Knowledge Searching, Integrating and Performing: Always a Tuned Trio for Innovation?

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Abstract

External search strategies remain ineffective without the ability of the firm to communicate and share internally what has been absorbed from the environment. However, most of the literature remains silent on the advantages (and disadvantages) firms may get when they combine internal integration mechanisms and innovative management practices into their efforts to search for external knowledge inflows with the aim of product innovation. To bridge this gap, this work has investigated the external knowledge search practices firms deploy to innovate their products, exploring the relationships among the use of such practices, some internal organizational characteristics and innovation performance. In so doing, the paper raises two key findings. First, there is a complementarity between the use of search practices and practices used to facilitate horizontal cross-functional integration and to encourage, address and manage employees' efforts in generating new solutions to technical or market issues in the front-end of innovation processes. Second, taking into consideration the complementarity between external search and such internal organization mechanisms allows unveiling a quadratic effect stemming from the use of search practices on innovation performance. This "complementarity lens" also allows us to explore different configurations for managing the front-end of innovation processes and their related outcome on the innovation process. In this regard, we found evidence of some "indifference zones", where the effectiveness of the external search processes firms activate does not depend on the extent of the internal mechanisms firms use to absorb and articulate external knowledge.

Keywords: innovation performance, search practices, inbound open innovation, integration capabilities, knowledge-based view, survey

Introduction

CampBike Group (a fantasy name) produces mechanical technologies for professional road cycling. One day, Jacob Locke, a CampBike salesman, met a prospect customer at an international bicycle fair. The prospect was in search of a new shifting system for his company's project: developing a small electric bike for urban transportation. At that time, CampBike did not cover what was regarded to be an emerging market. The prospective customer's needs were for miniaturized components equipped with electronic controls for the bike's on-board diagnostics.

After the fair, Jacob went back to CampBike and began speaking with members of the New Product Development Area to assess the feasibility of a new shifting system. At first glance, the idea seemed promising and required the use of new and lighter material and a recombination of some mechanical components already developed. Then, Jacob and Richard Brown—from the New Product Development Area—decided to meet with two process engineers to assess the manufacturability of the new product. Jacob then contacted the customer in order to fix more precise technical specs. Jacob and Richard decided to formalize a business case for the new idea and to present the document in the next quarterly Innovation Committee, where employees advance new innovative ideas and ideas compete each other for getting budget for their development. The next selection came soon and there were many interesting new product ideas, such as new mechanical group sets for cyclocross bikes and waterproof components for the water gym market. The NPD vice president supported Jacob and Richard in developing a business case. He regarded their business idea as promising due to its expected market potential and capital expenditures for the Product Development project. The Committee was composed of the CEO, the Marketing and Sales Director, the CTO and the NPD vice president.

The idea presented by Jacob was chosen to enter the product development stage. After two months, a first prototype was shown to the customer, and further improved. After two years from the first contact between Jacob and the customer, the shifting system for the electric bike

represented 10% of the total revenue for CampBike, thanks to the acquisition of three new large customers.

Behind success cases like the invented story of CampBike there is the common wisdom that benefiting from external knowledge flows merely by being exposed to them is nothing more than unattainable hope (Cohen and Levinthal, 1990). This implies that successful open innovation models are based on more than permeable organizational boundaries and customers that determine the pace of product innovations.

In success stories, open innovation is usually described as having been triggered by a process of articulation of individual knowledge that depends on the social ties linking boundary spanning roles (i.e., the salesmen in the CampBike example) and external stakeholders (i.e., the prospect customer). However, limited attention has been focused on the lateral cross-functional linkages and formalized processes of knowledge management that support firms like CampBike in the process of knowledge articulation and storage that are critical to pursuing new market opportunities. Also, less attention has been focused on other critical managerial phases, such as setting priorities among the innovative ideas that are generated on the firm's organizational boundaries, and, for the development stage, selecting the ones more consistent with the firm's business strategy. Over-commitment of scarce resources can lead to dysfunctional outcomes, including longer product development times, poor products that do not entirely meet customer needs, and declining productivity of the human and intellectual resources deployed in product development (Austin, 2007).

The CampBike story thus reflects the common wisdom that external search alone can be ineffective—and even detrimental—to firm's innovation processes (Laursen and Salter, 2006), as firms may be not able to capitalize and apply the knowledge acquired outside because the search process may be simply inconclusive in increasing the firms' actual knowledge stock (Deeds and Hill, 1996; Katila and Ahuja, 2002; Laursen and Salter, 2006; Rothaermel and Alexandre, 2009;

Leiponen and Helfat, 2010; Sisodiya et al., 2013) due to firm's bounded rationality and limited internal information processing (March and Simon, 1958).

Despite the consensus on the importance of combining external search with appropriate internal mechanisms, the debate on the organizational configurations and organizational practices that allow firms to capitalize on knowledge acquired through external search is still open and increasingly important (Quintas et al., 1997; Escribano et al., 2009; Ihl et al., 2012; Brunswicker and Hutschek, 2010) due to the unprecedented levels of environmental complexity firms have been exposed during the last decade. Overall, this process of acquiring and using external knowledge internally can take a variety of forms (Barki and Pinsonneault, 2005) that have a different impact in the way firms assimilate and integrate knowledge resources. This article aims to enrich this debate by exploring the theoretical mechanisms and empirical evidence on how firms can develop internal practices to assimilate and exploit the knowledge absorbed through external search. This focus can shed light on the internal routines, practices, processes and systems typical of open innovation approaches that produce the desired results in terms of knowledge creation and achievement of new market opportunities (Huizingh, 2011). In so doing, we may add a contribution to exploring the microfoundations of an open innovation capability more comprehensively (Bierly et al., 2009; Laursen, 2012; West and Bogers, 2013).

Consistent with the structure of knowledge creation spirals in organizations (Nonaka, 1994), we focus specifically on two pillars of this cycle described in the stylized story of CampBike that have utmost importance in the fuzzy front-end of new product development. The first pillar is represented by the lateral linkages (e.g., project teams, liaison roles) aimed to facilitate communication between interdependent functions and increase information processing capacity (Daft and Lengel, 1986) in order to help firms integrating dispersed and contradictory signals, and allocate and combine knowledge resources across the units (Jansen et al., 2009). As such, we refer to these characteristics as "internal integration mechanisms". The second pillar is represented by

the processes through which firms set priorities among innovative ideas, and empower their line employees to search for new ideas through their interaction with the external environment. We label these processes "idea management practices".

Thus, the article analyzes how, in the fuzzy front-end of new product development, external search practices are combined with firms' managerial and organizational choices in lateral communication, internal entrepreneurship and prioritization, and assesses the impact of these choices on two dimensions of innovative performance: 1) knowledge created and applied for product innovation endeavors; 2) revenue from innovative products, which capture a firm's ability of capitalizing market opportunities that stem from open innovation.

This topic is explored on a sample that includes both medium-sized enterprises (MSEs) and large firms in Italian hi-tech industries. This sample composition reflects the traditional industrial structure of hi-tech sectors in Italy (Bonaccorsi, 1992), where, putting aside the micro and small companies, there is a still considerably high percentage of medium-sized firms. European statistics (European Commission, 2014) show that these firms are above the European union average in introducing product or process innovations (e.g., Verbano et al., 2013), a fact helping to explain their high incidence on the Gross Domestic Product created (i.e., 18%) by medium-sized enterprises in Europe-28 (European Commission, 2014). Their localization is mainly in geographical clusters, especially in the north and central Italy, specializing in mechanics, industrial machinery, software, biomedical, sport equipment, automotive, electrical equipment and pharmaceutical industry. In these clusters, medium-sized firms often exhibit a model of open innovation that reflects the imprint of industrial districts (Biggiero, 2002; Verbano et al., 2013), and as such have a great level of integration with local firms, institutions, universities and large transnational enterprises. As a result of these traits, medium-sized Italian firms are progressively adopting open innovation practices relying on external sources as a chance to get more innovative ideas.

In management studies, however, there is limited attention paid to how medium-sized enterprises are adopting open innovation models, and there is no clear disentanglement between whether they follow inbound or outbound models of open innovation models. In this regard, past literature have shown that medium-sized firms often tend to transfer technology to third parties because of the lack of complementary assets in manufacturing or marketing more complex product systems. This attitude raises problems of a limited appropriability of the returns of their innovation efforts, especially when they sell their products on international markets. Hence, the Italian MSEs provide the natural setting to carry out empirical investigations in an attempt to understand whether and how the trend is shifting towards the adoption of inbound open innovation practices (Parida et al., 2012), and whether they differ considerably from their larger counterparts in using formalized practices to exploit external knowledge.

In dealing with this topic, the article is organized as follows. Section 2 discusses the role that external search, lateral linkages and idea management systems can have in the process of knowledge creation triggered by scanning the external environment. Section 3 illustrates the theoretical mechanisms behind the hypotheses of a complementary effect between external search practices and the above-mentioned internal mechanisms. The methodology and the empirical evidence obtained are illustrated in Sections 4 and 5, respectively. Section 6 discusses the contribution this research has for research and managerial practice on open innovation.

Theoretical Background[1]

How to Search: Perspectives and practices. Innovative search is a process (Paananen, 2012) based on knowledge search, generation, integration and synthesis. There are many types of knowledge (Grant, 1996), and transfer and use of it from external sources may help in expanding firms'

[1] Literature review was carried out by Web of Science (WOS) and Scopus searching the following keywords: "external search," "inbound open innovation," "knowledge search," "external knowledge search" (searching in Topic concerning WOS, and Article Title, Abstract, Keywords concerning Scopus). We combined these searching keywords with "innovation performance," "Medium-sized Enterprises", "MSE" by means of the AND operator.

knowledge bases (e.g., Nonaka and Takeuchi, 1995), providing access to new ideas that promote the generation of new products and technology (Grant and Baden-Fuller, 2004; Rosenkopf and Nerkar, 2001), and affecting the firms' ability to earn economic rents (Spender and Grant, 1996). Of relevance then are product and service ideas, new ways of using them, new unexplored applications, supported by the analysis of emerging trends and changing scenarios (Kang and Kang, 2009).

