The Complementary Effect of Search for External Knowledge and Organizational Innovation on the Firm's Innovative Performance

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The candidate confirms that the work submitted is his/her own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

This study examines the complementary effect of search for external knowledge and organizational innovation on the firm's innovative performance. Specifically, I argue that firms can marginally increase their innovative performance by engaging in both activities simultaneously. I posit, however, that the effect of the joint occurrence of search for external knowledge and organizational innovation varies significantly depending on what is the external search strategy that firms follow. Building on the organizational learning literature, I argue that the success or failure of organizational innovation may be contingent upon conflicting objectives that different external search strategies may involve.

I test my hypotheses by using a sample of 46,862 companies expanding in twelve CIS countries. The results of the study confirm my arguments, suggesting that the complementary relationship between external search and organizational innovation on the innovative performance is likely to exist only for those firms that adopt a search breadth rather than search depth knowledge sourcing strategy. Further, the findings indicate that this effect is stronger for the radical than for the incremental innovative performance of the firm. However, further analysis also reveals the conditions under which the complementary effect of depth external sourcing and organizational innovation on the firm's innovative performance can be unlocked. The theoretical and managerial implications of the study are addressed.

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Chapter 1: Introduction

1.1. Chapter Overview

This chapter presents an overview of the thesis. The first section outlines the background and objectives. In section two, the research questions and the theoretical approach followed to answer the proposed questions are described. Finally, a summary of the study's contributions and the overall thesis structure are outlined.

1.2. Background and Objectives of the Thesis

Innovation has long been recognized as a crucial component of competitive advantage (e.g., Danneels, 2002; Dutta et al., 2005). For this reason, over the past few years, the determinants of innovation have increasingly received attention in the strategic management and innovation literature. Given that introducing substantially novel products or services requires new ideas and knowledge, search for external knowledge has been suggested to be one of the most important determinants of innovative performance (e.g., Kafouros and Forsans, 2012; Laursen and Salter, 2006;). In the literature, search for external knowledge has been repeatedly described as a problem-solving activity in which firms solve problems through combining knowledge elements to create new products (Katila, 2002). Laursen et al. (2012) argue that search for external knowledge provides significant information benefits that positively affect the firm's innovative performance. In the same vein, Sparrowe et al. (2001) claim that search for external knowledge is an important pathway of information and capabilities and as such, it is likely to offer significant innovative performance advantages.

While one strand of research has shown that innovative performance hinges on the openness to external knowledge sources (e.g., Laursen and Salter, 2006; Leiponen and Helfat, 2010), another developing strand has highlighted the positive effects of organizational innovation (e.g., Evangelista and Vezzani, 2010; Miravete and Pernias, 2006). More explicitly, the latter strand of research has found that organizational innovation, defined as the use of new managerial and working routines and practices (Damanpour, 1987), positively affects the firm's innovative performance since it allows the control and coordination of managerial activities that can facilitate innovation (Lawrence and Lorsch, 1967).

Despite widespread agreement within the literature on the benefits of both search for external knowledge and organizational innovation on the firm's innovative performance, only few studies have investigated the link between these two innovation activities with inconsistent arguments and results. For instance, in their studies, Foss et al. (2011), Han et al. (1998) and Mol and Birkinshaw (2009) have emphasized, inter alia, the joint effect of external knowledge and organizational innovation, indicating that organizational innovation moderates the relationship between search for external knowledge and innovative performance. While this stream of research accentuated the importance of organizational innovation for leveraging innovative performance benefits when firms engage in search for external knowledge, it has remained silent on how search for external knowledge can impact on the firms' ability to introduce organizational innovations that streamline innovation. Dealing with this limitation, Zobel (2016) posited and found that organizational innovation mediates the relationship between search for external knowledge and innovative performance. In contrast to previous research, this study elucidated the positive impact of search for external knowledge on organizational innovation, however, it has failed to address the

impact of organizational innovation on the firm's external sourcing activities and recognize potential innovative performance benefits.

While the previous studies have collectively neglected to examine how external search and organizational innovation can interchangeable reinforce each other, the present thesis addresses this limitation by theorizing around the coexisting bidirectional relationships between search for external knowledge and organizational innovation, and their respective innovative performance outcomes. More specifically, in this study, I propose that external search and organizational innovation are complementarity activities such that the return in terms of innovative performance from engaging in one activity increases if a firm also engages in the other activity.

