and NPD (seven-point scale, $M = 6.48$, $SD = .58$). Based on the above information, we determined that the respondents were qualified to inform on the constructs of interest.

3.3. Instrument and measures

Our research incorporates two types of measures, archival and perceptual. The archival measures refer to objective and financial data publicly reported in official documentation. Consistent with prior research (e.g., Lee & Grewal, 2004), the archival data came from the Center for Research on Security Price (CRSP) and Compustat databases. In our model, resource slack, firm performance and several control variables derive from these archival sources.

Perceptual measures assess the remaining constructs—i.e., survey-based questions to which qualified managers replied. Perceptual measures can take two forms, reflective and formative (Bollen & Lennox, 1991). In this research, we conceived open innovation and product turbulence as reflective constructs. The items for these scales are interchangeable as they tap into the construct domain, and they represent the "reflections" of the construct. In turn, we conceived relational capability, network spillovers and market turbulence as formative (Diamantopoulos & Winklhofer, 2001). These scales include items or dimensions that can be independent of each other, and they form a construct rather than reflecting it (Bollen & Lennox, 1991). For example, in the case of relational capabilities, a firm may have extensive knowledge regarding interfirm relational interactions but only a limited relationship initiation knowledge store.

Whenever possible, we used preexisting measures for the perceptual scales. However, as no measures previously existed, we developed new measures for open innovation, interfirm relationship initiation knowledge stores, and network spillovers. For these new scales, we followed recommended prescriptions (e.g., Churchill, 1979). After, developing the individual measures, we assembled the complete survey instrument and pretested it on a group of 25 MBA students, most of whom had managerial experience. The pretest did not indicate any problems with the instructions or scales. As a final check, a senior executive responded to the instrument and evaluated it in an in-depth debriefing session with the researchers. No issues were discovered, and no further changes were required. Below, we discuss all the measures including the development procedures for the new measures. The Appendix provides measurement details.

3.3.1. Open innovation

Given its central role, we attended carefully to the development of the new scale for open innovation. First, based on its conceptual definition, the extant literature (e.g., Chesbrough, 2003) and information from the interviews, we produced an initial set of items. Second, the item pool was assessed by the eight managers we interviewed; they provided feedback that we used to cull and refine the items. Third, the scale was evaluated by researchers familiar with the research topic and survey research. They specifically evaluated item content and clarity, and fit with the conceptual definition. Fourth, prior to the overall pretest, we separately pretested the six-item open innovation measure that resulted from the previous steps. No problems were encountered in either pretest. For the final scale, participants indicated the extent to which they strongly disagreed (1) or strongly agreed (7) with six items such as "we actively seek out external sources of knowledge and technology when developing new products" and "we purchased external intellectual property to use in our own R&D."

3.3.2. Relational capability

Relational capability is a second-order formative construct formed by three types of interfirm relationship knowledge stores: interactional, functional and initiation. For all the items, respondents indicated the extent of their knowledge on a scale ranging from 1 ("very little knowledge") to 7 ("extensive knowledge"). The interactional and functional relationship dimensions were drawn from Johnson et al. (2004). Both were conceptualized as first-order formative constructs, and both included five specific knowledge elements (see Appendix) that formed the respective store construct (Bollen & Lennox, 1991).

Based on theory (e.g., Dwyer et al., 1987) and the field interviews, we included a third first-order construct (i.e., initiation knowledge store) to relational capability. The items of initiation knowledge store derived directly from the field interviews. Consistent with the two other knowledge stores, we focus on five items that capture varied knowledge related, for example, to the quality of the interfirm match, relationship benefits, relationships development, and the judgment of when to commit (see Appendix). Similar to the newly created open innovation scale, the face validity of this scale was assessed by survey experts and the scale was pretested with the MBA sample.

3.3.3. Network spillovers

Building on the current literature on network spillovers (e.g., Kaiser, 2002; Lee et al., 2008; Los & Verspagen, 2000) and our preliminary fieldwork, we derived a five item formative scale to measure network spillovers (e.g., the richness and availability of knowledge in a firm's network). This scale identifies the sources of information that firms can use to find relevant inputs. Respondents indicated, on a scale from 1 ("not at all") to 5 ("to a large extent") the extent to which different sources—white papers, conferences, professional journals, personnel from other firms, and general industry interactions—were used to expand their knowledge. Given the usage of different sources of information is not necessarily correlated and interchangeable, this construct is formative. Again, the face validity of this scale was assessed by survey experts, and this scale was successfully pretested.