In searching for external relevant knowledge, Phelps (2010) and Aloini and Martini (2013) illustrate that firms' behavior relate the perspectives of where to search and how to search. Contributions on the former perspective (*where*) entail choices concerning knowledge proximity along the value chain (e.g., local vs. distant search, adaptive search), knowledge attitude of agents (e.g., backward vs. forward looking, trial and error search, rational vs. heuristic search). It can also involve knowledge along different domains by means of recombinant search, rather than creating knowledge in co-evolving contexts and regimes.

Literature on the second perspective (*how*) digs into how firms should be organized to scan the external environment and use external knowledge inflows appropriately. The relevant elements in these organization design choices are designing the lateral coordination mechanisms and the decision-making systems that can foster the absorption of external knowledge (Demarest, 1997; Maes and Sels, 2014). The focus of this paper is on the "how" perspective, which is explored taking into account the practices used to search for and use relevant external knowledge and the way that the use of these organizational resources is institutionalized in firms.

External search practices. External search practices support the firm in developing effective and continuous collaboration linkages with the innovation ecosystem, as represented by universities, lead users, established customers, and experts with a high degree of specialized knowledge for a company. External search practices have a key importance in the fuzzy front-end of new product

development and can take different forms, such as technology trend analysis, customer trend analysis, market research, a continuing interaction with lead users and customers, ethnographic approaches to analyze how customers use current products (Koen et al., 2002). There are thus various ways through which the firm can use effectively the knowledge resources available in their innovation ecosystem and all of them entail an attitude towards experimentation (Rheinberger, 1997) and the exploration of different strategic scenarios (Kang and Kang, 2009; Oliveira and Rozenfeld, 2010).

In this same vein, external search practices are likely to be effective when they are used in bundles as *experimental systems* that entail a certain degree of decentralization in the decision-making power. Empowered employees can better scan the environment, identify potential opportunities of market growth through product innovation, and enact to lead the processes of internal and external collaboration that are needed to develop innovation ideas. As such, experimental systems are highly complementary with formalized mechanisms through which firms can encourage the generation of ideas of innovation and continuous innovation in their operating line (Anand et al., 2002).

Another crucial role in enacting search practices can come from the use of *ICT technologies in* supporting knowledge scouting. Recent literature has shown how ICT-based tools can support the creation of knowledge, which may concretize in Internet-based toolkits for idea competitions (Piller and Walcher, 2006), new technology product blogs (Droge et al., 2010). Developments of ICT favor the rise of flexible networks over hierarchical portals, and holistic knowledge systems over exclusive expert systems. By using Web 2.0 technologies, firms may either choose to interact with innovation communities, or to post innovation challenges on innovation platforms (Frey et al., 2011). ICT in support of external knowledge search offer tools to compare data, information and explicit knowledge, develop alternative scenarios, support online communities of practice, help make information and knowledge accessible based on people's social, cultural and educational

background (incorporating language translation, social translation, formatting tools, etc.). They should also help people to present their information and knowledge in appropriate and effective ways (Van der Velden, 2002). Finally, the potential of applications for the identification of lead users can be unlocked, especially for getting information concerning both the user experience and the product/service-related knowledge (Bilgram et al., 2008). Thus, the role of ICT becomes not only that of an artifact through which knowledge can be articulated, stored, shared, and retrieved, but also through which firms can enlarge their social networks in search for new relevant knowledge.

In the perspective of organization behavior, external search practices support the sense-making efforts of relevant environmental trends when they become institutionalized in firm's processes and routines. *Institutionalizing* can unlock both the individual and collective intentionality in acting, and ascertains how to look beyond the boundaries of the firm (Smith and Searle, 2003). An external search attitude in the front-end of innovation becomes institutionalized when the firm appoints someone to scout external ideas; when dedicated task forces are appointed to combine or recombine external knowledge; when employees at all levels regularly attend conferences, workshops, seminars, technology fairs in order to cross-fertilize their ideas with new ones coming from tightly or loosely related fields of interests (Felin and Foss, 2009); and, when dedicated budgets, spaces and time slots (e.g., Google's rule on "20% time") allow employees to work on side projects of exploration and experimentation.

Internal practices: Integration mechanisms and idea management. Decisions made in the product development process require heterogeneous knowledge, such as customer preferences, product design or local market requirements. As a result, individuals involved in this process specialize in tasks. Internal integration mechanisms are thus needed to bring "around the same table" employees with expert knowledge relevant to decisions. In terms of organizational knowledge creation,

internal integration mechanisms allow knowledge articulation, consisting of deliberate efforts to articulate and share the experiential knowledge developed from the enactment of external search routines (Zollo and Winter, 2002).

Various internal integration mechanisms have been identified in innovation studies (Huston, 2004; Foss et al., 2013). The formation of dedicated teams to research and implementation of externally sourced ideas, the use of "network ambassadors", boundary spanners, gatekeepers, and project brokers (De Brentani and Reid, 2011), who can help innovation teams connect with other people company-wide when new knowledge or insight is needed. These mechanisms can facilitate more fluid communication and knowledge flows within the organization and can thus contribute to knowledge combination and the sense-making effort (Weick, 1993; Dhanaraj et al., 2004). In the stylized example of CampBike, the strong social ties that promote communication and collaboration among employees in different functions of the firm allow the organization to make a sense of the prospect customer's requests and to assess their technical and market feasibility.

Internal integration mechanisms can also take the form of informal social networks and norms for collaboration (e.g., Gupta and Govindarajan, 2000). All these mechanisms can support firms in integrating fragmented and widely dispersed knowledge, a task that poses serious challenges to organizational routines at all levels: time and other resource requirements increase; firms, as agents with bounded rationality (Simon, 1955), lose overview (Egidi, 1996); knowledge possessed by different organizational actors becomes asymmetric (Fransmann, 1998); structural uncertainty and ambiguity rise as decision makers cannot *ex ante* specify all relevant alternatives or outcomes (Minkler, 1993). This process of use of external knowledge becomes even more difficult when knowledge is tacit (Zander and Kogut, 1995), affected by causal ambiguity (Szulanski, 1996) and complexity (Hansen, 1998; Sorenson et al., 2006).

Knowledge integration within the organization is thus the process of translating the raw knowledge into actionable knowledge by means of an acute understanding of the business context. Such a translation necessitates of the establishment of a closely linked series of organizational routines of knowledge integration and recombination (Costello, 1996; Grant 1997). Following the Knowledge-based View of the firm (KBV) (Grant, 1996), these routines, in their long-term development, rise barriers for competitors as the greater the span of knowledge being integrated and the more sophisticated the integration mechanisms, the more difficult is it for any potential rival to accomplish replication. However, internal integration mechanisms might allow companies to replicate knowledge internally, paving the way to a future stream of innovative outcomes. Also, in terms of organizational design, the KBV suggests that new product development teams can be structured depending on their tacit and explicit knowledge bases, fluidity of team membership and structure of hierarchies. At a higher level, cross-functional coordination and the deployment of functioning interfaces are required.

Products with a complex architecture entail a complex task structure in product development with a system of interrelated decisions and communication flows that involve different actors (Henderson and Clark, 1990). In these types of contexts, hiring people with different background and integrating mindful that *diversity* can be considered a key factor in the promotion of beneficial forms of innovation and growth, a means to hedge against exposure to strict uncertainty and cognitive bias in decision making over alternative searching strategies, a tool for mitigating the adverse effects of lock-in in long term technological trajectories, and a way of accommodating the disparate array of interests and values (Stirling, 1998). But, it is also true that too much diversity becomes detrimental for any innovative activity to start. Recalling Ross Ashby's Law of Requisite Variety (1958), we might interpret the link between external searching and internal integration and generation mechanisms as follows: the variety of stimuli impinging upon a system must be countered by the variety of responses the system can muster (Boisot and

MacMillan, 2004). In other words, to deal properly with the diversity of challenges the world can throw at any company, firms should be able to enact a repertoire of responses as nuanced as the challenges they face. Then, another useful internal integration mechanism firms should have in order to use external knowledge effectively are *filtering processes* that distinguish relevant information from noise. Such filters can allow firms to keep their strategic focus when they process external information and absorb external knowledge.

In terms of creation of organizational knowledge, organizational learning cycles cannot solely work through the knowledge articulation made possible through internal integration mechanisms. Knowledge codification efforts are needed to develop artifacts and codes (e.g., manuals, post-mortem reports) from the articulated knowledge. Idea management practices can serve for codifying knowledge coming from external search, impeding its depletion due to forgetting processes (Walsh and Ungson 1991,) and low managerial attention. They allow the firm to rely on the creativity, the entrepreneurial attitude and the motivation of all the employees. More specifically, idea management practices can be conceptualized as the process of recognizing the need for ideas, subsidizing, generating, evaluating and prioritizing them (Gamlin et al., 2007; Vandenbosch et al., 2006; Flynn et al., 2003). Some key issues involved in idea management deal with information acquisition and processing, but also devising incentive systems to reward ideas coming from employees. It needs to address the types and processes of interaction associated with ideas. Brem and Voigt (2007) see idea management as a phase aimed at a systematic coordination, linked to strategic ideas, with other operational instruments of rationalization and innovation advancement. Hence, idea management can be conceptualized as an organizational process that structures members' acting and thinking towards stability and/or change. Then, the concept of idea management aims to enhance the cultivation and use of creative ideas from employees (Fairbank and Williams, 2001). Idea management practices should be understood as all actions an

organization undertakes in order to signal, evaluate, and reward ideas, and to bring the further into the organization where they can be implemented.

Hypotheses

As in the opening example of CampBike, external knowledge search practices, idea management practices and internal integration mechanisms can represent three interrelated organizational building blocks of successful open innovation approaches (see Figure 1 on our conceptual framework).

