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EXPLORING THE ASYMMETRIC COMPLEMENTARITY BETWEEN EXTERNAL KNOWLEDGE SEARCH AND MANAGEMENT INNOVATION

ABSTRACT

This paper hypothesizes about and tests the conditions under which firms experience substitutional and complementary effects from the synchronous deployment of innovation search—in the form of external knowledge sourcing, and management innovation—in the form of new organizational processes, practices, and structures, on innovative performance. Theoretically, this represents an interesting puzzle as the extant literature offers two contradictory explanations regarding their synchronous effects, built on fundamentally different problem-solving mechanisms that expose distinct managerial challenges for coordinating external search activities. Specifically, we predict the existence of a substitutional effect between external search depth and management innovation, and a complementary effect between external search breadth and management innovation. We found strong evidence relevant to our theoretical predictions. Our study offers new theoretical insights regarding the synchronicity of innovation search and management innovation.

Keywords: collaboration; complementarity; external knowledge search; management innovation; innovation search

1. Introduction

External innovation search has had a great deal of attention in the innovation literature for nearly two decades (e.g., Damanpour et al., 2009; Evangelista and Vezzani, 2010; Laursen and Salter, 2006). Most prior studies portray external innovation as a problem-solving activity in which firms develop new products through identifying and integrating external sources of knowledge (eg., Katila and Ahuja, 2002; Knudsen and Levinthal, 2007; Laursen and Salter, 2006). For both innovation scholars and practitioners, much of the interest on this activity is driven by the recognition that openness to external sources boosts innovation performance (Katila and Ahuja, 2002; Laursen and Salter, 2006; Leiponen and Helfat, 2010; Love et al., 2014). Despite its perceived importance, however, some studies have often maintained the idea that external innovation search induces a principal managerial challenge. Its collaborative nature often requires purposefully initiated management innovations (Chen et al., 2011). Put simply, firms who search for external knowledge often need to redefine internal processes, practices, and structures to make them more compatible with external sources (Alexy et al., 2012, Salter et al., 2014).

Management innovation, however, often comes with its own managerial challenge. Departure from established organizational routines is not an easy task due to a variety of internal and environmental constraints (Hannan and Freeman, 1977). Redefining well-internalized processes, practices, and/or structures, in particular, can be difficult because it “robs an organization's history of survival value” (Hannan and Freeman, 1984: 160). Firms who attempt it, therefore, will often seek for external validation. Prior studies indicate a viable approach to achieving external validation through external innovation search. Introducing management innovations previously implemented in other contexts can help in building legitimacy for these innovations (Mol and Birkinshaw, 2009). Specifically, because these innovations are embraced by other organizations, they may be also viewed as sensible

approaches for the focal firm (Meyer and Rowan, 1977). If external innovation search is so important for management innovation and vice versa, then firms who implement both should have an advantage over others in their ability to appropriate innovation rents.

Investigating this assumed complementarity is a particularly interesting puzzle for research as the literature offers two contradictory theoretical explanations regarding the synchronous effect of external innovation search and management innovation. The first explanation suggests that existing processes, practices, and structures may act as core rigidities (Leonard-Barton, 1992; Liao et al., 2008; Tripsas and Gavetti, 2000) that prevent the firm from exploring new market and technological domains. Therefore, external innovation search requires a complementary management innovation as a means to realign the underlying processes, practices, and structures and reduce forces of inertia. The second explanation, however, points to a possible alternative consequence. The uncertainty and complexity of external innovation search are well documented (e.g., Danneels, 2002; Felin and Zenger, 2014; Fleming and Sorenson 2004). If these are accompanied by the avowed ambiguity and social complexity of management innovation (Birkinshaw et al., 2008; Damanpour and Evan, 1984; Santos-Vijande et al., 2007), then it is possible to argue that the synchronous deployment of external innovation search and management innovation will induce no complementary effect or may even have a detrimental effect on innovation performance. To put it differently, if both activities are highly uncertain and complex, why would a firm be better off engaging them synchronously? The juxtaposition of these two explanations poses the question of whether external innovation search and management innovation are complementary or substitutional activities?

However, to date, literature on innovation has provided little guidance for understanding the conditions under which the synchronous adoption of both innovation activities will lead to higher or lower performance benefits. Scholars who studied explicitly

the link between innovation search and management innovation typically focus their attention on individual external search channels (i.e., users and/or customers) (Foss et al., 2011) or on processes, practices, and structures that are well-tailored to the internal rather than external search demands (e.g., Cyert and March, 1963; Foss et al., 2011; Hannan and Freeman, 1984; Nelson and Winter, 1982). While these studies investigate the links that trigger positive performance benefits, they devote far less attention to theorizing the links that can inhibit innovation. On the other side of the disciplinary divide, some scholars who study the relationship between external innovation search and management innovation (e.g., Ganter and Hecker, 2013; Simao and Franco, 2018) typically leave the consequences for the innovation performance unexplored or assumed. In fact, these studies are directed more toward locating external search channels used by firms to adopt management innovation than toward understanding the impact of their mutual adoption on innovation.

The prevalence of these approaches is curious, particularly among innovation scholars that are primarily charged with the task of understanding the different innovation outcomes and their sources. To make progress on this issue, we start with focusing on two different external search strategies namely, depth and breadth, and treating them as fundamentally different conceptual levels (Laursen and Salter, 2006; Vasudeva and Anand, 2011). A number of studies has stressed their heterogeneity concerning the problem-solving mechanisms they apply to various problem situations (Belderbos et al., 2004; Terjesen and Patel, 2017; Tödtling et al., 2009). Drawing on these differences, we assume that these two strategies may have unique implications for innovative performance when adopted in conjunction with management innovation. Specifically, we propose and find that external search depth, characterized by intensified search activities within a knowledge domain, and management innovation mainly act as substitutes for each other in affecting the firm's innovative performance. Conversely, our theorizing and findings confirm that external search

breadth, characterized by intensified search activities across a broad spectrum of knowledge domains, and management innovation mainly act as complements for each other in affecting the firm's innovative performance.

Our study makes an important contribution to the growing line of work that seeks to identify the relationship between innovation search and management innovation (i.e., Colombo et al., 2021; Foss et al., 2013; Gentile-Lüdecke et al. 2020). While this study provides evidence in support of the positive benefits that stem from the synchronous deployment of these activities, it also clarifies conditions under which their coexistence is counterproductive. Therefore, this study opens up interesting avenues in identifying the conditions through which management innovation can result in positive or negative performance outcomes when companies engage in external search. It also contributes to the burgeoning literature on external sourcing (e.g., Katila and Ahuja, 2002; Laursen and Salter, 2006) by highlighting additional challenges that firms are likely to face when searching for external knowledge. New attention to mechanisms, such as management innovation, which can either facilitate or prohibit different external search strategies, may help to resolve puzzles about the effects of external search strategies on innovative performance (e.g., Arranz et al., 2019).