3.3.4. Tobin's q

We used Tobin's q to assess firm performance because it is a forward looking measure of firm value that reflects long-term profitability (Chung & Pruitt, 1994; Lee & Kim, 2010), an objective that is consistent with our interviews and also with extant literature (e.g., Rubera & Kirca, 2012). Further, it is comparable across firms and industries (e.g., Anderson, Fornell, & Mazvancheryl, 2004). Consistent with Lee and Grewal (2004), we used Chung and Pruitt's (1994) method to calculate Tobin's q:

$$\text{Tobin's}\, q = \frac{\text{Market value of stock} + \text{Preferred Stock} + \text{Debts}}{\text{Total assets}}.$$

To determine the market value of stock, we took stock price of the publicly traded firm and multiplied it by the number of outstanding shares. Because of the volatility in stock price, we used the average stock price at the end of the four quarters rather than the year-end stock price (e.g., Lee & Grewal, 2004). In qualitative terms, Tobin's q compares a firm's market value with its replacement cost (Morgan & Rego, 2009). A Tobin's q greater than one suggests that a firm has large positive cash flows and/or important intangible assets (Anderson et al., 2004) which greatly contributes to its long term success and profitability.

3.3.5. Financial resource slack

Consistent with prior research (e.g., Fang et al., 2008; Lee & Grewal, 2004), we conceptualize firm flexibility as resource slack, which represents firm liquid assets—that is the firm's current assets less its current liabilities. The association between flexibility and resource slack is rather intuitive: when a firm possesses a high level of liquidity, it has the financial resources to immediately respond to new opportunities.

3.3.6. Control variables

Other factors also could influence the relationships of interest, so we included control variables to account for possible extraneous influences. Specifically, we controlled for market turbulence, technology turbulence, firm size, firm age, and return on assets (ROA). Technological turbulence involves the pace of technological change in an industry, whereas market turbulence refers to changes in consumer preferences and demands (Jaworski & Kohli, 1993). We adapted scales from Jaworski and Kohli (1993) for both turbulence measures. Because firm size may confound the results about resources and capabilities (Moorman & Slotegraaf, 1999), we accounted for its influence with the number of employees, annual sales, and annual R&D expenses. We controlled for age because older firms may have acquired more knowledge and may have more refined capabilities, which could mask and interfere with the relationships being studied (Sinkula, 1994). Finally, we controlled for return on asset (ROA) because it may relate to resource slack (Lee & Grewal, 2004). Consistent with research convention, we used logarithmic transformations for employees, sales, and age.

4. Results

4.1. Measure validation and descriptive statistics

We followed accepted guidelines (Bollen & Lennox, 1991) to assess the psychometric properties of the reflective and formative scales. For the reflective scales, open innovation and technological turbulence, we assessed validity with a confirmatory factor analysis (CFA). After the deletion of two items for open innovation because of high correlated errors (see Appendix), the final CFA model fit reasonably well, with a χ^2 of 7.87 ($p = .02$) and acceptable fit statistics (nonnormed fit index = .93, confirmatory fit index = .98, square root mean residual = .04, goodness-of-fit index = .98). Factor loadings ranged between .49 and .86 for open innovation and from .67 to .92 for technology turbulence, all exceeding recommended cutoffs (Nunnally & Bernstein, 1994). The construct reliability was .80 for open innovation and .84 for technology turbulence, both greater than the .7 criterion (Bagozzi & Yi, 1988). Following Fornell and Larcker (1981), we used the average variance extracted (AVE) to evaluate the convergent validity. The AVEs for open innovation (.51) and technological turbulence (.63) exceeded the .5 criterion. Overall, the CFA results provided evidence of the validity for our reflective constructs.

The other perceptual measures—relational capability, network spillovers, and market turbulence—are formative constructs (Diamantopoulos & Winklhofer, 2001) as these scales included items or dimensions that could be independent of one another (Bollen & Lennox, 1991). For formative constructs, validity derives largely from content validity and conceptual reasoning (Diamantopoulos & Winklhofer, 2001). Here, our rigorous scale development procedures, past measure history and conceptual definitions, and visual inspection of the items all provided support for the content validity of our formative scales.

For discriminant validity, we compared the AVEs of the reflective measures with the variance shared by each construct and all other constructs (Fornell & Larcker, 1981). Table 3 shows AVEs for the reflective constructs, as well as the zero-order correlations and descriptive statistics. In each case, the square root of the AVE was greater than the squared interconstruct correlation estimates. For the remaining measures, the correlations in Table 3 revealed that with the exception of some established control variables (i.e., sales, employees, and age, collected from the secondary data sources), none of the zero-order correlations were of sufficient magnitude to warrant concern about discriminant validity. Given that the measure assessment overall indicates valid constructs, we took the average of relevant items to make the scales for hypotheses testing.

4.2. Additional psychometric tests for the open innovation scale

The novelty and importance of the open innovation construct prompted us to perform additional analyses to validate it. Specifically, we further assess its discriminant and nomological validity (Peter, 1981) by examining its associations with two constructs included in our survey: closed innovation (i.e., an innovation process that is principally based on internal knowledge and processes) (Chesbrough, 2003), and product innovativeness (i.e., the degree of uniqueness of a new product) (e.g., Gatignon & Xuereb, 1997). To demonstrate further the discriminant validity of open innovation, we assess its linkage with closed innovation. These two forms of innovation should negatively relate because they rely on radically different processes. To assess nomological validity (i.e., the extent to which open innovation is linked to the variables it should be linked based on theory), we predict that open innovation, compared with closed innovation, is more strongly associated with product innovativeness. Indeed, because open innovation incorporates varied external inputs, it should lead to greater products uniqueness.