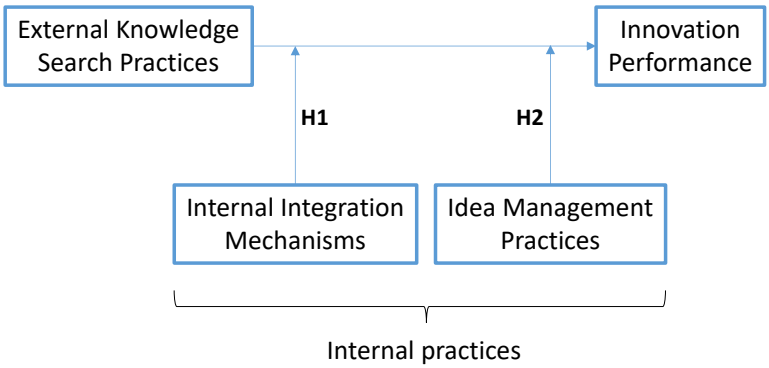

Figure 1. Theoretical framework

Our purpose is to explore theoretical insights and empirical evidence of the complementarity effects (Caloghirou et al., 2004; Cassiman and Veugelers, 2006) external search practices may have with the internal mechanisms used by firms to articulate, codify, integrate and select external knowledge coming from the external environment. This complementarity idea lies in the attributes of knowledge as a quasi-public good (Oliver, 1997) whose use as a strategic resource for the firm entails reproduction and diffusion processes that cannot be taken for granted. Since knowledge "is essentially dispersed, and cannot possibly be gathered together and conveyed to an authority charged with the task of deliberately creating order" (Hayek, 1988, 77), internal integration mechanisms and idea management practices can support firms in collecting and using knowledge inflows absorbed through external search practices. This is like saying that these "internal variables" play a moderating effect in the relationship between the search for external

knowledge in the front end of innovation and innovation performance. A theoretical explanation for this moderation effect is proposed in the following.

Why external search practices need internal integration mechanisms. There are a number of specific arguments for believing that the extent to which a firm can screen, value, and utilize externally sourced technologies depends on the level of its internal integration-generation mechanisms. External knowledge needs to be processed, assimilated and transferred by the organization in order to get an effective innovation impact (Cohen and Levinthal, 1990; Grant, 1997; Eisenhardt and Santos, 2001). Following the argument of absorptive capacities literature (Cohen and Levinthal, 1990; Jansen et al., (2005), external search strategies remain ineffective without the ability of the firm to communicate and share internally what has been absorbed from the environment. In this regard, Arora and Gambardella (1994) have illustrated that firms may need internal know-how to use external know-how effectively. According to de Brentani and Reid (2011), information flows in the early development of innovations move from the environment into the firm only when it is facilitated by boundary spanners that act as crucial cross-functional interface (Ancona et al., 2002; Keller and Holland, 1975).

In a knowledge-based perspective (Grant, 1991), integration mechanisms are a foundation of the combinative capabilities (Kogut and Zander, 1992) that allow firms to synthesize and apply current and newly acquired external knowledge. As such, they are of utmost importance when firms need to integrate knowledge from different technological, scientific and market domains (Zhou and Li, 2012; Martini et al., 2015), or deal with changes in product architectures that, to a great extent, involve customers' requirements (Henderson and Cockburn, 1994).

Firms may increase the effectiveness of external search practices through the use of internal integration mechanisms also due to the role integration practices can have in supporting employees' effort of sharing and articulating external knowledge by strengthening their social ties.

Through these mechanisms, employees are engaged in debriefing efforts or in knowledge codification efforts that force them to ask questions about the value of external knowledge inputs and on the problems arising in their use for new product development. In this process of sharing and articulating knowledge and combining it with internal know-how, employees can collectively unveil some of the causal ambiguity that pertains to product development activities, and to how products fail in meeting customer's requirements (Romme et al., 2010). These efforts of knowledge articulation can raise the level of mindfulness about the effectiveness of external knowledge, and draws attention to the need to respond to external changes. The articulation efforts can be especially needed in medium-sized enterprises (Lane et al., 2006; Muscio, 2007); in these settings, absorptive capacities comprise a set of non-stable organizational routines (Costello, 1996) and processes for this purpose (Zahra and George, 2002; Liao et al., 2003).

A further set of arguments for the importance of combining external search and internal integration mechanisms lies in the need for balancing knowledge articulation and external knowledge search efforts, which can be conflicting goals for some organizations. The more time and resources employees and managers invest in knowledge articulation, the less time and resources they will dedicate to the actual experiencing of interactions with the external work. In this respect, balancing external search and internal knowledge processing can be the basis for the sense-making effort described by Weick (1995).

Based on these arguments, we may expect a positive interaction effect on innovation performance due to the use of external search practices and internal integration mechanisms. In a perspective of absorptive capacities (Su et al., 2013), this can happen, since external knowledge absorption enable firms to predict future developments more accurately (Cohen and Levinthal 1994), allowing them to engage in exploratory innovation activities through unpredictable or rare combinations of resources. This can have a dramatic impact on innovation performance, seen in

terms of knowledge created that is immediately fungible for product industrialization, and in terms of the firm's capacity to seize new market opportunities. Based on these arguments:

> *H1. Internal integration practices positively moderate (interaction effect) the impact of external search on the innovation performance.*

Why external search needs idea management practices. Organizations active in new product development work must have a system of sorts to keep the flow of ideas coming (Conway and McGuinness, 1986). Idea management practices respond to this need and create what Nielsen (2011) calls architecture of attention, used to not dispose of the external search efforts, catalyzing them towards recombination that makes more sense from an economic standpoint, according to the resources available to the company. This architecture of attention is built on incentives, financing systems, and R&D budget prioritization mechanisms, workflow rules to propose ideas, give comments and discussions (to discover shortcomings within the original idea and to develop and improve it), ratings (used for filtering the best ideas), grouping and clustering (helping to keep track of idea submissions), and status assessments (assign an explicit development state to each idea). These systems may support firms in activating the virtuous circle starting with getting new knowledge till creating a conversational critical mass of actors, who, harnessing the latent micro-expertise of its components (i.e., employees), find innovative solutions that would not be possible to generate with only the internal integration mechanisms (Sandström and Björk, 2010). This critical mass rapidly explores a much larger area of ideas and knowledge than any individual could do on their own. In so doing, idea management practices provide directions for external search and allow firms to reach a state of designed serendipity where, instead of being an occasional fortuitous coincidence, serendipity becomes commonplace. In other words, idea management practices can provide the necessary infrastructure to run external search practices appropriately, and to ensure

that firms are adaptive to opportunities and have flexible strategic-making processes (Zhou and Wu, 2010). Then, the probability of finding the most advantageous and competitive knowledge recombination drawing on external knowledge is higher when the idea management practices work not only as a catalyst, but also as organizer of attention, expertise and incentives.

As early ideas of product innovation can be very fragile, and may not even be put forward for consideration (Baker and Freeland, 1972), idea management practices are needed to reverberate and absorb ideas inflow, especially when the “not-invented-here” syndrome may lead organizations to discard preliminary ideas that come from external exploration and scanning. Furthermore, ideas go through transformation or "translation" by host institutions (Morris and Lancaster, 2006). Translation is the process whereby an idea or a management principle is transferred and reinterpreted in a new setting (Czarniawska-Joerges and Sevón, 1996; Sahlin-Andersson and Engwall, 2002). Carriers of the idea and hosts collaborate to redefine or privilege certain practices, and discard others. New management ideas thereby sediment with longer-standing ones (Morris and Lancaster, 2006). The use of the concept of translation also draws on the work of Latour (1986) to denote the transfer and rendering of something into a different form via a chain of actors, a process involving senders and receivers and the transformation of an idea into practice. Individuals and organizations need to coordinate all these idea management mechanisms in order to leverage the search phase inputs.

The importance and the complexity of the idea generation and management mechanisms reverberate along the external search phases to avoid the risk that the economic potential of an innovation idea is assessed based only on the judgment of one or a few individuals, or does not encounter a broad circle of preliminary support within the organization (Conway and McGuinness, 1986). In other words, idea management practices can support the credibile seeking of ideas, and they can mitigate cognitive bias that can lead to the rejection of “false negative” ideas or the superficial assessment of “false positives.” These are induced by fads and managerial fashions, or

by “neighbor’s greener grass” effect (Chesbrough et al., 2006). For the assessment of external ideas, gatekeepers can have a crucial importance, since they are the first to introduce and assess external ideas within the organization (Allen, 1977). In a similar manner, what recent studies identify as the “project broker” plays a role of utmost importance for discontinuous innovation, since by enacting their social ties he conducts a first formal screen for a new product development project and determines whether the concept moves further along into the formal new product development stages. After a first screening, gatekeepers or project brokers can enact a more intensive process of internal and external search, if more search was deemed necessary. Usually, the problems needing more intensive search relate to whether or not a sufficiently large market existed, the missing technological link is solvable, or the production process can be mastered, etc. To investigate these problems usually required a specific approval for the use of company resources. These considerations highlight that the use of internal integration mechanisms and idea management systems are deeply intertwined in making open innovation a systemic approach.

Idea management practices can thus strengthen the quality and depth of the decision-making process in the screening stage of innovative ideas. This should prevent firms from applying a “garbage can” model (Cohen et al., 1972) in decision situations about innovation, or from using rigid and inappropriate evaluation metrics that can limit a firm’s capacity for experimentation and exploration (Sethi and Iqbal, 2008). Existing studies (Cooper, 1988; Feldman and Page, 1984; Krishnan et al., 1997; Langerak et al., 2004; Parry and Song, 1994; Pavia, 1991) also emphasize how difficult the evaluation and selection of new product ideas is, because of the relatively high levels of complexity and uncertainty that characterize the screening stage (Froehle et al., 2000). From this perspective, idea management systems should help companies in taking the most of the different cognitive styles and managerial attitudes (Alam, 2003) towards innovations of the participants to decision situations. Vandenbosch et al. (2006) identify different archetypes of participants to innovation decision situations, who differ in behavioral traits, like the use of

analytical approaches, visionary attitude, and consensus-seeking in decision-making processes that regard innovation choices.