In order to test this assertion this study seeks to examine the potential complementarity of organizational innovation and external search on the firm's innovative performance. Specifically, my line of argument is that search for external knowledge and organizational innovation mutually reinforce each other for the purposes of innovation. However, I argue that the joint occurrence of organizational innovation with different types of external search exerts asymmetric effects on the firm's innovative performance. In the literature, external search breadth and external search depth have been identified as the two components of external search (e.g., Laursen and Salter, 2006). External search breadth is defined as the number of external channels that firms draw upon, while external search depth is described as the extent to which firms draw intensively from these channels (Laursen and Salter, 2006). In this study, I posit that the complementary relationship between external search and organizational innovation on the innovative performance is likely to exist only for those firms that engage in search breadth rather than search depth external knowledge sourcing strategy. I suggest, moreover, that the complementary effect of external

breadth sourcing and organizational innovation will be greater for the radical than for the incremental innovative performance of the firm.

In order to develop my arguments, I use several theoretical approaches. First, I use absorptive capacity to theorize about how the introduction of new managerial and working routines and practices may allow the firm to better appropriate knowledge when engaging in external search. Specifically, I assume that engaging in external search for knowledge sources will increase the need for new managerial and working routines and practices inside the firm (e.g., Mol and Birkinshaw, 2009). Second, I use organizational learning theory (e.g., March, 1991) to argue how deep interactions with external channels of knowledge may impede the implementation of new managerial and working routines and practices. Further, I use the organizational learning viewpoint to tie the introduction of truly novel offerings to external search breadth.

The findings confirm my assumptions revealing that the impact of the coexistence between external search and organizational innovation is different depending on which external search strategy the firm follows. More explicitly, the results suggest that the complementary relationship between external search and organizational innovation on the innovative performance only exists for those firms that adopt a search breadth rather than search depth external search strategy. I theorize that these asymmetries appear because the success or failure of the implementation of an organizational innovation is contingent upon the conflicting objectives and respective learning effects that different external search strategies induce (Lubatkin et al., 2006). The findings also reveal the complementary effect of external search breadth and organizational innovation exerts a more positive influence on the radical rather than the incremental innovative performance of the firm.

To further unpack these findings, the study tests the complementary relationship by taking into consideration different levels of external search. The results illustrate that high degrees of intense dependence on external sources of information are likely to unlock the potential complementary effect of external search depth and organizational innovation on the firm's radical but not on the firm's incremental innovative performance. I interpret these findings as evidence that after a certain degree of intense interaction with external actors, search activities can become so broad that activate the same facilitating mechanisms and induce the same learning effects as external search breadth. This, in turn, is likely to facilitate the implementation of truly novel managerial and working routines and practises, unlocking potential complementarities between organizational innovation and external search depth and promoting the introduction of radical innovations.

1.3. Research Questions Addressed in this Thesis

Past empirical studies (e.g., Evangelista and Vezzani, 2010; Laursen and Salter, 2006; Leiponen and Helfat, 2010; Miravete and Pernias, 2006) have found that external search and organizational innovation are two determinants of a firm's ability to successfully innovate. In this respect, a few other studies (e.g., Foss et al., 2011; Mol and Birkinshaw, 2008) have tried to unravel the complex links between external search and organizational innovation. However, their findings have been inconsistent. In this study, I claim that the reason for these inconsistencies is that external search and organizational innovation mutually reinforce each other and, therefore, should be implemented in parallel in order to incrementally increase the innovative performance of the firm. I also contend that the confirmation of such a link is only useful if we are

able to distinguish how organizational innovation and different external search strategies relate and recognize the asymmetry of their facilitating mechanisms (March, 1991).

By definition, external search is a strategy that aims to increase the amount of experimentation on the ways that knowledge from external sources can be leveraged (Laursen and Salter, 2006). As such, it usually entails organic structures which are likely to induce exploratory learning (March, 1991). On the opposite direction, external depth is a strategy that aims to increase the stability and efficiency of exchanges and collaborations with external actors (Laursen and Salter, 2006). Therefore, it is facilitated by mechanic structures that induce primarily exploitative learning (March, 1991). Having introduced these arguments, I have reasons to believe that the conflicting nature of the mechanisms that facilitate external search breadth and external search depth may undermine the effect of their joint occurrence on the innovative performance of the firm while it may also lead to different degrees of novelty achieved. Mechanic structures have been traditionally considered as a source of organizational and operational stability while organic structures have been linked to intense experimentation and organizational flexibility (March, 1991). Therefore, I assume that not only external breadth is more likely than external depth to complement new managerial and working routines and practices, but also this effect will be greater for the firm's radical than for the firm's incremental innovative performance. To shed more light on these complicated relationships, this thesis aims to answer the following two questions:

1. *What is the effect of the joint occurrence of search for external knowledge and organizational innovation on the firm's innovative performance?*

To answer this question, I develop arguments on how organizational innovation in the form of new managerial and working routines and practices can increase the efficiency of the external search activities and, therefore, the innovative performance of the firm. I explain how external search breadth activities may boost the ability of the firm to implement new managerial and working routines and practices which in turn, increases the firm's innovative performance. Yet, for external search depth, I explain how such activities may undermine any complementary effect on the firm's innovative performance. Yet, I recognize and explain under which circumstances the complementary relationship between external search depth and organizational innovation might be productive.