To measure closed innovation, we developed a new scale with three items: "the firm relies as much as possible on its own R&D program," "the firm believes it is best to develop technology and intellectual property on its own for itself," and "the firm believes that its own R&D group is the best source of technology, information, ideas and knowledge for developing products." We followed the same development procedure as for the open innovation scale (see Section 3.3). For product innovativeness, we used an established three-item scale (Gatignon & Xuereb, 1997) which included: "our new products are pioneering, first of their kind," "our new products incorporate new technology when compared to existing product," and "our new products differ from other products available on the market."

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Table 3
Correlation matrix and descriptive statistics (n = 204).

	1	2	3	4	5	6	7	8	9	10	11	12
1. Open innovation	**.72**											
2. Relational capability	.17 [a]	–										
3. Network spillovers	.23 [b]	.16 [a]	–									
4. Resource slack	.15 [a]	−.10	.09									
5. Age	−.15 [a]	.01	−.16 [a]	−.34 [b]	–							
6. Employees	−.15 [a]	.06	−.14 [a]	−.52 [b]	.44 [b]	–						
7. Sales	−.13	.10	−.18 [a]	−.56 [b]	.46 [b]	.87 [b]	–					
8. R&D	.10	.17 [a]	−.09	−.33 [b]	.10	.67 [b]	.61 [b]	–				
9. Market turbulence	−.00	.10	.10	.04	−.04	−.12	−.12	−.12				
10. Technology turbulence	.24 [b]	.28 [b]	.25 [b]	.12	−.29 [b]	−.27 [b]	−.29 [b]	−.04	.37 [b]	**.80**		
11. Return on assets	−.11 [a]	.00	−.07	−.16 [b]	.30 [b]	.35 [b]	.46 [b]	.04	−.14	−.23 [b]		
12. Tobin's q	.22 [b]	.13	.22 [b]	.11	−.20 [b]	−.32 [b]	−.35 [b]	−.12	.06	.17 [b]	.01	–
Mean	4.85	4.77	3.39	.39	1.42	2.89	8.14	1.25	2.94	3.22	−.04	2.14
St. dev.	1.26	.91	.62	.25	.32	1.04	1.26	.81	.74	.95	.25	1.83

Notes: In bold, the diagonal indicates the square root of AVE for the reflective constructs. The constructs with no values on the diagonal are either formative constructs (i.e., relational capability, network spillovers and market turbulence) or archival measures (i.e., resource slack, Tobin's q, age, employees, sales, R&D, return on assets).
[a] Correlation is significant at $p < .05$ level.
[b] Correlation is significant at $p < .01$ level.

For this additional validation, we conducted a CFA that included the open innovation, closed innovation, and product innovativeness scales. This CFA exhibited a reasonable fit, with a χ^2 of 62.12 (df = 32, $p = .001$), CFI of .96, Tucker–Lewis index of .94, and root mean square residual of .068. All item loadings were large and significant; all AVEs exceeded .5 (open innovation = .51; closed innovation = .60; product innovativeness = .55). The construct reliabilities for open innovation, closed innovation and product innovativeness were .80, .82, and .78, respectively.

The results confirmed our contention; the two forms of innovation are conceptually and empirically distinct. As evidence of discriminant validity, we found that open and closed innovation correlated negatively ($r = -.52$, $p < .001$). As evidence of nomological validity, only open innovation related positively to product innovation ($r = .27$, $p < .01$), whereas closed innovation was unrelated to this construct ($r = -.04$, $p = .68$). Overall, these results provided further evidence for the construct validity of open innovation.

4.3. Common method bias

As recommended by Podsakoff, MacKenzie, Lee, and Podsakoff (2003), we relied on procedural remedies for this potential bias. Because the dependent, one moderator, and several control variables come from different data sources, common method bias should be a minimal concern. As an additional validation, we checked for common method bias in our perceptual variables using the Harmon's one-factor test (Podsakoff et al., 2003). The results suggested minimal common method bias as the largest extracted component accounted for only 24.1% of total variance.

4.4. Hypotheses tests

For the hypotheses tests, we developed product terms to test the moderated effects. To alleviate concerns for multicollinearity in the use of product terms, we mean centered the composites for each measure (Cohen, Cohen, West, & Aiken, 2003). Table 4 provides the ordinary least square moderated regression estimates for the hypotheses tests. A preliminary inspection of the results indicated that all the pertinent equations were statistically significant. The main effects model produced an R-square value of .28; with one exception, increases in the R-square were statistically significant when we included the product terms for the moderated effects. The exception pertained to H3 (see the fourth column in Table 4). Among the control variables, sales, R&D expense, and ROA related significantly to Tobin's q.

As the basis for the moderated effects we have hypothesized, we expected that open innovation would exert a positive impact on performance. Our results verified this prediction (see second column), with an estimate of .19 ($p < .05$) indicating that open innovation improved performance represented as Tobin's q. Furthermore, we posited that relational capability would moderate this influence. The results shown in Table 4 (second column) indicate support for H1; the parameter estimate of .06 for the open innovation–relational capability product term was statistically significant ($p < .05$).