Overall, our findings call innovation scholars to dive deeper into our understanding of discrete external search strategies, remove assumptions of discrete external search strategies–management innovation symmetry, and better contextualize the adoption of management innovation as an integration mechanism, when knowledge stems from external sources (Collinson and Liu, 2019; Yayavaram and Chen, 2015). Although search depth, search breadth, and management innovation all trigger positive performance benefits, our findings suggest that their respective joint effects for firms may not always follow the same pattern.

2. Theoretical background and hypotheses development

2.1. Theoretical background

It is widely recognized in studies on innovation that the breadth and depth of external knowledge search are important determinants of innovative performance. According to Laursen and Salter (2006, p. 4-5), search depth refers to “the extent to which firms draw deeply from the different external sources or search channels” and search breadth refers to “the number of external sources or search channels that firms rely upon in their innovative activities.” Consistently, empirical research has yielded the claim that an organization's ability to innovate is a function of the knowledge targeted and accessed by these search strategies (Jung and Lee, 2016; Ko et al., 2021; Mina et al., 2014). Specifically, firms can improve their innovativeness and often sustain innovation advantages by leveraging knowledge, which can be found when searching widely and/or deeply in external settings (Ehls et al., 2020; Katila, 2002; Ko et al., 2021).

A central question in this research, however, involves how firms can effectively transfer external knowledge internally (e.g., Ferreras-Méndez et al., 2015; Ferreras-Méndez et al., 2016; Flor et al., 2018). Accordingly, the internal integration of external sources of innovation has become a central issue in the literature (Cabigiosu et al., 2013; Chesbrough, 2003; Santoro et al., 2020; Peng and Turel, 2020). A belief in the value of absorptive capacity is broadly supported by relevant studies. Absorptive capacity can be framed as a capability pertaining to assimilation and utilization of new knowledge (Bierly et al., 2009; Zahra and George, 2002). Even though external search strategies can permit access to external knowledge, firms may not have the capability to absorb and apply it for its own use. In fact, firms require absorptive capacity in order to learn from external channels and thus, leverage the potential benefits of external search (Cohen and Levinthal, 1990; Santoro et al., 2020; Vasudeva and Anand, 2011). Theoretical and empirical studies in the field show how such

capacity can help firms assimilate new knowledge gained from both deep and wide searches in external settings (Cohen and Levinthal, 1990; Ferreras-Méndez et al., 2015; Ferreras-Méndez et al., 2016).

Research on external search, meanwhile, has shown that significant changes at the organizational mechanisms, particularly the introduction of management innovation is connected neatly to absorptive capacity, as it represents an important means of transferring and assimilating external knowledge internally (Ali et al., 2016; Colombo et al., 2021; Foss et al., 2011). Management innovation refers to dedicated new organizational processes, practices, and structures that facilitate reconfiguration, realignment and assimilation of knowledge (Gibson and Birkinshaw, 2004; Kale and Singh, 2007; Matusik and Heeley, 2005; Raisch and Birkinshaw, 2008). As many aspects of absorptive capacity are distinctly organizational, management innovation can be used to develop such capacity and thus, create the conditions for transferring new external knowledge within the firm (Foss et al., 2011; Jansen et al., 2005). Such a transferring allows external knowledge to flow across the structures of the firm (Al-Atwi et al., 2019; Amankwah-Amoah and Adomako, 2021) and thus, to be deployed in the context of innovation (Ali et al., 2016; Jansen et al., 2005). Accordingly, this has inspired researchers to investigate how management innovation can influence the link between external knowledge sourcing and innovative performance outcomes. For example, Foss et al. (2011) has analysed how management innovation enables firms to identify, assimilate, and exploit knowledge from the external environment necessary for successful innovation. Likewise, Gentile-Lüdecke et al. (2020) show that firms who implement management innovation are readier to search and can more effectively integrate external knowledge into their own knowledge base.

Yet, despite its generally beneficial role, management innovation may also destabilize “taken-for-granted” organizational elements and therefore, decrease the reproducibility of

internal structures (Hannan and Freeman, 1984; Hannan et al., 2006). As prior studies suggest lack of reproducibility can set the liability of newness clock back to zero, and can therefore, weaken the overall effectiveness of knowledge integration (Birkinshaw et al., 2008; Birkinshaw and Mol, 2006; Singh et al., 1986). Such a weakening effect resonates also with existing findings in organizational change literature that alterations in the internal processes, practices, and structures may often be detrimental to organizational performance (De Keyser et al., 2021; Hannan et al., 2006; Haveman, 1992). Further, observations by researchers suggest that implementing management innovations disrupts the identities of internal actors and therefore, creates organizational uncertainty (Birkinshaw and Mol, 2006; Santos-Vijande et al., 2007). From this perspective, organizations that implement management innovation are more prone to failure than others who depend upon well-established organizational routines (Birkinshaw and Ridderstråle, 2017; De Keyser et al., 2021; Khanna et al., 2016).

However, little systematic attention has been paid to conditions that determine when and how management innovation will be related to the effectiveness or failure of integration of knowledge acquired through external search. While in the literature there are two contradictory perspectives, one that views management innovation as beneficial and the other that describes management innovation as perilous, there is the possibility that both perspectives are correct depending on the search strategy that firms follow (Amburgey et al., 1990; Colombo et al., 2021; Singh et al., 1986;). In fact, there is a limited understanding so far, of how search breadth and search depth strategies differ in their capacity to interact with management innovation. This is surprising given the fundamental distinctions between search breadth and search depth (Laursen and Salter, 2006; Terjesen and Patel, 2017; Vasudeva and Anand, 2011). As prior studies suggest, firms, who follow different external search strategies (i.e., search depth or search breadth) may enjoy differential knowledge access (Laursen and Salter, 2006; Tang et al., 2020; Vasudeva and Anand, 2011). Importantly, because search

depth and search breadth tend to build on fundamentally different problem-solving mechanisms (e.g., Alnuaimi and George, 2016; Fleming and Sorenson, 2004; Zollo and Winter, 2002), it is possible that their interactions with management innovation will influence an organization's innovative performance in different ways. We draw on specific mechanisms considered as common features of search depth and breadth in prior research and theorize around the joint influence of external search strategies and management innovation on innovative performance. In our hypotheses, we discuss two types of joint effects: (1) a substitutional effect concerning the synchronous adoption of external search depth and management innovation; (2) a complementary effect concerning the synchronous adoption of external search breadth and management innovation.

2.2. Hypotheses development

2.2.1. The substitutional relationship between external search depth and management innovation

Laursen and Salter (2006) conceptualize search depth in the inter-organizational context, suggesting that external search depth involves intense interactions and occurs through recurrent exchanges with a defined set of external partners. We argue that organizations that engage in such repetitive interactions with external partners tend to rely on existing organizational arrangements and interfaces that have been developed from the tacit accumulation of experience (Zollo and Winter, 2002) and are common between partners in the network.