Based on these considerations, we may expect that employees' involvement in external search can be more effective in knowledge creation, and in supporting their firm's strategic flexibility, when external search is combined with a formal management system for generating, developing and selecting innovative ideas. Thus, we advance the following hypothesis:

H2. Idea management practices positively moderate (interaction effect) the impact of external search on the innovation performance.

Why we may expect curvilinear effects of external search practices on innovation performance. We might expect that the returns on innovation performance from the development of external search practices along with the internal mechanisms described above are not linear, but follow an increasing marginal rate above certain levels of implementation of search practices. The idea of curvilinear returns from innovation efforts is well-rooted in recent innovation studies. Laursen and Salter (2006) show the inverted U-shaped effect on innovation performance due to external search. Diericks and Cool (1989) have theorized how the dynamics of intangible assets accumulation are path-dependent and subject to time compression diseconomies (Knott et al., 2003), whose effect on performance is not linear. Romme et al. (2010) theorized how knowledge codification and articulation efforts can have increasing marginal returns on the development of new routines, or decreasing effect at high levels of knowledge articulation due to a coercive effect induced by the bureaucratization of knowledge management (Adler and Borys, 1996). The idea of nonlinearity in returns also lies in the complexity of the asset stock accumulation dynamics that characterize the development of an open innovation system. As this type of approach entails firms to enact a complex bundle of practices that can be developed gradually over time, firms may not see effects

in innovation performance at lower levels of implementation of practices for external search and internal integration.

An implication of these arguments is that internal integration mechanisms and idea management practices may prevent firms from over-search problems (Laursen and Salter, 2006). This means the inverted U-shape relationship between the extent of external search and innovation performance can be more evident for firms that are poor in their internal integration mechanisms on in managing their decision-making processes on innovation projects.

Research Methodology

Sample and data collection. To test the hypotheses, we used survey data collected in a study of medium high-tech Italian firms (selected according to the OECD classification). We then used the AIDA dataset (i.e., the main repertoire for financial information on Italian firms) to randomly extract 500 firms with more than 50 employees.

Data collection took place through an online survey between May 2009 and February 2010. We contacted each of the 500 selected firms by phone to introduce the research initiative and identify respondents, who were either R&D department's vice presidents, or CEOs. Of the 500 surveys mailed in Italy, we received 112 responses (22.4% response rate), of which 88 with responses on the scales useful for the analysis presented in this article. The sample of 88 enterprises analyzed in the article is composed by 41 large-enterprises, of which 13 are local units of large transnational enterprises having a median size equal to 106 employees. The remaining 47 respondents are medium-sized enterprises (i.e., their number of employees range from 50 to 250 employees) whose median size is 115 employees. Table 1 reports the sample composition by industry type and size.

To test the non-response bias we compared the responses of early and late respondents groups by t-tests, which yielded no statistically significant differences (at 95% confidence interval)

in terms of size, labor productivity and incidence of intangible assets over their fixed assets. We could thus claim that respondent firms are comparable to non-respondents in many structural traits, including their attitude towards innovation. Moreover, we compared responses given by CEOs and the other types of respondents, without finding any systematic response bias due to the respondent role.

Table 1. Sample composition by industry type and size range

Industry	**No. firms**	**Size**	**No. firms**	**Units belonging to large corporate groups**
Pharmaceuticals	6	50-100 employees	33	9
Scientific instruments	2	100-250 employees	27	4
Mechanics	27	250-500 employees	12	n.a.
Electrical machinery and equipment and apparatus	23	500-1,000 employees	9	n.a
Chemicals	14	More than 1,000 employees	7	n.a.
Other manufacturing (e.g., sport equipment, domestic appliances, etc.)	12			
Software and IT services	4			
Total	100%	Total	100%	

Measures and construct validation. For construct operationalization we used multi-item scales that are well-consolidated in literature (see Tables A1 and A2 in the Methodological Appendix). We used five-point Likert scales with end points corresponding to strong disagreement and strong agreement respectively. The scale scores accounts for the mean value of the items. We also assessed a reliability test on all the item groups pertaining to each construct, through Cronbach's alpha test and Confirmatory Factor Analysis (CFA) using Principal Component extraction with Varimax Rotation. Although some refinements were necessary, all the expected constructs were confirmed and we dropped only a few items out (i.e., the items with no loadings reported in the following tables). Cronbach's alphas of the constructs resulted in the range between 0.65 and 0.82, therefore indicating an acceptable degree of reliability (Nunnally, 1978).

Dependent variables. As explained above, two measures of innovation performance were taken into account. *Innovative Knowledge Creation* was operationalized as an intermediate outcome of

organizational learning processes. As such, we operationalized it through the learning constructs used by Zahra et al. (2000) and Atuahene-Gima (2005). In this context, knowledge creation reflects: a) a firm's technological and market learning in both familiar and new domains; and, b) the development of new organizational competencies (Dosi and Teece, 2008)—or the enrichment of pre-existing ones—that are applicable in product development processes. In this perspective, organizational competencies refer to shared pieces of knowledge and routines concerning the governance of coordination and social interactions within the organization and with outside entities (Dosi et al., 2008, 1170). Coherently with the importance of innovation in both the domain of incremental and radical changes, we considered both the exploratory and the exploitative dimensions of knowledge creation in innovation processes, which refer to radical and incremental innovation, respectively. To consider a firm's capacity to generate knowledge in these two domains, we referred to the traditional approaches in empirical studies on ambidexterity, by computing the average of the factor scores in the exploration and exploitation dimensions.

Our second measure of innovation performance was the *Revenue from Innovative Products*, which as operationalized as the share of sales revenue in 2009 stemming from radical and incremental product innovations introduced between 2007 and 2009. This measure is commonly used as a dependent variable in studies on the determinants of innovation performance (e.g., Atahuene and Gima, 2005; He and Wong, 2009).

Independent variables. In order to operationalize external search and internal mechanisms for knowledge articulation and storage as practices (i.e., the how-to-search), we referred to the fuzzy front-end literature. This literature makes a distinction between idea generation and idea management processes. Idea generation refers to opportunity identification and analysis carried out mainly by external search. Idea management is the process of capturing, storing and organizing ideas adopted in the late front-end process. A total of 28 items were generated from both literature

and 80 case studies developed by the Innovation Lab scholars. I-Lab is an international learning network (www.innovation-lab.org) covering around 200 firms in 12 countries, which acts as a co-laboratory (Bessant and Tsekouras 2001). Literature analysis and case studies led to identify external search practices, idea management practices and internal integration mechanisms as three separate theoretical constructs. The operationalization and measurement scales for these constructs were validated in a recent study (Aloini et al., 2013), and are synthetized in the Methodological Appendix.

The use of *External Knowledge Search Practices* refers to two distinct dimensions that were identified through a second-order component analysis. The first dimension takes into consideration the firm's openness towards the market and refers to the use of practices such as focus groups with lead users, market research, technology forecasting analysis, observation of the product in use, etc. The second dimension looks at the technical dimension of product innovation and takes into consideration the firm's openness towards potential and current technology partners. As such, it considers the use of technology gatekeepers, to the use of innovation intermediaries, to the participation of R&D employees at technology fairs.

The use of *Idea Management Practices* takes into account a broad array of organizational mechanisms to support the generation, the selection and the financial backing of innovation ideas that have a high economic potential and a clear strategic consistency. As such, we included in this measure the use of incentive and resource allocation mechanisms for innovative side projects (i.e., budgets, task forces), resource prioritization methods, empowerment systems to encourage ideas from employees at all levels, and the deployment of centralized systems with feedback loops for submitted ideas.

The extent of use of *Internal Integration Mechanisms* was operationalized by looking at the use of practices facilitating cross-functional interfaces and heterogeneity of skills and background in the workforce. More precisely, we looked at the extent of use of practices able to

routinize such a diversity within organizations, or able to arrange ad-hoc innovative teams by leveraging the role of gatekeepers and boundary spanners.

Control variables. We looked for possible confounding effects due to size, the ratio of R&D spending on annual turnover, capitalized intangible assets, firm age, market dynamism and hi-tech sectors, since these factors can influence resource management strategies in innovation processes and their impact on performance. Size (considered both in terms of number of employees and revenue), age and R&D spending were considered in a logarithmic form. We operationalized dynamism with a multi-items 5-level Likert scale (Birkinshaw et al., 1998; Jaworski and Kohli, 1993; Dill, 1958; Volberda and Van Bruggen, 1997) by making reference to how frequently customers ask for new products and services, changes in technology and product/services occur, and volumes of products and services to be delivered change.

Analysis methods. In order to test the research hypotheses, we chose hierarchical regression techniques in Stata 11. Hierarchical regression adds controls, explanatory variables and joint effect terms incrementally to gauge relative contributions. Tobit models were used when sales revenues from new products were taken into account as a dependent variable. For all models, we adopted an additional sensitivity check in order to deal with the limited size of our sample, using bootstrap resampling to generate estimates and robust standard errors. When using a small sample, we can underestimate standard errors, and the regression coefficients can become statistically significant, although they may not be so in the bootstrap methods environment, where the normality assumptions relied upon with large samples are not required. In other words, bootstrapping resampling may provide significantly robust (and thus more prudent) estimates.