To understand this interaction pattern, in Fig. 2 we plotted the predicted values of Tobin's q for high and low levels of open innovation and relational capability. As suggested (Cohen et al., 2003), we used "− 1" and "+ 1" standard deviations for the variables of interest in this and all other plots. Based on Fig. 2, the highest level of Tobin's q is observed for high levels of both open innovation and relational capabilities. Other

Table 4
The effects of open innovation and its moderators on firm performance (Tobin's q).

	Main effects	OI × RC (H1)	OI × RC × NS (H2)	OI × RC × SL (H3)	OI × RC × SL^2 (post-hoc analyses)
Open innovation (OI)	.16 [a]	.193 [a]	.19 [a]	.20 [a]	.21 [a]
Relational capability (RC)	.07 [b]	.061 [b]	.02	.06 [b]	.04
Network spillovers (NS)	.34 [a]	.380 [a]	.27 [b]	.37 [a]	.43 [a]
Resource slack (SL)	− 1.48 [c]	− 1.482 [c]	− 1.49 [c]	− 1.57 [c]	− 1.15 [a]
OI × RC		.064 [a]	.08 [c]	.06 [a]	.05 [b]
OI × NS			.11		
RC × NS			−.00		
OI × RC × NS			.12 [c]		
OI × SL				.14	.24
RC × SL				.02	.04
OI × RC × SL				.22 [b]	.21 [b]
SL^2					− 1.11
OI × SL^2					.32
RC × SL^2					2.23 [c]
OI × RC × SL^2					1.42 [a]
Age	−.10	−.08	−.04	−.07	−.34
Employees	−.21	−.22	−.12	−.20	.06
Sales	−.94 [c]	−.93 [c]	−.98 [c]	−.94 [c]	− 1.00 [c]
R&D	.60 [c]	.60 [c]	.56 [c]	.59 [c]	.49 [a]
Market turbulence	.10	.11	.11	.09	.02
Technological turbulence	−.05	−.04	.01	−.30	−.01
ROA	2.46 [a]	2.42 [c]	2.32 [c]	2.41 [c]	2.28 [c]
R^2	.28	.30	.32	.31	.38
ΔR^2	.02 [a]	.03 [b]	.01	.08 [c]	
F-change	4.63 [c]	4.20 [c]	2.32 [a]	.81	5.16 [c]

Note: the presented coefficients are unstandardized regression results.
[a] Significant at the .05 level.
[b] Significant at the .10 level.
[c] Significant at the .01 level.

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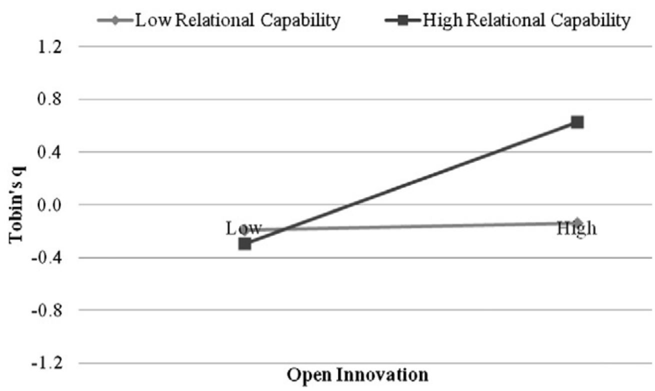

Fig. 2. Moderation of open innovation–firm performance relationship by relational capability.

open innovation and relational capability combinations show lower and negative performance values. Based on this pattern, it seems that when open innovation combines with high levels of relational capability, positive financial performance ensues.

In H2, we argued that network spillovers would combine with relational capability to enhance further the performance gains from open innovation. As we show in Table 4 (third column), we found a statistically significant three-way interaction among open innovation, relational capability, and network spillovers ($\beta = .12$; $p < .01$), in support of H2. We plotted this interaction in Fig. 3. The top panel (bottom panel) shows firms with low (high) levels of relational capabilities. Overall, the combination of high open innovation, high relational capability and high network spillovers clearly associates with the highest Tobin's q. In this combination, the Tobin's q value is greater than 1, a strong indicator of superior performance. All of the other combinations in Fig. 3 present substantially lower values of Tobin's q with many appearing in the negative range.

In H3, we posited that the combinative effects of relational capability and resource slack would enhance performance gains from open innovation. As shown in Table 4 (fourth column), addition of product terms to test H3 did not increase the R-square to a statistically significant extent, and the parameter estimate for the three-way interaction (open innovation, relational capability, and resource slack) was only marginally significant ($\beta = .22$; $p < .10$). Although we found quite limited support for H3, we plotted it in Fig. 4 to determine if our general logic was correct. The top panel shows firms with low relational capability; they achieve greater performance when they possess low levels of resource slack. The bottom panel shows the performance of firms with a high relational capability. The pattern is counter to our hypothesis that firms with high relational capability and flexibility would outperform firms with low flexibility. High relational capability-low flexibility firms appear to outperform high flexibility firms when they pursue open innovation. We find no support for H3 as originally specified.