Thus, the managerial imperative under requirements for accumulative problem-solving is to replicate already existing processes and practices (Szulanski, 1996). As organizations become deeply embedded within collaborative arrangements, the established practices of knowledge assimilation are directly replicable and create synergistic effects as search

intensity increases, which result in the automatic deployment of organizational activities to facilitate knowledge exchange, transfer, and integration. While Winter and Szulanski (2001) argue that management innovation is a necessary condition to replication since the firm must first create or refine existing processes, practices, and structures to pursue knowledge searches, it is clear that in those instances in which firms engage in external search depth, the synchronous adoption of management innovation can negate the possibility for replication. This argument is compounded with the suggestion that the implementation of management innovation entails a significant level of uncertainty and social complexity stemming from fears of change (Birkinshaw et al., 2008). Any changes in the organization and management of collaborative interactions with existing external partners could therefore generate strong internal resistance and can have negative consequences for the organization (Birkinshaw et al., 2008)

The need for synchronous management innovation to support an external search depth strategy also diminishes due to the low interdependency between external partners for knowledge transfer and integration. Since the knowledge to be searched is familiar, collaborative partners are able to perform search processes independently without the need for complex integration arrangements (Alnuaimi and George, 2016; Karamanos, 2003; Siggelkow and Rivkin, 2005). Once the processes, practices, and structures supporting independent searches and modular integration are established, any major organizational realignment may have negative consequences for innovation performance (Karim, 2009; Turner and Fern, 2012). This is because any potential change is often organizationally disruptive since it requires significant departures from existing well-internalized activities that tend to be customized as integration mechanisms in particular knowledge domains (Tripsas and Gavetti, 2000).

To concurrently engage in management innovation and external search depth therefore puts the firm at risk of innovating-away any benefits that accrue from the tacit accumulation of experience between collaborative partners and the replication of existing managerial processes and practices provide for repeatable and predictable problem-solving. This creates a potential substitution effect that reduces the firms innovative performance to a point below that of when it engages in each activity in isolation or neither at all. Consequently, we hypothesize that:

Hypothesis 1 (H1) *The synchronous deployment of external search depth and management innovation will have a substitutional effect on the firms innovative performance.*

2.2.2. The complementary relationship between external search breadth and management innovation

The basic premise of an external search breadth strategy is for organizations to build their inventories of knowledge by developing diverse networks of external partners, which may include users, suppliers, universities, and competitors among others, to bolster collaborative innovation processes (Cassiman and Valentini, 2016; Cassiman and Veugelers, 2002). Thus, the multiplicity of institutional norms, values, and practices within such innovation networks creates complexity that requires adequate managerial responses (Monteiro and Birkinshaw, 2017). External search breadth increases the variation of available choices and emphasizes combinatorial problem-solving across heterogenous organizational interfaces (Laursen and Salter, 2006). Therefore, if sustaining the benefits of accumulative problem-solving for external search depth requires efficient replication of cooperation and knowledge assimilation processes, practices, and structures, then external search breadth may expose limits to replication in the absence of a synchronous management innovation.

Fleming and Sorenson (2001; 2004) argue that combinatorial patterns of innovation across multiple heterogeneous partners do not benefit from highly modular knowledge configurations and will more likely occur under conditions of high interdependency, which increases the managerial challenge of knowledge integration. This underlying mechanism of combinatorial problem-solving and low modularity of knowledge create alternative requirements for managing inter-organizational collaboration contra to those for external search depth. Under such conditions, the managerial imperative is to develop strong capabilities for integration and realign existing processes and practices to navigate the complexities of knowledge recombination across multiple knowledge domains (Siggelkow and Rivkin, 2005). Prior studies suggest that executing changes in organizational structures under conditions of high interdependency will have a positive effect on innovation performance (Ginsberg and Abrahamson, 1991; Karim and Kaul, 2015).

This integration challenge is further compounded with the diversity of external partners characteristic of a search breadth strategy (Laursen and Salter, 2006). Unlike search depth, which is generally utilized to produce significant technological advances within an existing or proximate technological paradigm, search breadth is deployed to explore distant knowledge domains and new technological paradigms (Breschi et al., 2003). Navigating such domains, however, is likely to expose inadequacies with de facto managerial processes, practices, and structures within a focal firm (Bresman, 2013). Since organizations are less reliant on direct experience within such networks, they need to concurrently engage in efforts to build new processes, practices, and structures through management innovation in conjunction with searching technological knowledge. Thus, in contrast to the accumulative pattern of problem-solving that benefits from the replication of managerial processes and practices within established organizational structures for search depth, we argue that external search breadth will more likely require synchronous changes in managerial processes and practices to enable

the effective integration of distant technological knowledge across multiple innovation partners.

While the concurrent deployment of management innovation and external search breadth induces similar acceptance hurdles as in the case of external search depth, the focal organization will unlikely rely on the replication of existing processes and practices to tap into multiple distal domains. To put it differently, existing processes, practices, and structures will more likely act as core rigidities (Leonard-Barton, 1992; Tripsas and Gavetti, 2000) if a firm innovates through the utilization of external search breadth, because of the increasing challenge of coordinating interdependent searches across a diversity of innovation partners. Building on Damanpour and Evan (1984), we assert that when searching broadly, innovation performance will be positively affected by the synchronous deployment of management and innovation search. Hence, we propose the following hypothesis:

Hypothesis 2 (H2) *The synchronous deployment of external search breadth and management innovation will have a complementary effect on the firms innovative performance.*

3. Data and variables

3.1. Data

The data used for this study were obtained from the Community Innovation Survey (CIS) conducted by Eurostat in Denmark covering the period from 2013 to 2015. The CIS is a microdata questionnaire that measures innovation activities at the firm-level and represents a stratified sample of the European economy based on industry type and firm size. The questions and measures used in the CIS are described in the Organization for Economic Co-operation and Developments Oslo Manual (OECD, 2005) and have been used in several academic articles in strategy and innovation management (e.g., Cassiman and Valentini,

2016; Cassiman and Veugelers, 2006; Laursen and Salter, 2006). To ensure the interpretability, reliability, and validity of the survey, the questionnaire was subject to extensive piloting and pre-testing in different European countries and across firms from different industries. Hence, we assume that all measurements are both reliable and valid.

All survey questions regarding external knowledge search strategies and management innovation refer to the average of the three-year period (2013 to 2015). Innovative performance, however, is only evaluated for the last year of the period. Measuring performance this way temporally separates the independent from the dependent variables and therefore accounts for the time lag that exists between innovation activities and outcomes (Hess and Rothaermel, 2011). This also helps address issues of common method bias (Rothaermel and Alexandre, 2009).

The 2015 wave of CIS data that we had access to comprised of 5,206 Danish responding firms. Yet, due to a large volume of missing data points in key variables of interest, many observations were omitted from our final database during the cleaning and validation phase of our study. Thus, the final database consisted of a sample of 3,698 firms.