Findings

Descriptive statistics. Table 2 shows the descriptive statistics. Table 3 reports the Pearson correlation coefficients. The overall evidence stemming from descriptive statistics shows some key facts. First, firms in the sample on average exhibit a strong attitude towards innovation, being on average the revenue share stemming from new products on average equal to 59.7% and R&D spending equal to 15.2% of revenues. Consistent with this fact, the level of environmental dynamism experienced by firms in the sample is high (mean value: 3.694), and the firm attitudes towards external search are high as well (mean value 3.562 on a scale with a maximum value of 5). External search resulted having a high correlation with both internal integration and idea management systems. Quite surprisingly, neither the use of external search practices or the presence of idea management systems resulted correlated with environmental dynamism. Instead, a positive—albeit weak—correlation emerged between dynamism and the degree of internal horizontal integration in knowledge use. In a similar way, both internal practices and external search are not correlated with size: medium-sized firms do not show considerable differences with large enterprises for what regards the three dimensions of open innovation approaches under analysis. This could be due to the high attitude to innovation that medium-sized firms have in Italy, which make them comparable to their larger counterparts. Also, despite their greater availability of resources, large enterprises can face more difficulties in enacting practices of external search, internal integration and idea management, since they face a higher organizational complexity and they are more likely to deal with bureaucratic rigidities.

We also noticed the absence of a significant correlation between the two innovation performance variables. A scatter plot analysis and a regression analysis showed a significant—albeit weak—U-shaped effect of innovative knowledge creation and revenue from new products[2].

Table 2. Descriptive statistics

	Variable	**Mean**	**std. dev.**	**min**	**Max**

[2] Regression estimates and scatter plot showing the U-shaped relationship linking innovative knowledge creation from the revenue share from new products are not reported to conserve space. They are however available upon request to the authors.

Control variables	Size (log)	2.409	1.003	0.85	8.24
	Age (log)	2.828	0.968	0	4.45
	Revenue 2005-08 (log)	4.593	.5663	2.968	5.958
	Intangible assets (log)	6.262	2.389	0	14.90
	R&D spending	0.152	0.178	0	0.806
	Hi tech sectors	.102	.304	0	1
	B2B specialization	.863	.345	0	1
	Dynamism	3.694	.727	1.667	5
Search practices	Idea Management Systems	3.093	.836	1.166	4.667
	External Search	3.562	.656	1.8	5
	Internal Integration	3.096	.928	1.25	5
Innovation Performance	Innovative knowledge creation	3.139	.633	1.3	4.55
	Revenue from innovative products	59.768	24.971	0	100

Hypotheses validation. Beyond testing our hypotheses, we also assessed whether the use of external search practice has some quadratic effects on innovation performance, and whether this effect is more evident when internal integration mechanisms and idea management practices are taken into account as moderators in the relationship between external search and innovation performance. Models 1 and 2 (Table 2) show a negative—albeit weak—quadratic effect on innovative knowledge creation due to the use of external search practices. Models 7 and 9 (Table 3) show the presence of a clearer inverted U-shaped effect on sales revenue from product innovation.

With regard to the first-order effect related to the use of internal integration mechanisms, all the models in Table 3 showed that the use of internal integration mechanisms has a positive first-order effect on innovative knowledge creation. Instead, we did not find any evidence of an effect of internal integration mechanisms on revenue generation from innovative products (see Table 3). Models 3 and 4 in Table 3 showed a positive effect on the amount of innovative knowledge created due to the interaction between the extent of use of internal integration mechanisms and the quadratic term related to the adoption extent of external search practices. Figure 2 illustrates this interaction effect as estimated by the regression model, and shows a quadratic effect of the use of external search practices on innovative knowledge creation that is more evident the higher the use of internal integration mechanisms. The same type of effect can be noticed when the revenue share from new products is taken into account as a dependent variable.

Model 10 (see Table 4) shows a positive and significant coefficient for the interaction term between the quadratic term for the use external search practices and internal integration mechanisms. Figure 3 illustrates this effect and shows that for a high use of internal integration mechanisms the effect of external search practices on innovation performance follows a U-shaped effect. Both Figure 2 and Figure 3 show that firms using internal integration mechanisms extensively achieve better innovation performance when they apply practices for external search broadly or when they exhibit a low degree of openness towards their external environment. These plots also show that, for firms with a limited use of internal integration mechanisms, the extent of use of external search practices has an inverted U-shaped effect on innovation performance. Therefore, firms that have a limited internal openness are more likely to fall in over-search problems when they apply external search practices extensively. Putting these results together, we can conclude that Hypothesis H1 is supported, and that the positive moderation effect exerted by the use of internal integration mechanisms becomes evident when the quadratic effect of external search on innovation performance is taken into account.

In Hypothesis H2, we claimed that the use of idea management practices could have a positive moderation effect in the relationship between the use of external search practices and innovation performance. Model 6 shows a positive and significant coefficient associated to the interaction between idea management systems and the quadratic term for the use of external search practices when innovative knowledge creation is considered as dependent variable. Figure 4 illustrates this interaction, thereby showing that a positive quadratic effect on innovation knowledge creation due to the use of external search practices in the presence of systems for encouraging and managing idea generation in firms. Similar to what occurs for the moderation effect of internal integration mechanisms, when firms exhibit a limited use of idea management practices, external search practices have an inverted U-shaped effect on innovation performance, thereby suggesting the presence of over-search phenomena. When we shift the lens on revenue

share from new products as a measure of innovation performance, we have confirmation of the positive moderation effect due to idea management practices in the relationship between external search practices and innovation performance. However, this positive moderation occurs only when the first level effect of external search practices is taken into account (Model 11), but it does not apply to its quadratic term (Model 12). Figure 5 illustrates this interaction graphically, showing the presence of a complementarity effect between external search practices and idea management systems, and a negative effect on innovation performance due to a configuration combining a high use of external search practices with a limited use of idea management systems. Lastly, it is worth noticing that the first order effect of idea management systems on the two measures of innovation performance is not significant. This reinforces the idea that the value of idea management practices lies not in their standalone role. but rather in their complementarity with practices aimed at an effective knowledge searching. Thus, putting together these results, we can conclude that hypothesis H2 is confirmed.

Table 3. Impact of external search practices, organizational configuration on innovation performance. Dep. var.: innovative knowledge creation. Robust Std. err. in parentheses.

	Hypotheses	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Constant		2.902*** (0.719)	2.307*** (0.589)	2.471*** (0.584)	2.418*** (0.637)	2.992*** (0.692)	2.924*** (0.867)
Size (log)		-0.272* (0.129)	-0.281* (0.129)	-.260 (0.127)	-0.209† (0.127)	-0.254* (.128)	-0.212† (0.128)
Age (log)		0.072 (0.055)	0.077 (0.051)	0.071 (0.050)	0.081 (0.055)	0.075 (0.052)	0.085 (0.053)
Revenue 2005-08 (log)		0.157 (0.178)	0.183 (0.182)	0.155 (0.180)	0.132 (0.186)	0.154 (0.174)	0.142 (0.187)
R&D spending		0.893** (0.2)	0.871** (0.29)	0.812** (0.302)	0.801† (0.350)	0.376** (0.204)	0.612† (0.312)
Intangible assets (log)		0.018 (0.031)	0.014 (0.030)	0.111 (0.302)	0.007 (0.030)	0.016 (0.030)	0.017 (0.030)
Hi tech sectors		-0.201 (0.183)	-0.215 (0.184)	-0.229 (0.171)	-0.285 (0.175)	-0.217 (0.177)	-0.223 (0.187)
B2B specialization		0.024 (0.219)	0.106 (0.192)	0.007 (0.187)	0.073 (0.184)	-0.004 (0.003)	0.094 (0.192)
Dynamism		0.087 (0.057)	0.076 (0.051)	0.078 (0.049)	0.080 (0.047)	0.089 (0,057)	0.103 (0.053)
Idea Management Practices		0.062 (0.105)	0.085 (0.105)	0.074 (0.109)	0.073 (0.106)	0.071 (0.103)	0.005 (0.107)
Internal Integration		0.244* (0.105)	0.259* (0.102)	0.242* (0.101)	0.169 (0.115)	0.263* (0.105)	0.226* (0.107)
External Search		0.105 (0.115)	0.079 (0.109)	0.091 (0.113)	-0.069 (0.124)	0.103 (0.113)	-0.035 (0.124)
External Search Squared		….	-0.093† (0.054)	…	0.006 (0.110)	….	-.452* (0.210)
External Search X Internal Integration	H1	….	…	-0.107* (0.060)	-0.075 (0.132)		….
External Search Squared X Internal Integration		….	….	….	0.127* (0.052)	….	….
External Search X Idea Management Practices	H2	….	…	….	…	-0.098† (0.054)	0.011 (0.121)
External Search Squared X Idea Management Practices		….	….	….		…	0.127* (0.055)
F Test		6.34***	7.32***	7.59***	9.41***	6.69***	7.90***
R Square		52.72%	50.89%	51.19%	54.86%	52.20%	55.23%

*† p-value<10%; *p-value<5%, **p-value < 1%, ***p-value < 0.1%*

Table 4. Impact of external search practices, organizational configuration on innovation performance. Dep. var.: revenue share from innovative products. Robust Std. error in parentheses. Estimate through Tobit regressions.