2. *Are all the innovation outcomes equally affected by the joint occurrence of external search breadth and organizational innovation?*

To answer this question, I develop arguments on why external breadth is more likely to stimulate radical innovation than to foster incremental innovation. Further, I explain how organizational innovation can help firms to synthesize and manage their innovative efforts so as to leverage external knowledge that drill down to the essence of an emerging breakthrough. Last, I explain how the mechanisms that facilitate external search breadth may favour the introduction of organizational innovation.

3. Are all the innovation outcomes equally affected by the joint occurrence of external search depth and organizational innovation?

To answer this question, I develop arguments on why external search depth is more likely to stimulate incremental than to foster radical innovation. I also explain how organizational innovation facilitates the development of tighter intraorganizational linkages and the streamlining of the handoffs between the innovation processes,

promoting the development of increment improvements. Last, I explain why external search depth can help firms to establish the cognitive legitimacy needed for the successful implementation of organizational innovation.

1.4. Contribution of the Thesis

This study makes several contributions to different streams of research. First, by examining the complementary effect of external search and organizational innovation on the firm's innovative performance, the study builds on a growing line of work that seeks to identify the relationship between external sourcing and new organizational practices. The results of this study clarify the inconsistent findings of previous empirical studies that investigate the relationship between these innovation activities (e.g., Foss et al., 2011; Mol and Birkinshaw, 2008). More specifically, the findings confirm that innovative performance benefits might stem from the coexisting bidirectional relationships between search for external knowledge and organizational innovation. Therefore, they shed more light on the complicated relationships between search for external knowledge and organizational innovation as well as on the underling mechanisms that enable firms who engage in both activities simultaneously to leverage innovation performance benefits. Far beyond providing evidence on potential complementarities between external search and organizational innovation, this study clarifies conditions under which their coexistence is also counter-productive. It well reported in the literature that firms commonly set different learning objectives such as explorative or exploitative (Lubatkin et al., 2006). By definition, external search breadth represents an explorative approach to learning, whereas external search depth represents an exploitative approach. Firms engage in either external search breadth or external search depth because they tend to strategically prioritize their

innovation activities with explorative versus exploitative objectives, respectively. The conflicting nature of these objective has been well reported in the literature (e.g., March, 1991; Lubatkin et al., 2006). In this respect, this thesis provides evidence on how such a conflicting nature might explain the asymmetric effects of the coexistence of different external search strategies and organizational innovation on the firm's innovative performance.

The study also adds to the line of work that examines the relationship between different external search strategies and different innovation outcomes (e.g., Foss et al., 2011; Laursen and Salter, 2006). By illustrating differences between learning in different external search strategies, and by indicating conditions under which certain types of external search are facilitated by different types of learning (e.g., exploitative or explorative), the study explains how external search strategies drive different innovation outcomes. By doing so, this study clarifies why and under which conditions external search breadth and external search depth are likely to facilitate the introduction of more radical or more incremental innovations.

This study also contributes to the open innovation literature to the extent that it adds organizational components to external sourcing. More specifically, the findings of this study provide evidence that the open innovation model is contingent upon internal management processes. The results of this study confirm that firms who engage in organizational innovation in the form of new management and working routines practices are better able to reach and process information and knowledge accessed through search for external knowledge.

Further, this study contributes to the organizational innovation literature by emphasizing the importance of external search for the successful introduction of new organizational practises. While organizational innovation appears to increase the

benefits gained through search for external knowledge, it is evident that search for external knowledge might also facilitate the introduction of organizational innovation by providing access to useful information and insights on organizational routines and practices implemented in other settings. Far beyond this, the findings illustrate that under the context of open innovation, successful introduction of new organizational practises does not necessarily lead to successful implementation. In particular, the study clarifies some of the ideas developed in the organizational learning literature (e.g., Gupta et al., 2006; He and Wong, 2004) and tries to integrate these insights into the discussion on how external sourcing and organizational innovation relate with each other. In this respect, the findings of this study confirm the importance of organizational structures in explaining why firms who engage in different external search strategies might experience different pressures from organizational inertia. Therefore, the study opens up interesting avenues in identifying the conditions through which organizational innovation can be successfully introduced and implemented by companies that engage in multiple and in-depth interactions with external channels of knowledge.