3.2. Variables

The following section describes the dependent and independent variables used for our econometric analysis. First, we document the dependent variable used to measure firm-level innovative performance and then introduce the independent variables of external knowledge search and management innovation, and conclude with a description of controls.

3.2.1. Dependent Variables

To test our hypotheses, we employ a measure of innovative performance that is frequently used as a dependent variable in prior research (e.g., Cassiman and Veugelers, 2006; Laursen and Salter, 2006). Specifically, we account for sales that are attributed to the introduction of

new or significantly improved products that are considered new to the market (*New to Market Sales*). This measure was calculated by using the proportion of revenue generated from new to the market products. In a supplemental analysis, we also employed an alternative measure of innovative performance namely, *New to firm sales*. To calculate this measure, we used the percentage of sales that are attributed to the introduction of new or significantly improved products that are considered new to the firm. The use of both measures of innovative performance in our models produced qualitatively similar results. The analysis using the alternative measure of performance is presented in the Online Appendix.

3.2.2. Independent Variables

To test the hypothesized substitution and complementary relationship between management innovation and external search depth, and management innovation and external search breadth respectively, we first used the CIS data to operationalize separate variables for each type of innovation activity. Management innovation was operationalized as a count variable that indicates the number of areas of management innovation a firm engaged in. CIS asks respondents to indicate whether they have introduced different types of management innovation. Specifically, responding firms are asked to indicate if they introduced new method of organizing external relations, new business practices for organizing procedures, or new method of organizing work responsibilities and decision-making. Our variable takes the value 0 for no management innovation activity at all, with 1 added for each type of management innovation the firm engaged in.

External search breadth (*Search Breadth*) was operationalized as a count variable that measures the degree to which firms search widely across a number of different external knowledge sources (Laursen and Salter, 2006). From our data, it was possible for firms to search across a combination of 10 external sources, which we coded as 0 to indicate “no use” and high intensity interactions which as explained below appear to be a better proxy for the

external search depth strategy of the firm and 1 for “active use,” and took the summation of each to derive a total breadth score. Similarly, we measured external search depth (*Search Depth*) as the degree to which a firm engages in high, medium, or low intensity interactions with a given external knowledge source. Again, we coded these interactions as 1 for high intensity interactions (high use of an external source) and 0 otherwise and took the summation of each across the 10 different external knowledge sources to derive a total depth score (Laursen and Salter, 2006). In a separate analysis, however, we also employed three additional measures of external search depth. Specifically, we calculated an alternative measure by using both medium and high intensity interactions. We took the summation of these interactions to calculate our total depth score. Further, because our former measures are based on summations may not be able to capture accurately the extent to which firms draw deeply from the different external sources or search channels (Kohler et al., 2012). To deal with this issue, we divided both our focal and our alternative measure of external search depth by the number of external sources used, so that the resulting variable takes a minimum value of 0 and a maximum of 1 (Kohler et al., 2012). All three alternative measures yielded qualitatively similar results to the focal measure. These results are shown in the Online Appendix.

3.2.3. Control Variables

We also included a series of control variables. Specifically, we control for possible *Industry* differences by including another series of dummies that distinguish between industries according to their NACE classification code¹. We account for the size of the firms perceived product *Market* by including a categorical variable that captures whether the largest market is “local,” “regional,” “national,” or “international,” which takes values ranging between 0 and 3, with 0 corresponding to local and 3 corresponding to international. We also account for *R&D Intensity*, measured as the firms total R&D expenditure divided by total sales turnover,

to control for any potential effects of R&D productivity on innovative performance. Finally, we control for firm size by including variables that capture the firm's total number of *Employees* and *Prior sales*. All control variables refer to the average of the three-year period (2013 to 2015), with the exception of prior sales and past performance (used in supplemental analysis section) which are evaluated for the first year of the period.

4. Empirical strategy and results

4.1. Empirical strategy

To test our hypotheses, we used ordinary least squares (OLS) regression models. We included also robust standard errors to account for heteroskedasticity. Following prior studies (e.g., Poppo and Zenger, 2002; Siggelkow, 2002), we tested for the presence of complementarity or substitution between different types of external knowledge search and management innovation, by specifying interaction terms and examining the marginal benefit of external search on innovative performance depending on the levels of management innovation. The inclusion of interaction terms in our analysis is based on one of the most commonly used complements/substitution assessment models in the field of economics (e.g., Topkis, 2011; Vives, 1990). The conditions under which a complementary or substitutional effect can occur are reported below:

$$\text{Complementary condition for search breadth \& management innovation: } f(B_H, M_H) - f(B_L, M_H) > f(B_H, M_L) - f(B_L, M_L)$$

$$\text{Substitutional condition for search depth \& management innovation: } f(D_H, M_H) - f(D_L, M_H) < f(D_H, M_L) - f(D_L, M_L)$$

where B and D denote search breadth and search depth, and H and L denote high levels and low levels of these innovation activities, respectively. If search breadth and management innovation interact as complements, the marginal gain between the high level of search

breadth and the low level of search breadth should be greater when they work under a higher level of management innovation, that is, $f(B_{H}, M_{H}) - f(B_{L}, M_{H})$, rather than under a lower level of management innovation, that is, $f(B_{H}, M_{L}) - f(B_{L}, M_{L})$. Accordingly, if search depth and management innovation interact as substitutes, the marginal gain between the high level of search depth and the low level of search depth should be greater when they work under a lower level of management innovation, that is, $f(D_{H}, M_{L}) - f(D_{L}, M_{L})$, rather than under a higher level of management innovation that is, $f(D_{H}, M_{H}) - f(D_{L}, M_{H})$. To test these conditions, we created interaction terms and compared the marginal returns through the examination of slopes in the graph. Following Aiken et al. (1991) advice, we plotted the simple slopes of external search (i.e., search breadth; search depth) and innovative performance regression at 1 SD below the mean and 1 SD above the mean of management innovation. We also assessed the threat of multicollinearity in our analysis by calculating the variance inflation factors (VIFs) for each coefficient. The maximum estimated VIF was 3.01, well below the conventional threshold of 10 (Neter et al., 1985).

4.2. Main results

Table I summarizes the descriptive statistics of our variables. On average, firms search widely across 3.922 external knowledge sources and deeply across 0.756 external knowledge sources. The average number of areas of management innovation that firms engaged in is 0.159. The average expenditures on R&D relative to total sales is 1.670. The overall sample mean of total sales derived from new or substantially improved products that are considered new to the market is 2.450, whereas the average prior sales firms reported is 15.769. These averages as well as the standard deviations reflect sufficient variance on all variables, to permit further analysis.

[Insert Table I here]

[Insert Table II here]

Table II reports the results of the regressions performed. We first estimated a baseline model including direct effects only (see model 1). As a next step, we estimated a model including both control variables and direct effects (see model 2). Finally, we estimated a model including the direct effects and the interaction effects (see model 3) and a model including the direct effects, the interaction effects and all the control variables (see model 4). We conducted the analysis without any control variables too because running the analysis in such a way offers important information about the utility of our explanatory variables to explain uncontrolled variance in the dependent variable (Becker et al., 2016; Breaugh, 2006; Glaser et al., 2016). Our main results were not affected by the exclusion of the control variables, providing support for the validity of our findings.