	Hypotheses	**Model 7**	**Model 8**	**Model 9**	**Model 10**	**Model 11**	**Model 12**
Constant		59.859*** (6.632)	56.318*** (27.125)	44.409*** (30.009)	44.069 (29.906)	38.397*** (30.669)	47.209*** (28.912)
Size (log)		9.260 (6.632)	10.298† (5.996)	8.571 (6.249)	10.316† (6.030)	8.208 (6.171)	9.415 (5.830)
Age (log)		1.932 (4.242)	2.818 (3.814)	3.304 (3.694)	2.099 (3.783)	2.494 (3.891)	2.595 (3.938)
Revenue 2005-08 (log)		-19.896* (9.533)	-20.804* (9.410)	-18.525† (9.873)	-18.588† (9.586)	-16.263† (9.215)	-19.331* (9.264)
R&D spending		0.287† (0.156)	0.230 (0.149)	0.274† (0.139)	.160 (.154)	0.244† 0.147	0.168 (0.156)
Intangible assets (log)		-0.991 (1.494)	-1.763 (1.551)	-1.512 (1.657)	-1.865 (1.582)	-2.257 (1.451)	-2.035 (1.504)
Hi tech sectors		-14.780* (6.835)	-19.166** (6.628)	-17.441* (7.053)	-19.299** (6.090)	-16.766* (7.771)	-17.895* (7.118)
B2B specialization		-15.708* (7.508)	-22.262** (6.961)	-21.234** (7.217)	-18.261* (7.169)	-25.746** (6.308)	-24.868** (7.544)
Dynamism		5.471† (3.236)	4.423 (2.899)	4.250 (2.883)	5.081† (2.889)	5.140† (3.098)	5.113† (3.011)
Idea Management Practices		-5.136 (6.791)	-3.610 (7.005)	-3.222 (7.088)	-2.779 (6.745)	-0.925 (6.039)	-3.177 (6.361)
Internal Integration		0.627 (4.915)	3.363 (5.218)	4.748 (5.247)	-.174 (5.887)	3.336 (5.265)	2.348 (5.413)
External Search		6.069 (5.891)	0.761 (5.756)	4.748 (5.247)	-5.184 (6.389)	0.084 (6.089)	1.089 (6.589)
External Search Squared		…	7.216** (2.188)	…	3.252 (5.407)	….	5.545 (14.807)
External Search X Internal Integration	H1	…	….	7.431** (2.557)	4.216 (6.025)	…	…
External Search Squared X Internal Integration		…	…	…	5.414* (2.906)	….	….
External Search X Idea Management Practices	H2	…	…	…	….	6.550* (2.451)	-1.300 (8.307)
External Search Squared X Idea Management Practices		…	…	…	….	….	1.010 (3.149)
Chi-square		24.28*	30.70**	30.60***	33.61***	28.71**	30.78**
R Square (from OLS regression)		31.17%	37.11%	37.47 %	40.30%	35.71 %	37.16%

****p-value < 0.1%; ** p < 1%; * p < 5%.*

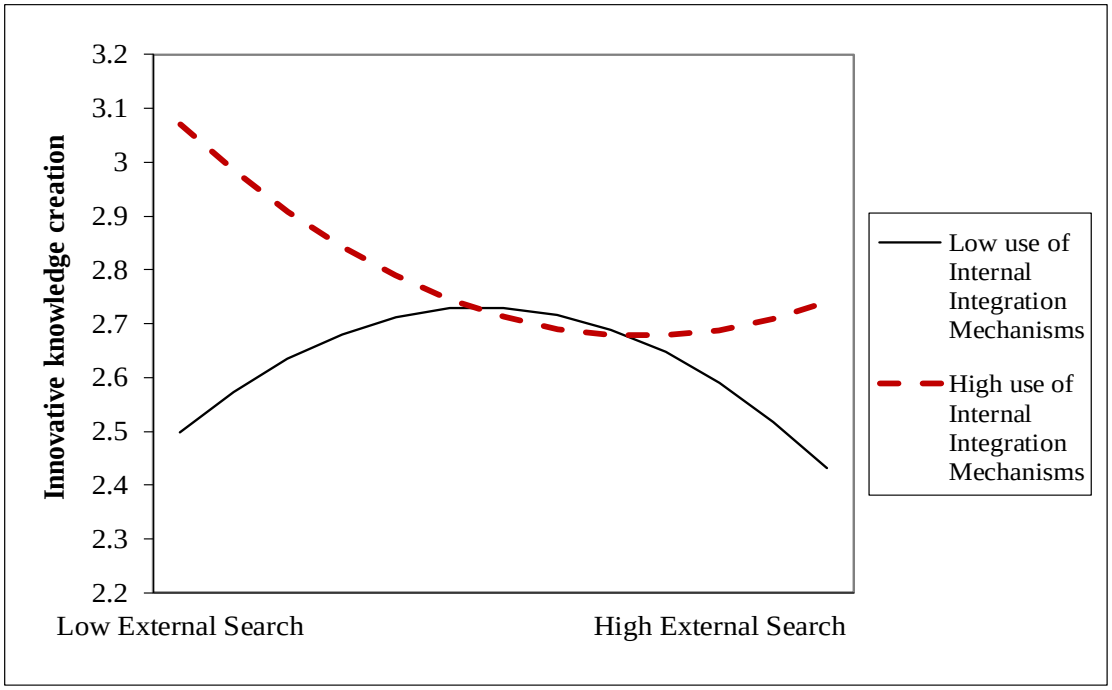

Figure 2. U-shaped effects on innovative knowledge creation due to the interplay between external search practices and internal integration mechanisms (Model 4)

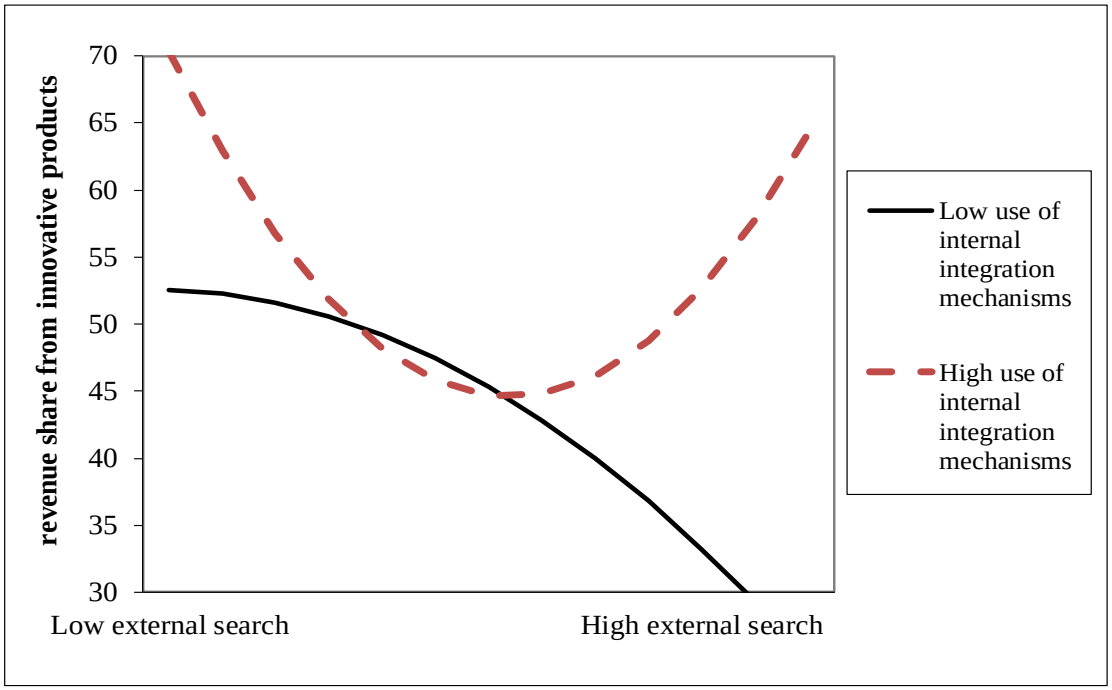

Figure 3. U-shaped effects on revenue from innovative products due to the interplay between external search practices and internal integration mechanisms (Model 10)

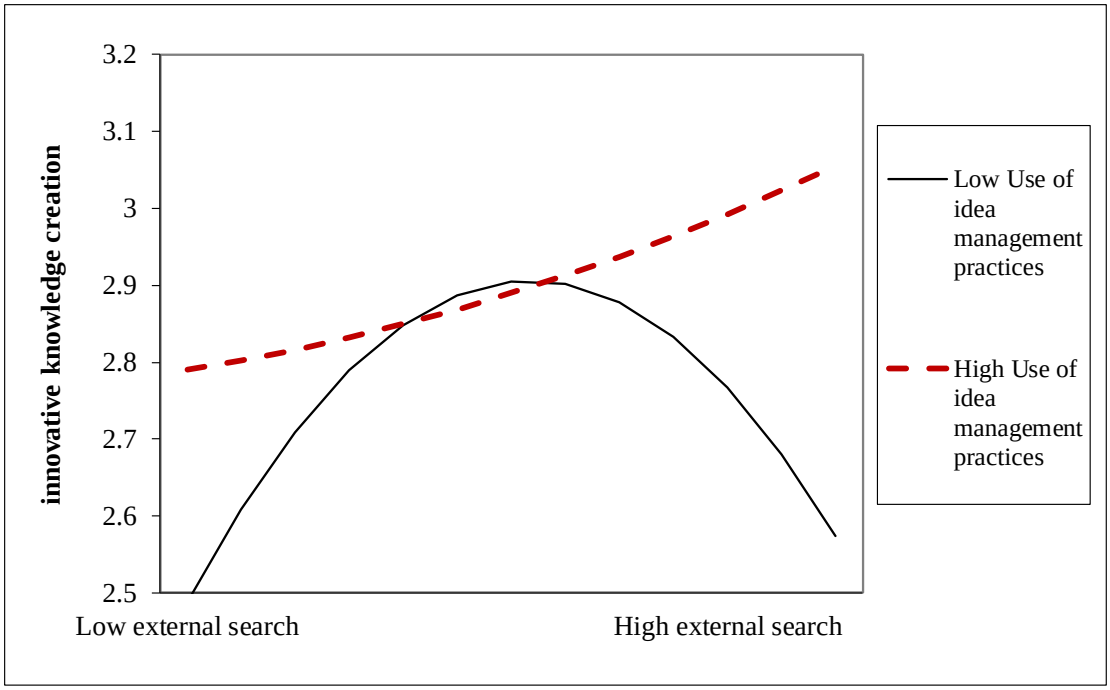

Figure 4. Interaction effect on innovative knowledge creation from the use of idea management practices (Model 6)