4.5. Post-hoc analyses

We performed post-hoc analyses to clarify the potential interplay among resource slack, open innovation, and relational capability. We have reason to believe that the moderating effects of resource slack are nonlinear, so we probe this possibility by using a squared term (see George, 2005). The results for this analysis, in the last column of Table 4, reveal that adding product terms for the nonlinear interaction

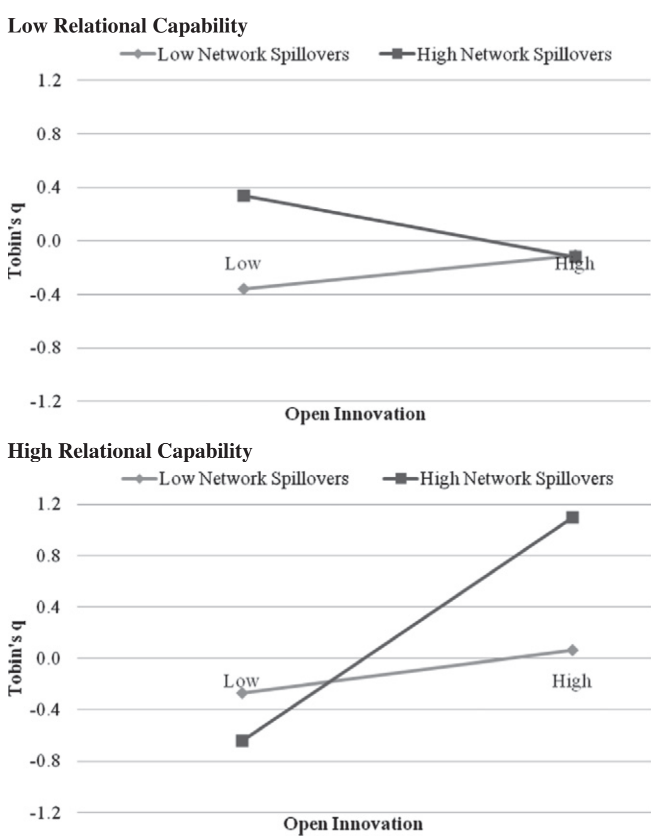

Fig. 3. Moderation of open innovation–firm performance relationship by relational capability and network spillovers.

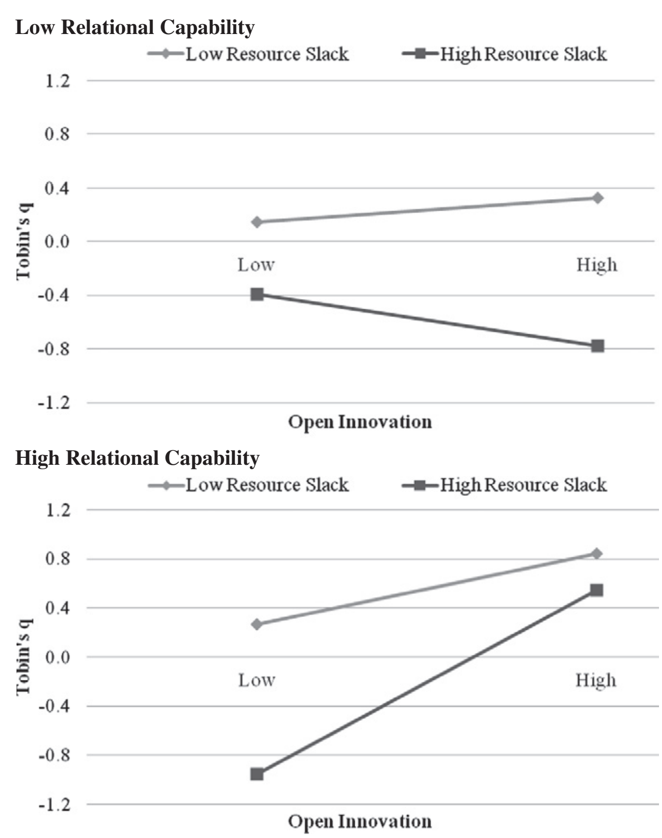

Fig. 4. Moderation of open innovation–firm performance relationship by relational capability and resource slack.

increased the explained variance to 38%, an increase that was statistically significant. The parameter estimate of 1.42 for the product term involving the nonlinear interaction (i.e., open innovation, relational capability, and squared resource slack) also was statistically significant ($p<.05$).

To delineate this complex interplay, we plotted the interaction in Fig. 5. When firms have a low level of relational capability (the top panel), the values of Tobin's q tend to decrease as resource slack increases, regardless of the level of open innovation. We note a similar pattern for firms with a high level of relational capability which did not adopt an open innovation approach (dotted line in the bottom panel); Tobin's q keeps decreasing as resource slack increases. This may indicate that a too large amount of "sleeping" liquidity or resources means that a firm is not taking advantage of the opportunities present in its environment.