Hypothesis 1 posits that the synchronous deployment of external search depth and management innovation will have a substitutional effect on the firm's innovative performance. We thus expect the interaction between external search depth and management innovation to be negative and statistically significant. The coefficient in Model 4 shows that indeed the synchronous engagement in external search depth and management innovation is negative and statistically significant ($\beta = -0.517$, $p < 0.05$). A simple-slope test also indicates that the relationship between search depth and innovative performance was not significant when management innovation was high (simple slope = 1.005, $p > 0.1$), but was significant when management innovation was low (simple slope = 0.370, $p < 0.01$). These results are portrayed in Figure 1. Our findings collectively suggest a substitution effect.

In Hypothesis 2, we suggest that the synchronous deployment of external search breadth and management innovation will have a complementary effect on the firm's innovative performance. Therefore, we expect the interaction of search breadth and management innovation to be positive and statistically significant. In Model 4, the coefficient

of this interaction term is indeed positive and statistically significant ($\beta=0.288$, $p<0.01$). A simple-slope test indicates that the relationship between search breadth and innovative performance was significant when management innovation was high (simple slope = 0.260, $p < 0.01$), but was insignificant when management innovation was low (simple slope = -0.028, $p < 0.01$). These results are portrayed in Figure 2. Taken together, our results support the complementary effect.

4.3. Robustness checks

A possible concern relating to our results is that the choice to pursue external knowledge search and management innovation activities is an endogenous decision, which may cause bias in the prior estimations. One proper solution to this issue would require a two-stage instrumental variable regression analysis. Given that all the variables available in the CIS dataset do not adequately satisfy the exclusion restriction, we tried to mitigate this endogeneity concern by following an alternative two-step approach (e.g., Cassiman and Valentini, 2016). As a first step, we controlled for past performance in the innovative performance regression. It has been reported that when firms who have ties with different knowledge sources fail to compete successfully, they may introduce new management practices to cope with this failure (e.g., Utterba, 1994). Therefore, the results in the main analysis may be biased because firms who introduced a management innovation were low performing before doing so, and as such, they have introduced a management innovation as a means to increase their performance. Including past performance as a control variable in the innovative performance regressions can help purify the error terms from possible correlations with the innovation strategies (Cassiman and Valentini, 2016).

To measure past performance, we use the innovative performance (New to Market Sales) that firms reported during the first year of our study. As this measure reflects how

successful the firm's previous strategies were, it can be considered as an important contextual and managerially relevant indicator that firms use to evaluate their past strategies and thus, decide whether they should pursue immediate corrective actions (Baum and Ingram, 2002; Levinthal and March, 1993). The results of this analysis can be found in table III and are qualitatively similar to those presented in the main analysis.

[Insert Table III here]

As a next step for the endogeneity test, we examine whether external search and management innovation are influenced by the firm's past low performance. If these innovation strategies are endogenous in nature then past low performance should influence their adoption. To investigate this possibility, we run two bivariate probit models with search depth and management innovation and search breadth and management innovation respectively. We also include a number of additional control variables. Since larger firms generally have more resources to commit to external knowledge search and often require advanced management routines and processes to facilitate the assimilation and exploitation of knowledge (Schmidt, 2005), we include number of *Employees* and *Prior sales*. Similarly, we expect that a firm's access to *External funding* will affect external search and management innovation decisions, as firms who receive external funding may engage in larger innovation projects that require substantial resource and organizational reconfigurations, as well as access to distant knowledge. We also include a variable that captures whether the firm is part of a multinational or multidivisional entity, as *Multi-entity* organizations require more sophisticated management innovation systems to transfer dispersed knowledge across business units (Dunning, 1993; Gupta and Govindarajan, 2000). Further, we expect market and internal barriers including low *Demand*, intense *Competition*, and *Lack of personnel* to positively affect management innovation, as firms who face adverse market forces and internal inefficiencies tend to make substantial changes in organizational templates and

practices (Baum and Haveman, 1997; Hannan and Freeman, 1977, 1989). Finally, we include variables that account for internal objectives of entering *New markets* and building *New partnerships*, as firms which aim to do so may search also more broadly and deeply for interfirm collaborations that provide access to new market capabilities. Table IV reports the results of the bivariate probit regressions. The coefficient of *Prior performance* is not significantly different from zero in all cases. This indicates that prior performance does not have any significant influence on both external search strategies and management innovation. This is a good indication that reverse causality is not an issue here.

[Insert Table V here]

Finally, we control for potential selection bias using a Heckman estimation. Since our sampling frame includes only firms that are innovation active, the sample is non-random and left-censored, as it excludes firms that chose not to introduce a new innovation in a given time period. Therefore, the regression coefficients may be biased (Greene, 2000; Heckman, 1987). In such instances, the regression is corrected by following a two-stage Heckman correction. First, a Heckman probit model is used to account for the choice decision of firms to introduce a new innovation to the market [1] or not [0] in a selection equation. This approach corrects selection bias by calibrating estimates using the inverse mills ratio in a second stage estimation if the differences between firms that chose to introduce a new innovation to the market [1] and those that do not [0] estimated in the first stage are statistically significant. The results of this analysis can be found in table V and they show that our main conclusions are not significantly affected.

[Insert Table VI here]

5. Discussion and conclusion

5.1. Discussion

Innovation search—in the form of external knowledge sourcing (Ehls et al., 2020; Katila and Ahuja, 2002; Laursen and Salter, 2006; Leiponen and Helfat, 2011), and management innovation—in the form of new organizational processes, practices, and structures (Birkinshaw et al., 2008; Colombo et al., 2021; Damanpour and Evan, 1984), represent critical determinants of firm-level innovative performance. Although prior studies have examined the links between these two innovation activities (e.g., Foss et al., 2013; Gentile-Lüdecke et al. 2020), the conditions under which there is a complementary or substitution effect from their synchronous deployment, such that they symbiotically unlock or inhibit performance benefits, is yet to be explored (Cassiman and Valentini 2016; Damanpour, 2014). Theoretically, this represents an interesting puzzle for research, as prior approaches to organizational change have painted a somewhat confusing picture of the consequences of management innovation. The first view has praised management innovation as beneficial (e.g., Ali et al., 2016; Foss et al., 2011), whereas a second view has highlighted its detrimental effect, because of the avowed ambiguity and social complexity that accompany this innovation activity (e.g., Hannan and Freeman, 1984; Hannan et al., 2006; De Keyser et al., 2021).