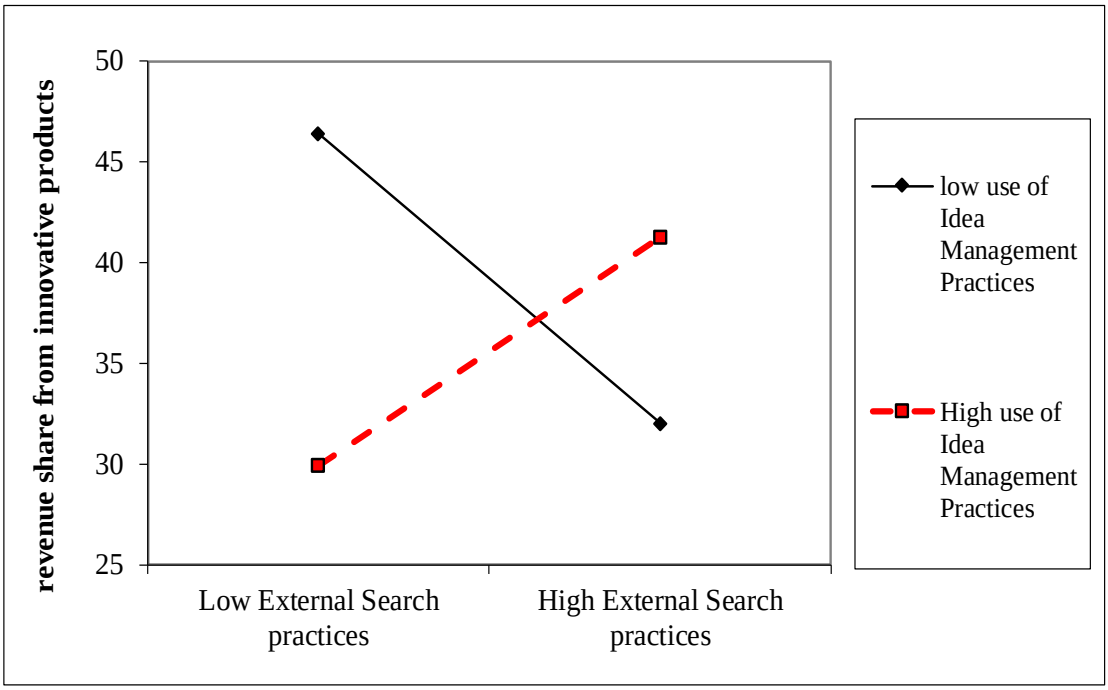

Figure 5. Interaction effect on revenue share from innovative products between external search practices and idea management practices (Model 11)

Discussion and Conclusions

Theoretical contribution. Successful innovation is increasingly dependent on the effective recombination of knowledge inputs across firm boundaries (Mina et al., 2014). Accordingly, searching for external relevant knowledge has been the object of increasing attention in the past

few years, coherent with the rise of firm's innovation models based on a higher degree of openness towards external actors. Only in the last few years have innovation studies begun to give increasing attention to investigating how firms should combine practices used for external knowledge search with the way internal roles, coordination systems and the organization structure should be designed, in order to allow firms to assimilate and exploit the knowledge absorbed from the external environment (see Jansen et al., 2005).

Consistent with this type of focus, our work has investigated the knowledge search practices firms deploy to innovate their products, exploring the relationships among the use of such practices, some internal organizational mechanisms and innovation performance. In so doing, the paper has shown that external search practices have a positive effect on innovation performance, and that this effect is fairly more evident when the moderation effects due to internal practices for integrating and articulating knowledge and for managing and selecting innovative ideas are taken into account.

Overall, the idea that firms should be open and appropriately design their organizational structure to effectively use knowledge resources coming from the external environment is evident, starting from the seminal works by Cohen and Levinthal (1990) on absorptive capacities, and even by Burns and Stalker's (1961) distinction between organic and mechanistic structures. Our specific contribution to the field lies in the evidence of a quadratic effect of search practices on innovation performance being particularly evident when firms combine the use of external search practices with practices aimed at enhancing internal and cross-functional integration and formalized processes for generating, managing and selecting innovative ideas that can also be advanced by employees without managerial responsibilities. The importance of the complementarity between practices used to search for knowledge outside the firm and the practices used to manage and recombine knowledge internally implies that, when the moderation effect due to the second type of practices is not taken into account, the extent of use of search practices for capturing external

knowledge has a weak effect on innovation performance, especially when performance is considered in terms of new knowledge creation for product innovation. More precisely, on this variable a quadratic effect of external search practices is weak and can be barely detected. Also, a further specific contribution of our research lies in the evidence of the effect of external knowledge search practices and its complementarity with internal practices on two measures of innovation performance: the flow of innovative knowledge created and the flow of revenue created from innovation (in terms of their share on the firm's total revenue).

The theoretical insights of these results are straightforward. In order to effectively use knowledge absorbed from the external environment, firms need integration mechanisms that break functional-silos and allow a more effective articulation process of external knowledge and a process of recombination with other knowledge resources. Also, firms open to external knowledge need a formalized process to manage the many product development initiatives that may be triggered by extensive external search. The complementarity between idea management and external search also lies in the following principle: the fuzzy front-end of innovation processes is more effective when the technical and market challenges employees are required to solve are contextualized to given innovation problems (i.e., given costumer requirements), or themes stemming from sensing the market and interacting with external stakeholders, such as customers, universities and research centers.

These results also add some theoretical insights and empirical evidence on the effects and the causes of over-search problems (Laursen and Salter, 2006). As Figures 2, 3 and 4 illustrate, in the absence of practices to generate and recombine knowledge internally the use of a great number of external search practices is detrimental to innovation performance. Estimates from regression models indeed suggest that, the lower the use of internal integration mechanisms, the more the relationship between the use of search practices and innovation performance is characterized by an inverted U-shaped relationship.

Our research also adds counterintuitive findings on the performance implications of different types of innovation approaches, which advocate the existence of different strategies for capitalizing the results of R&D activities. More precisely, by comparing the effects shown in Figures 2 and 3, we can conclude that firms combining a low use of external search with a limited use of internal integration practices are particularly poor in creating innovative knowledge flows; however, on a horizon of three years, are able to generate an intermediate level of revenue from new products. Figure 3 indeed suggests that firms with limited use of both external search practices and internal practices for knowledge creation and recombination are poor in generating innovative knowledge; however, they have—relatively to the sample—intermediate level of sales revenue from new products. Figure 4 and 5 show similar results, when the systems for encouraging and managing innovative ideas are taken into account as a moderator of the relationship between external search and innovation performance. Considering the high aggregate orientation to R&D investments of our sample, we may add speculatively that this mismatch might stem from capitalizing and exploiting the knowledge created by past "technology-push" R&D activities. In other words, when the configuration of internal practices does not support the firm's absorptive capacity, the lower the effort for search of external knowledge, the higher the innovation performance, as firms should concentrate on harvesting the results of past internal R&D investments. The more these firms use external search practices, the lower their sales revenues from new products. Then, the detrimental effect on revenues due to the extensive external search does not only lie in the problems of over-search (Salge et al., 2013), but also in a lack of focus on few innovation projects induced by external search. This occurs especially in firms poor in designing internal organizational configurations being then nimble in capitalizing external knowledge flows.

In the same vein, Figure 2 also shows that firms using internal integration practices extensively have two ways from monetizing their investments in innovation. First, they limit their

external search. Second, they search extensively for new knowledge outside their boundaries. The second way to innovation performance is not surprising and reflects the complementarity among internal and external search advocated in this study. By contrast, firms following the first way are successful at both creating new innovative knowledge and at exploiting these knowledge in product innovations that are marketable. For these companies, the contribution to innovation probably stems from recombining internally new knowledge without adding any considerable stock of external knowledge coming from the market or technological partners. Past studies (March and Simon, 1958; Nelson and Winter, 1982) discuss this approach as essentially being based on searching for local optima, which in the long term can be detrimental to the overall firm performance, especially when market or technological discontinuities arise. Searching for local optima makes short-term profits more appealing (Wei et al., 2013) and is considered the natural consequence of the behavior and decisions of agents with bounded rational agents (Simon, 1955). Such agents are also constrained by their limited inspection capability, which, in the terms of Bergson (1903-23), can be thought of as a combination of intelligence and intuition. Whereas intelligence allows organizations to identify and plan the starting and the ending points of a certain path of innovation development, intuition is what allows an emerging adaptation of the path once organizations solve some bites of technological and market uncertainty. Integration mechanisms and idea management systems thus allow firms to deploy what in Bergson's lenses is a combination of intelligence and intuition. As such, our research highlights the role that internal integration mechanisms and idea management practices have in supporting a firm's strategic flexibility (Wei and Guo, 2013), namely they help firms in seizing the opportunities identified through external search. However, this view of the practices for internal integration of external knowledge and for the subsequent selection and management of the innovation ideas stemming from its absorption risks to be reductive. Seen from a different perspective, these internal

mechanisms are the building blocks that support the coordination through which firms make a sense (Weick, 1993) of shifting markets, new technologies, changing customer requirements, etc.

Whereas most of the theoretical arguments behind the idea of a complementarity between external search and internal practices are straightforward, the arguments for explaining the quadratic effects that external search exerts on innovation performance are less clear and cannot be only seen as the consequence of an over-search problem that occurs under given circumstances. In other words, further research is still needed to understand how firms can enjoy increasing marginal returns from external search once they have enacted a critical mass of search practices that is combined with appropriate internal mechanisms. Seen from a perspective based on the economics of innovation processes, the positive quadratic effects reflect the key properties of the dynamics of accumulation of intangible and knowledge-based assets illustrated by Dierickx and Cool (1989). More specifically, path dependency and time-compression diseconomies in the accumulation and use of external knowledge in firms' innovation process may explain why the returns in the use of search practices are visible on innovation performance only above a certain threshold of use which reflects the breadth of the practices used. Under this point of view, a broader extent of use of search practices may reflect firms that have started to deploy practices and organizational configurations to absorb external knowledge earlier than others and as such they have progressively and gradually accumulated more and more practices to absorb and assimilate external knowledge. A speculative interpretation can be that firms with a broader use of external search practices having started earlier than others to use and accumulate external search practices are more able to use external knowledge effectively and are less likely to "over-search". In particular, as companies using external search practices extensively are more likely to use also appropriate internal coordination mechanisms, these firms know better "where-to-search" thank to a better coordination between the internal areas and the boundary spanning roles. A systemic view of the practices and the organizational mechanisms enacted by firms for executing open innovation

could help future works in exploring at a further level of details the relationship between external search and innovation performance.