However, we find an interesting and different pattern for the high relational capability-high open innovation combination (full line in the bottom panel). High levels of open innovation and relational capability, coupled with relatively lower or higher levels of resource slack, produced greater performance gains than mid-range levels of resource slack. This is interesting first because it is associated with the generally highest levels of performance observed in the whole Fig. 5, and second because a clear U shaped pattern emerged.

Extant evidence on the resource slack–firm performance relationship has suggested an inverted U-shaped effect (e.g., Nohria & Gulati, 1996), or diminishing performance returns from greater slack. In contrast, our results (for the high relational capability and high open innovation combination) show a U-shaped pattern, indicating a threshold effect. If a firm is going to maintain slack, it appears that there is some critical level necessary, in conjunction with effective boundary spanning and open innovation, to realize performance gains. If that threshold level of slack cannot be attained and maintained, from a performance perspective, it may be more desirable to minimize any investment in slack, because lower levels produce higher performance when open innovation and relational capabilities are high.

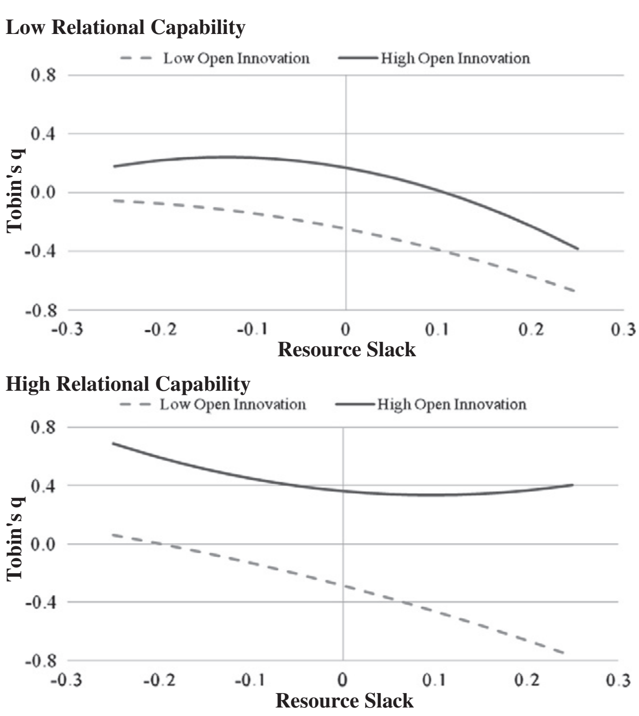

Fig. 5. Moderation of open innovation–firm performance relationship by relational capability and resource slack.

5. Discussion and implications

Open innovation has long been the subject of considerable interest in the business press, and anecdotal evidence suggests it as a new avenue to superior performance (e.g., Huston & Sakkab, 2006). To probe these claims and provide more understanding of the practice, we have provided a first systematic, empirical assessment of the performance implications of inbound open innovation in business markets. By doing so, we aim to provide rigorous evidence that goes beyond popular anecdotes for business-to-consumer firms (e.g., Huston & Sakkab, 2006). We advance the notion that the open innovation–performance relationship is not necessarily straightforward; rather, important factors in the firm context enable and facilitate the realization of performance gains from open innovation. Heightened performance can derive from open innovation, but as our results indicate, firms must have the ability to enact it, specifically through their relational capability. Along with this ability, firms need appropriate opportunities to enact open innovation, whether through a knowledge-rich industry context or resource slack that engenders their agility and responsiveness.

5.1. Theoretical implications

Theoretically, open innovation provides an opportunity to move beyond traditional perspectives and create value by explicitly considering alternative pathways for innovation to achieve profitable growth. Given the large impact of business-to-business organizations on global economy, we believe that our research contributes to the business innovation literature in three important ways.

First, we find that a positive relationship between firm performance and open innovation is enhanced by a firm's ability to engage effectively in boundary spanning with other firms. With open innovation, firms become attuned to their environment and benefit from the potential pools of resources that reside in their networks, by leveraging these potential resources and opportunities internally. Therefore, the ability to access knowledge, technology, and information through relationships with other firms facilitates open innovation, which helps the firm effectively implement it. The relatively poorer performance experienced by less open firms with high relational capabilities likely arises because even though these firms build relevant knowledge bases and develop an ability to connect with others, they cannot effectively or optimally leverage their valuable relational skills, such as in conjunction with open innovation. Rather than accessing enhanced resource bases through their superior relational capability, these firms continue to work in isolation in their innovation development efforts, expending valuable firm resources in suboptimal manners.

Second, we not only consider open innovation as a potential avenue to firm performance but also note factors in the firm context that make it viable. Certain resources, relational capability, information-rich networks, and resource slack all act as enabling mechanisms to make open innovation work. Our results indicate that open innovation–performance gains enabled by relational capability are even greater in an information-rich context. As we show in Fig. 3, when relational capability and network spillovers both are high, performance gains escalate. A firm that is well equipped to connect through external relationships is in a better position to garner and harvest resources from its networks. Beyond that effect though, when this superior connecting ability is activated in a knowledge-rich context, even more significant performance gains accrue. Put simply, a firm engaging in open innovation, with the ability to harvest external resources through boundary spanning, and with ample, rich knowledge and technology resources available in its network, enjoys markedly improved performance.