Our hypotheses integrate these opposing views by explaining that management innovation is a double-edged sword, generating benefits and detriments for innovation, under certain conditions. While existing literature on innovation search has examined the benefits of management innovation independently of the different external search strategies adopted by the firms (i.e., Foss et al. 2011; Gentile-Lüdecke et al. 2020), our study shows that the effects of management innovation are not context-free and depend heavily on the distinct external search strategies that firms follow. Herein, we set out to demonstrate how a focus on the differences between search depth and breadth, particularly in conjunction with management innovation, can help us explain different performance outcomes.

Drawing on these differences, we posited and tested a model of asymmetric complementarity between external search depth and management innovation, and external search breadth and management innovation. In the case of an external search depth strategy, we theorized that the underlying mechanism of accumulative, step-by-step problem-solving, and low interdependency of relevant technological knowledge (Brusoni, 2005; Katila and Ahuja, 2002) between external partners, emphasize a need for the efficient replication of processes, practices, and structures to innovate. We posited, therefore, that when engaging in an external search depth strategy, the synchronous deployment of management innovation will offset the positive effects of innovation search, by reducing opportunities for replication. In the case of an external search breadth strategy, we argued that the underlying mechanism of recombinatorial problem-solving, and high interdependency of relevant technological knowledge between external partners, emphasize a need to realign processes, practices, and structures in order to innovate. Building on these arguments, we hypothesized that when engaging in an external search breadth strategy, the synchronous deployment of management innovation will accentuate the positive effects of innovation search by enhancing opportunities for realignment.

Our findings provide evidence that lends support to our theorizing regarding the contradictory considerations that emerge from the synchronous deployment of management innovation and external innovation search. They also imply the existence of more complex paths of absorptive capacity building—a condition necessary for effective external knowledge integration, when organizations engage simultaneously in management innovation and search for external knowledge. In fact, management innovation may act as a facilitator or obstacle of absorptive capacity in the context of external search. Because the problem solving mechanisms that underlie the different external search strategies may trigger the need to either sustain or overcome the organizational status quo, disrupting unconditionally this status

quo through management innovation can often discount the firm's absorptive capacity. Our theoretical rational would predict that as the deployment of management innovation activities in deep external knowledge searches increases, absorptive capacity building can decline, resulting in a less fertile environment for knowledge integration and less opportunities for emergence of innovation (e.g., Ahuja and Lampert, 2001; Eisenhardt and Martin, 2000). In contrast, it is likely that the deployment of management innovation activities in broad external knowledge searches would facilitate absorptive capacity building and therefore, the firm's ability to integrate external knowledge resulting in more innovation (Cohen and Levinthal, 1990; McGrath, 2001; Mumford, 2000). Such a rational would resonate with a prevalent theoretical stance claiming that organizational antecedents (i.e., search strategies; management innovation) may have differential effects on absorptive capacity, and subsequently can lead to different performance outcomes (Cockburn, Henderson, and Stern, 2000; Colombo et al., 2021; Zahra and George, 2002; Zollo and Winter, 2002). The question of why this is the case, however, requires further theoretical and empirical attention.

5.2. Conclusion

By examining the conditions under which the synchronous deployment of external innovation search and management innovation in collaborative arrangements creates negative and positive consequences for the firm, our study contributes to the emerging literature investigating the interdependencies among different types of innovation and their resulting performance implications (Carboni and Russu, 2018; Damanpour, 2014; Hullova et al., 2016). We conclude that the synchronous adoption of both practices is likely to be counterproductive when firms engage in external depth. Contrary to this, we found that these activities are mutually reinforcing, and their synchronous adaptation will result in synergetic benefits when firms engage in external breadth.

These results shed light on the conditions through which management innovation can result in positive or negative innovation performance outcomes when companies engage in interactions with external channels of knowledge. Therefore, they contribute to the burgeoning literature on external sourcing (e.g., Badir, et al., 2020; Bei, 2019; Katila and Ahuja, 2002; Laursen and Salter, 2006) by highlighting additional challenges that firms are likely to face when searching for external knowledge. Whereas recent accounts focus on the escalating complexity (Asimakopoulos, Revilla and Slavova, 2020), the coordination costs (Garcia Martinez, Zouaghi and Sanchez Garcia, 2017) and the need for configuring additional firm resources (Hou, Chen, and Xu, 2017), more remains to be understood about the contingent nature of the relationship between external sourcing and innovation performance. New attention to mechanisms such as management innovation that can facilitate or either hinder external search may help resolve puzzles about the effects of the different external search strategies on innovative performance (e.g., Arranz et al., 2019).

By treating external search depth and external search breadth as fundamentally different conceptual levels also, our study extends recent work that has highlighted the role of the firm's innovation strategy in influencing how management innovation supports the process of external knowledge absorption (Colombo et al., 2021; Gentile-Lüdecke et al. 2020; Tang et al., 2020). We contribute to this line of research by stressing the gap between deep and broad external knowledge search strategies, showing that, in the presence of the differential knowledge access they offer, implementing management innovation can maximize synergies but may also compromise innovation performance by limiting the firm's ability to replicate already existing processes, practices, and structures. As such we offer an additional potential explanation for why firms who search for external knowledge are sometimes prone to failure (Astebro and Michela, 2005; Roper et al., 2017). The results of our study are thus consistent with prior empirical work showing the existence of potential disadvantages related to the

different knowledge sourcing strategies (Alnuaimi and George, 2016; Arora et al., 2016, Ritala et al., 2018).

Our study provides also some unique insights into the literature on innovation management, as our findings imply that superior innovation performance is associated not only with a firm's ability to introduce new processes, practices, and structures as prior studies suggest (i.e., Schilke, 2018; Stouten et al., 2018), but also with its ability to select external search strategies where change of well-established organizational routines would be beneficial. A failure to recognize when management innovation is not appropriate while searching for external knowledge may hamper innovation. Drawing attention to management innovation in conjunction with the nature of the external search strategy that firms follow highlights an implication of complementarity and/or substitution that has perhaps been underemphasized in the relevant literature (i.e., Colombo et al., 2021; Foss et al., 2013; Gentile-Lüdecke et al. 2020).

Our work also brings needed clarity to the literature by explaining how management innovation fits into the broader set of external search strategies and vice versa. We demonstrated key differences among the different external search strategies (Alnuaimi and George, 2016; Tang et al., 2020; Terjesen and Patel, 2017) and explained how the synchronous deployment of these strategies and management innovation affects innovative performance. Our results showed that the type of external search strategy that firms follow represents a critical boundary condition in terms of creating synergies with management innovation for improved innovation performance. Most prior studies in the field do not explicitly theorize around the differences between the different external search strategies (e.g., Foss et al., 2013; Gentile-Lüdecke et al. 2020). By studying the different types of external search strategies, specifically, and the idea that search depth and search breadth interact differently with management innovation and trigger different performance outcomes,

we provide a more complete view and approach to the study of the link between external search and management innovation, forming a baseline for future research.