Managerial contribution. Our results have several implications for managerial practice. Beyond the recommendations that can be inferred from the complementarity argument illustrated above, there are three further implications. First, closed innovation is as successful in generating knowledge and revenue from innovation as open innovation when certain conditions are met: first, firms are able to build internal integration practices to break functional walls; second, and as a consequence, they let knowledge related to product innovation circulate across functional areas being enriched by multiple contributions. However, when firms following a closed innovation model (i.e., based on a low extent of external search practices) start enacting some external search practices, our results in Figure 2 and 3 suggest that they may experience a worsening of innovation performance (for these firms the marginal returns from the use/implementation of search practices are decreasing until an intermediate level in the adoption of external search practices). This result may signal that firms must be agile and quick in shifting from a closed to an open innovation model in order to avoid being stuck in the middle between the two models. The presence of decreasing marginal returns from the use of external search practices until a certain level of use may lie in the difficulties that firms could experience in combining closed and open innovation models: this can generate inconsistencies in routines, processes, incentives, strategic choices, etc.

Second, our evidence on the quadratic effect of external search over innovation performance imply (and this is graphically pointed out in the interaction plots reported) that an intermediate extent of search practices usage represents an "indifference zone" here, the use of internal practices for knowledge integration, articulation and selection does not considerably improve the effect that external search endeavors have on innovation performance. Therefore, internal mechanisms have a crucial importance when firms start searching extensively for external

knowledge. However, to make these practices effective, firms need time. Our arguments on asset compression diseconomies thus implies that managers should balance their efforts towards both external search and internal integration of knowledge since the earlier phase of their development path for a system of practices for open innovation.

Lastly, there is a subtle implication arising from our results on the systems that firms enact to foster and exploit their employees' creativity. Implementing practices aimed at stimulating creativity and idea management in firms is useless in the absence of search mechanisms for external knowledge that allow firms to correctly sense the market and technological conditions. In the absence of these boundary spanning competencies, workforce bottom-up participation to the innovation process risks to be dis-aligned with what customers want or with constraints and issues stemming from technology conditions and evolution.

Limitations and future research. This study suffers of some limitations. In particular, two types of limitations identify some important directions for future research. First, sample size is small and it includes only Italian firms, with a great incidence of medium-sized firms. This could limit the generalizability of our result outside the context investigated. In this regard, future studies should assess whether the same moderation effects occur in other organizational settings. For example, we might expect that such moderation could be more evident in larger enterprises, for which the use of formalized approaches for integrating and articulating external knowledge could have a more important role given the higher complexity of coordination and knowledge flows that affect the front-end of innovation processes. Also, we have not analyzed the way firms arrive at developing a "system" of open innovation over the time based on the three building blocks assessed in this study. A greater extent of practices for searching and integrating external knowledge, selecting the one with the highest market potential for the company, could incorporate learning effects of companies that have started earlier than others to use organizational structures

and practices for open innovation. Future studies—by using also a qualitative lens—could disentangle how the effectiveness of open innovation practices depends on the time dynamics through which firms have developed an organizational configuration for open innovation.

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Methodological Appendix

Table A 1. Internal and External Knowledge Search Practices

CONSTRUCT	DESCRIPTION
External Search **MARKET DIMENSION**	It makes use of conventional market research methods, such as: focus groups, interviews or telephone surveys, online surveys, brainstorming.
	We shake relations with lead-users (users of a particular product/service and suggest changes or improvements to existing products that are able to anticipate the needs of the market still untapped).
	We establish relationships with end customers (customers of customers in the B2B case) and you get regular feedback on their needs.
	We analyze the use of products and services in various real-life situations.
	Often prototypes and pilot tests are used as tools for learning and refining, to test new ideas.
	We explore the future, using tools and techniques such as scenario analysis, exploration of trends and other forecasting techniques.
	We use scenarios to help understand and influence our organization's future.
	We currently have someone (full or part-time) officially charged with scouting for new ideas outside the organization and looking for trends and developments that might have implications for our organization's future.
	We have a dedicated group of people (e.g., from marketing, sales, R&D) that explores new ways to apply our existing technology to new industries and new customers.
	When we have a very new and different technology, we search for multiple applications and conduct several market experiments to discover promising markets.
	We appeal to organizations/companies engaged in the third scanning and the search for innovative ideas.
External search **TECH DIMENSION**	We have a website where outsiders can submit their suggestions and ideas for new markets, products and/or services.
	There are brokers, which establish relationships outside the enterprise, to transfer knowledge.
	The different functions in the organization are encouraged to systematically collect ideas and opinions from outside sources.
	There is a website (i.e., blog, wiki, corporate social networks) where the different actors can submit suggestions and ideas about markets, products and/or services.
	We encourage people to attend events/conferences/workshops that help to increase knowledge and experience.
	We use an open innovation system in which technology-related challenges are posted online by our R&D staff so that a community of registered scientists anywhere in the world can propose their solutions.
	The research environment is open to collaborations with universities, research centres and specialized agencies.
	The company, along with long-term strategic alliances and consolidating, developing short-term technology partnerships with other companies.
Internal Practices **INTERNAL INTEGRATION MECHANISMS**	We consciously hire people who are different to encourage diversity within our organization.
	In the firm there are organizational practices that enable the integration skills, background or other features to support innovation.
	In our organization, we encourage radical innovation teams to expand their resource network by tapping into the knowledge of any employee in our firm.
	In our organization, we have "network ambassadors" who can help radical innovation teams connect with other people company-wide when new knowledge or insight is needed.

Internal Practices **IDEA MANAGEMENT PRACTICES**	The company has teams dedicated to research and implementation of strategically relevant ideas for new business. We encourage people to come forward with ideas, even if they have only a vague idea of the potential market applications for the idea. Our organization supports corporate entrepreneurship as part of our Discontinuous Innovation efforts. There is a centralized system for managing ideas, available throughout the enterprise, which each employee can submit ideas and receive feedback on which. There is a financing system designed to support radical innovation projects. In R&D budgets are sufficient resources dedicated to exploring new technologies that could potentially lead the company beyond its existing products and markets.

Table A 2. Construct operationalization for Innovation Performance

Innovative Knowledge Creation **KNOWLEDGE EXPLORATION** (Zahra et al., 2000; Atuahene-Gima, 2005)	Acquired manufacturing technologies and skills entirely new to the firm. Learned product development skills and processes (such as product design, prototyping new products, timing of new product introductions, and customizing products for local markets) entirely new to the industry. Acquired entirely new managerial and organizational skills that are important for innovation (such as forecasting technological and customer trends; identifying emerging markets and technologies; coordinating and integrating R&D; marketing, manufacturing, and other functions; managing the product development process. Strengthened innovation skills in areas where it had no prior experience.
Innovative Knowledge Creation **KNOWLEDGE EXPLOITATION** (Lane and Lubatkin, 1998; Kogut and Zander, 1992)	Improved the skills and knowledge about products and familiar technologies Invested in improving knowledge and skills in the use of mature technologies that serves to improve productivity. Reinforced skills in finding solutions to customer problems, starting from existing solutions, rather than completely new solutions. Enhancing skills in the development process of the product / service in which there is already a significant experience. Invested in improving knowledge and skills on mature technologies.
Revenue from Innovative Products (Atahuene-Gima, 2005; He and Wong, 2009).	Share of sales revenue in 2009 stemming from radical and incremental product innovations that were introduced between 2007 and 2009. This measure is commonly used as a dependent variable in studies on the determinants of innovation performance.

Table A 3. Pearson correlation matrix

		v1	v2	v3	v4	v5	v6	v7	v8	v9	v10	v11	v12
v1	Revenue from new products	1											
v2	Innovative Knowledge creation	0.1311	1										
v3	Size (Log)	0.089	0.0607	1									
v4	Age (Log)	-0.0563	0.0412	0.0652	1								
v5	Dynamism	0.2823*	0.2726*	0.0956	-0.0376	1							
v6	R&D spending	0.0399	0.2460*	-0.0875	-0.1228	0.0897	1						
v7	Revenue 2005-08 (log)	-0.2506*	0.0232	0.4205**	0.123	-0.0002	-0.0551	1					
v8	Intangible Assets s(log)	-0.2707*	-0.0118	0.3626**	-0.003	-0.0086	0.1339	0.5932**	1				
v9	B2B specialization	-0.1586	0.0654	-0.0744	0.0548	-0.0625	0.1275	-0.2339*	-0.1829	1			
v10	Hi-Tech industries	-0.113	-0.1192	0.012	-0.0243	0.039	0.0671	-0.0876	-0.0096	-0.0844	1		
v11	Idea Management Practices	0.052	0.5596***	0.1319	0.131	0.1621	0.0691	0.0645	-0.1117	0.1324	-0.0518	1	
v12	Internal Integration	0.1456	0.5895***	0.1861	-0.0525	0.2599*	-0.01	-0.0234	-0.2116	0.1493	0.0358	0.7493***	1
v13	External Search	0.1468	0.5834***	0.129	0.0168	0.1166	0.1646	0.0275	-0.1888	-0.0181	-0.0528	0.7991***	0.7574***

****p-value < 0.1%; ** p < 1%; * p < 5%.*