Third, with regard to slack, we anticipated that it would provide the flexibility necessary for the firm to respond as it engaged in open innovation, but we did not find support for the predicted relationship. Extant literature indicates a possibility of nonlinearity between slack and performance (Nohria & Gulati, 1996), so we also investigated this nonlinear effect, coupled with relational capability. As we show in Fig. 5, a particularly interesting finding emerged: Firms engaging in open innovation with high relational capabilities indicated a U-shaped influence of resource slack on performance. Somewhat counter to extant literature, we find what seems to be a threshold effect of slack when it couples with relational capability to influence the open innovation–performance relationship. Apparently, firms with superior relational capabilities enjoy performance gains from open innovation if they maintain little or no slack. Conversely, if they maintain slack, they must do so at some critical level before the performance benefits accrue. This threshold-like effect suggests that firms high in relational capability garner increased performance benefits from open innovation, if the relational capability is accompanied by adequate levels of slack. If firms cannot maintain this critical level, they may be better off staying lean in terms of slack and deploying their resources more efficiently and effectively elsewhere. The gains from open innovation, as facilitated by relational capability, are not necessarily diminished. Although this pattern of results from our data is logically appealing and informative, it is not consistent with extant literature.

5.2. Managerial implications

Managers of firms in business markets face numerous challenges, and the need to constantly innovate is omnipresent (Tellis, 2008). Our findings show that open innovation can stimulate this process under the right circumstances. Specifically, our findings provide several valuable insights to managers who consider the implementation of open innovation.

While we find overall support for the positive effects of open innovation on performance, the ability of the firm to maintain and develop external connections is the first critical enabler that explains higher levels of success. Since relationships take time to develop, managers must work on innovation concurrently with being engaged with their business environment. Here, relational capability can be viewed as the "net" that can be cast in order to capture the inputs from the environment. Without having developed an efficient and large "net," open innovation initiatives are less likely to be successful. So, firms and managers must devote sufficient time and the energy to develop all three dimensions of their relational capability. First, they need to develop the knowledge related to the initiation of the relationship, which entails identifying and contacting promising and trustworthy partners. Second, they also need to improve their interactional skills, such as their activities of negotiation, collaboration and problem resolution. Finally, they also need to have a clear understanding of the functions (i.e., cost reduction or speeding up delivery time) they plan to achieve through their collaboration with other firms.

Second, the presence of a knowledge-rich environment from which managers can select external inputs is important for open innovation given that it is premised in seeking out and gathering external inputs for innovating. Our findings suggest that relational capability enhances the benefits from open innovation even more when a firm operates in an environment that is rich in possible external inputs (i.e., network spillovers are greater). Since network spillovers can range from being costless to expensive, managers must identify sources of these inputs that not only resolve innovation needs but also provide value to the firm. Interestingly, our findings suggest that when there are fewer external inputs available via low spillovers (see Fig. 3), managers are unable to realize substantive open innovation-derived performance gains, regardless of their relational capabilities. Leveraging relational capabilities in efforts to access the limited external knowledge that is available does not make open innovation viable in terms of performance gains. Managers working in local environments characterized by poor knowledge flows and perhaps even barriers to IP access cannot rely on their superior relational capabilities to wring performance gains from open innovation. It may be ill-advised for managers in weak network spillover situations to engage in open innovation then. Perhaps these managers would be better served by relying on their own sources and keeping their innovation efforts confined within firm boundaries.

Third, our findings suggest that resource slack does not have a linear influence on the moderation of open innovation and performance by relational capability. These finding suggests that incremental improvements in the availability of slack resources might not result in net improvements in the performance of open innovation. In contrast, the U-shaped pattern found about the effects of resource slack suggests that performance gains could be obtained in two different manners. First, firms could consider maintaining a relatively high level of slack in order to leverage opportunities when they arise. We speculate that a high level of slack is needed because the incorporation of new inputs can create major changes within an organization, which could be expensive. Alternatively, if the appropriate level of requisite slack cannot be maintained, then managers should keep slack levels relatively low. Slack levels should be monitored, since we find in our data that resource slack can lead to a decrease in firm performance under many circumstances (Fig. 5).