The findings also suggest some important managerial implications. The study provides evidence on the complementary effects of the innovation strategies. More precisely, the study explains that firms should innovate internally by implementing new management routines and practices that support the identification, distribution, assimilation, and commercialization of external knowledge. The findings, however, suggest that the development of new management routines is only imperative for firms who interact broadly with external partners and not for firms who engage in deep and continuous interactions with external partners. In fact, new management routines were found to prohibit the deployment of deep interactions with external partners when firms sought to produce innovations. Overall, this study provides new managerial insights into how and when firms can benefit from their external sourcing activities when combined with management innovation and vice versa.

As with all studies, this study comes with its own limitations. First, due to inherited limitations of the data, this study focused on the more abstract level of management innovation. Future research should be expanded to deal with a more detailed level of management practices, processes, structures, and techniques. More research is needed to understand the dynamics behind potential complementarities between specific external channels, such as customers, universities, competitors or public institutions, and specific types of management innovation, such as total quality management, customer orientation, lean management, vertical disintegration, decision delegation, communication channels, reward systems etc.

Second, although we clarified conditions under which the complementary relationship between management innovation and external search is either productive or counterproductive, we were unable to unravel and distinguish potential complementary

effects between different external search strategies and more radical or incremental management changes. The data precluded a fine grained analysis of such a distinction. Insights into whether the degree of novelty associated with new management practises will be contingent upon the different external search strategies that firms follow and vice versa, can add important dimensions to the previous discussion. Finally, since the findings are based on cross-sectional evidence, our ability to fully address the potential endogeneity of the innovation strategies has been limited to a certain extent. Future research should address this issue through the use of longitudinal data.

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Table I. Summary and descriptive statistics of variables

Variable	Description	Mean	S. D
New to Market Sales	Proportion of total sales derived from new or substantially improved products that are considered new to the market.	2.450	5.386
Search Breadth	Count variable that indicates the degree to which firms search widely across a number of different external knowledge sources.	3.922	3.774
Search Depth	Count variable that indicates the degree to which firms search deeply across a number of different external knowledge sources.	0.756	1.196
Management Innovation	Count variable that indicates the number of areas of management innovation firms engaged in.	0.159	0.366
Market	Market categorical variable operationalized according to where the firm's largest market is local, regional, national, or international.	0.874	0.870
R&D Intensity	Expenditures on R&D relative to total sales.	1.670	8.050
Employees	Firm size categorical variable operationalized according to three categories of employee size that takes the value of 0 for firms with less than 50 employees, 1 for firms between 50 and 249 employees, and 3 for greater than 250.	0.763	0.980
Prior Sales	Log transformed variable of sales that the firm reported during the first year of the study.	15.769	1.990

Table II. Results of innovative performance regressions

	Model 1	Model 2	Model 3	Model 4
Search Breadth	0.404*** (0.026)	0.257*** (0.028)	0.379*** (0.028)	0.235*** (0.030)
Search Depth	0.397*** (0.102)	0.443*** (0.113)	0.536*** (0.118)	0.589*** (0.130)
Management Innovation	1.325*** (0.276)	1.137*** (0.298)	1.256*** (0.404)	1.281*** (0.441)
Search Breadth*Management Innovation			0.274*** (0.082)	0.288*** (0.093)
Search Depth*Management Innovation			-0.490** (0.235)	-0.517** (0.260)
Prior sales		0.132 (0.087)		0.130 (0.087)
Market		1.009*** (0.120)		1.012*** (0.120)
R&D intensity		1.431*** (0.245)		1.458*** (0.248)
Employees		0.489*** (0.165)		0.488*** (0.164)
Constant	0.377*** (0.056)	-1.584 (1.336)	0.377*** (0.051)	-1.567 (1.335)
Industry dummies	Included	Included	Included	Included
Adjusted R-squared	0.139	0.235	0.140	0.237
Model F	22.50***	38.38***	14.49***	36.53***

Robust standard errors are in parenthesis *** p<0.01, ** p<0.05, * p<0.1

Analysis for odd numbered models (1 and 3) = includes explanatory variables only; analysis for even numbers models (2 and 4) = includes both explanatory and control variables

Table III. Results of additional innovative performance regressions

	Model 5	Model 6
Search Breadth	0.258*** (0.028)	0.236*** (0.030)
Search Depth	0.454*** (0.113)	0.600*** (0.130)
Management Innovation	1.168*** (0.298)	1.286*** (0.442)
Search Breadth*Management Innovation		0.287*** (0.093)
Search Depth*Management Innovation		-0.516** (0.259)
Prior performance	-0.170** (0.086)	-0.170** (0.086)
Prior sales	0.133 (0.089)	0.130 (0.089)
Market	1.026*** (0.121)	1.029*** (0.121)
R&D intensity	1.400*** (0.244)	1.424*** (0.247)
Employees	0.484*** (0.167)	0.483*** (0.167)
Constant	-1.377 (1.364)	-1.353 (1.363)
Industry dummies	Included	Included
Adjusted R-squared	0.235	0.236
Model F	36.86***	35.16***

Robust standard errors are in parenthesis *** p<0.01, ** p<0.05, * p<0.1

Table IV. Results of bivariate probit

	Model 7	Model 8	Model 9	Model 10
	Search Breath	Management Innovation	Search Depth	Management Innovation
Prior Performance	-0.039 (0.037)	0.020 (0.038)	0.028 (0.033)	0.026 (0.038)
Prior sales	0.071*** (0.026)	0.020 (0.028)	0.045* (0.024)	0.025 (0.028)
Employees	0.007 (0.049)	0.127** (0.053)	0.074 (0.046)	0.118** (0.054)
Multi-entity	0.048 (0.066)	-0.012 (0.072)	0.061 (0.062)	-0.015 (0.072)
External funding	2.428*** (0.162)	0.336*** (0.066)	0.952*** (0.060)	0.343*** (0.066)
Lack of personnel	0.054* (0.029)	0.094*** (0.032)	0.060** (0.028)	0.095*** (0.033)
New markets	0.341*** (0.063)	0.249*** (0.077)	0.299*** (0.061)	0.254*** (0.077)
Demand	-0.044 (0.031)	-0.013 (0.034)	-0.046 (0.029)	-0.014 (0.034)
Competition	0.309*** (0.043)	0.104** (0.046)	0.243*** (0.038)	0.102** (0.046)
New partnerships	0.127*** (0.029)	0.406*** (0.031)	0.163*** (0.027)	0.404*** (0.031)
Constant	-1.825*** (0.404)	0.512*** (0.051)	-1.868*** (0.377)	0.212*** (0.039)
Industry dummies	Included	Included	Included	Included
Model's Chi ²		999.46***		1204.46***