6. Limitations and further research

Although we took great care in developing this study, a few limitations must be noted. First, though we used a forward-looking performance measure, other measures could be useful for gaining insights into the performance implications related to open innovation. Perhaps those focused on new product outcomes would be fruitful. Selecting appropriate measures for measuring success are important as some argue that firms will incur costs while following open innovation (Birkinshaw, Bouquet, & Barsoux, 2011). Second, our measure of resource slack as a proxy for flexibility reflected an accepted method, yet the complexity of findings related to slack continues to grow. Our results, which were not consistent with past research, reveal a novel, complex moderation effect. The issue of nonlinearity, particularly moderated nonlinearity, thus demands further research. Third, using survey data for some measures may be a limitation. By complementing these data with secondary data for the performance measure and other key variables and controls, we minimized issues related to common method bias, but as with all research, our results should be considered accordingly. Fourth, open innovation is a complex phenomenon. We believe we captured critical facilitating and enabling factors, but other effects could influence its effectiveness as a path to firm success. Fifth, open innovation, its contextual influences, and its performance implications may evolve over time. More could be learned about this important phenomenon with time-series or longitudinal approaches.

We also encourage research that examines the effects of *outbound* open innovation on firm performance. Our focus on inbound open innovation is not necessarily a limitation, but we recognize that the other facet of open innovation could play a role in explaining performance. Research on the usefulness and effectiveness of open innovation is in its nascent stages, leaving open various key issues. What are the antecedents of open innovation? More specifically, future research could consider organizational antecedents that can either enable firms to follow open innovation or lead to greater chances of success while following open innovation. Why would a firm consider open innovation? Our results hint that open innovation is not a panacea; without specific resources and capabilities in place, firms may struggle to realize gains from it. Thus, extremely important questions involve the downsides of open innovation (e.g., knowledge leakage, determining what to share and with whom, appropriating value from intellectual property, control of boundary spanning activities, costs of relationship management, etc.). Are the risks worth it? For example, knowledge leakage and appropriation will always be central strategic issues, yet open knowledge flows are fundamental for open innovation. What does this conflict mean for the firm? How can it define appropriate balances between knowledge sharing and knowledge guarding? These and other key questions continue to surround the notion of open innovation.

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Appendix. Measures

Inbound open innovation

In our firm, for our new product development, we (seven-point scale: 1 = "strongly disagree" and 7 = "strongly agree"; M = 4.85, SD = 1.26, Composite Reliability = .80, AVE = .51):

1. constantly scan the external environment for inputs such as technology, information, ideas, knowledge, etc.*
2. actively seek out external sources (e.g., research groups, universities, suppliers, customers, competitors, etc.) of knowledge and technology when developing new products.
3. believe it is good to use external sources (e.g., research groups, universities, suppliers, customers, competitors, etc.) to complement our own R&D.*
4. often bring in externally developed knowledge and technology to use in conjunction with our own R&D.
5. seek out technologies and patents from other firms, research groups, or universities.
6. purchase external intellectual property to use in our own R&D.

IR interactional knowledge stores

Please rate the extent of knowledge you believe your firm has in regards to (seven-point scale: 1 = "very little knowledge" and 7 = "lots of knowledge"; M = 4.78, SD = .96):

1. Negotiating with suppliers.
2. Interactions and contacts for partnering activities.
3. Developing and implementing cooperative programs with suppliers.
4. Building strong communication with suppliers through the use of networked computers.
5. Resolving disagreements with suppliers.

IR functional knowledge stores

Please rate the extent of knowledge you believe your firm has in regards to (seven-point scale: 1 = "very little knowledge" and 7 = "lots of knowledge"; M = 4.52, SD = 1.18):

1. Cost-reduction strategies involving suppliers.
2. Working with suppliers to reduce delivery times.
3. Working with suppliers on quality management.
4. Integrating suppliers into the firm's JIT system.
5. Enhancing suppliers' production capabilities and capacities.

IR initiation knowledge stores

Please rate the extent of knowledge you believe your firm has in regards to (seven-point scale: 1 = "very little knowledge" and 7 = "lots of knowledge"; M = 5.02, SD = 1.04):

1. Assessing the match between us and a potential exchange partner.
2. Developing relationships with partners.
3. Evaluating the benefits of a relationships with specific partners.
4. Figuring out when to commit to a partner.
5. Figuring out which exchange partner we can trust.

Network spillovers

In your industry, firms can easily expand their knowledge by (five-point scale: 1 = "not at all" and 5 = "to a large extent"; M = 3.39, SD = .62):

1. reading and following white papers.
2. participating in and attending conferences and presentations.
3. subscribing to professional journals.
4. taking advantage of turnover from other firms.
5. interacting with other firms within the industry.

Market turbulence

Please tell us the extent to which you agree or disagree with the following statements (five-point scale: 1 = "strongly disagree" and 5 = "strongly agree"; M = 2.94, SD = .74):

1. We cater to different customers than we catered to in the past.
2. In general, in this business unit (or division), market share is unstable among competitors.
3. Demand and customer tastes are not easy to forecast.

Technological turbulence

Please tell us the extent to which you agree or disagree with the following statements (five-point scale: 1 = "strongly disagree" and 5 = "strongly agree"; M = 3.23, SD = .95, Composite Reliability = .84, AVE = .63):

1. The technology in our industry is changing rapidly.
2. A large number of new product ideas have been made through technological breakthroughs in our industry.
3. In our principal industry, the modes of production and service change often.

* Item not included in final measures.
Notes: AVE = average variance extracted.

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