Robust standard errors are in parenthesis *** p<0.01, ** p<0.05, * p<0.1

Table V. Results of innovative performance regressions with Heckman correction

	Model 1	Model 2	Model 3	Model 4
Search Breadth	0.331*** (0.028)	0.237*** (0.029)	0.314*** (0.030)	0.215*** (0.031)
Search Depth	0.399*** (0.111)	0.378*** (0.114)	0.550*** (0.128)	0.540*** (0.131)
Management Innovation	1.072*** (0.301)	1.073*** (0.306)	1.516*** (0.473)	1.342*** (0.466)
Search Breadth*Management Innovation			0.260*** (0.084)	0.231*** (0.080)
Search Depth*Management Innovation			-0.518** (0.254)	-0.565** (0.259)
Prior sales		-0.743*** (0.163)		-0.763*** (0.163)
Market		1.002*** (0.126)		1.002*** (0.126)
R&D intensity		43.572 (30.962)		43.904 (30.738)
Employees		0.318* (0.173)		0.316* (0.172)
Inverted Mills	23.474*** (2.364)	46.210*** (8.082)	23.505*** (2.368)	47.052*** (8.080)
Constant	-1.429*** (0.196)	6.547*** (1.816)	-1.469*** (0.194)	6.727*** (1.818)
Industry dummies	Included	Included	Included	Included
Adjusted R-squared	0.176	0.245	0.177	0.247
Model F	16.03***	32.48***	11.44***	31.02***

Robust standard errors are in parenthesis *** p<0.01, ** p<0.05, * p<0.1

Analysis for odd numbered models (1 and 3) = includes explanatory variables only; analysis for even numbers models (2 and 4) = includes both explanatory and control variables

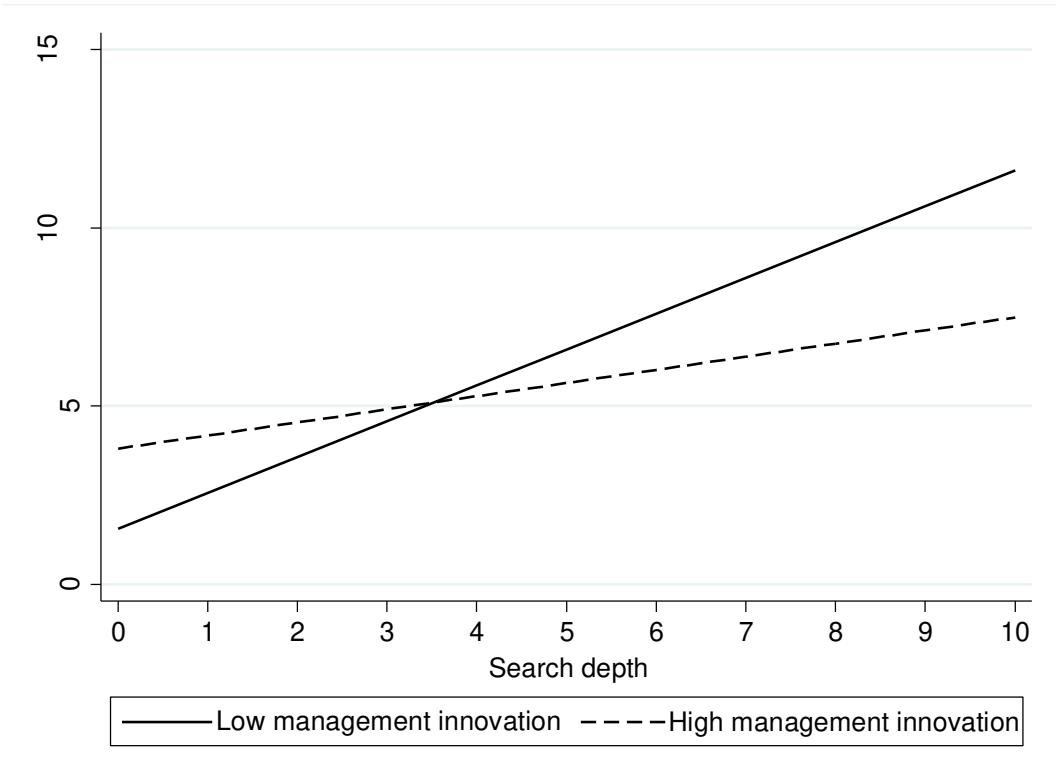


Figure 1. Substitutional Effect of Search Depth and Management Innovation on Innovative Performance

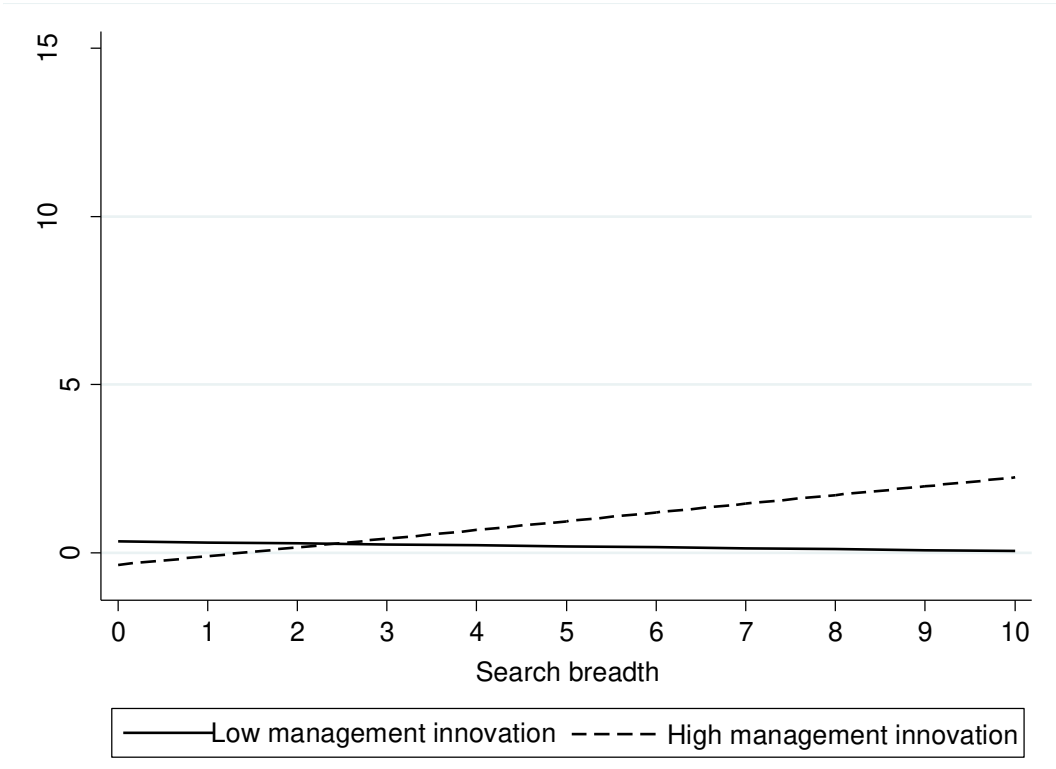


Figure 2. Complementary Effect of Search Breadth and Management Innovation on Innovative Performance

ⁱ NACE (Nomenclature des Activités Économiques dans la Communauté Européenne) is the European industry standard classification system.