In addition, this study contributes to the burgeoning literature on external sourcing (e.g., Laursen and Salter, 2006; Katila and Ahuja, 2002; Zhang and Li, 2010) by highlighting additional challenges that firms are likely to face when they search for external knowledge. New attention to different mechanisms that facilitate different external search strategies may help to resolve puzzles about the effects of the different external search strategies on the innovative performance of the firm. The conflicting nature of mechanisms (e.g., explorative versus exploitative objectives) that facilitate external breadth and external depth may be a very prominent factor that undermines their effectiveness when they are pursued simultaneously.

Last but not least, this study contributes to the dynamic capabilities literature by addressing its repeated calls for understanding the micro-foundations of organizational capabilities and performance (Barney et al., 2011; Eisenhardt et al., 2010). In particular, this study explains the contribution of external search on the development of new organizational routines that facilitate the innovative activities of individuals inside the firm. As Teece (2007) suggests firms that base their sensing, creative, and learning functions on the cognitive traits of few individuals are very likely to become vulnerable. In this context, the introduction of new managerial and working routines and practices is imperative because such routines and practices enable individuals to garner new technological information, tap developments in exogenous science, monitor customer needs and competitor activity, and shape new product and process opportunities (Teece, 2007). This study explains that perhaps in the context of open innovation, one of the greatest challenges that firms face is implementing successfully new managerial and working routines and practices.

1.5. Thesis Structure and Outline

The remaining thesis is organized as follows. Chapter 2 starts with a literature review on innovation, open innovation, search for knowledge, absorptive capacity, and organizational innovation. Building on this discussion, in chapter 3 I illustrate the relationships between the constructs of the study. Then, in chapter 4 I describe the research methodology and the philosophical underpinnings of the study. In chapter 5 I formalize and test the existence of complementarity with a multi-industry sample of 46,862 companies from the Community Innovation Survey (CIS). Last, in chapter 6

the results and the implications of the study, as well as directions for further research are thoroughly discussed.

Chapter 2: Literature Review

2.1. Chapter Overview

The purpose of this chapter is to provide a literature review on innovation, open innovation, search for knowledge, absorptive capacity, and organizational innovation. In the following section, I review the existing literature on the prevailing search strategies and organizational innovation theories that enable us to analyse the complementary effect of search for external knowledge and organizational innovation on the firm's innovative performance. The chapter consists of seven sections including this introduction. Section 2.2 introduces innovation as well as the definitions and categories of the concept. In Section 2.3 the dimensions and typologies of innovation as outcome are discussed. Section 2.4 discusses the dimensions and typologies of innovation as process as well as the different external search strategies found in the literature and their importance for innovation and performance from a strategic perspective. In Section 2.5 the concept of organizational innovation is discussed. Section 2.5 introduces the theory of complementarity. Finally, Section 2.6 provides a summary of the literature review.

2.2. Innovation

Since Schumpeter's (1928) seminal work regarding innovation as the driving force of capitalism, the concept has attracted substantial academic interest (e.g., Abernathy and Clarke, 1985; Damanpour, 1991). Motivated by increasing competition and shorter technology life cycles, scholars and practitioners alike, have started to recognize

innovation as a central component for firm survival. In the management literature, innovation is widely described "*as the life blood of corporate survival and growth*" (Zahra and Covin, 1994: 183). Firms should innovate to renew the value of their asset endowments (Schumpeter, 1950) and, therefore, gain superior performance advantages (Boyne et al., 2003; Roberts and Amit, 2003). Innovation is a means for changing an organization. It can be either the outcome of an organizational response to changes that occur in the firm's internal or external environment, or the outcome of a pre-emptive move taken to influence an environment. Because environments constantly change, firms must be able to adopt innovations over time (Damanpour, 1991; Henard and Szymanski, 2001; Porter, 1990).

Accordingly, innovation capability has been suggested to be one of the most important determinants of firm performance (e.g., Damanpour, 1991; Mone et al., 1998). Formally, innovation capability is described as the skills and knowledge needed to effectively absorb, master, and improve existing technologies, as well as the ability to create new ones (Lall, 1992). This capability is considered as the key to achieving long term competitive advantages and therefore, it is important for firms that operate in highly turbulent environments (Cohen and Levinthal, 1989; Dodgson, 1991, 1993; Hitt et al., 2000; Lall, 1992). Indeed, the positive relationship between innovation and firm performance has been validated empirically in numerous studies (e.g., Artz et al. 2010; Calantone et al., 2002; Damanpour et al., 2009). A summary of some empirical studies that investigate the link between innovation and firm performance is shown in Table 2.1.

In their study of the US software industry, Li and Calantone (1998) confirmed that innovativeness may positively influence several dimensions of the firm's financial performance (e.g., return on investment; return on assets; return on sales; firm's overall

profitability). Similarly, in their examination of the US Personal Computer Industry, Bayus et al. (2003) found a positive link between new product development and the degree to which the return on investment persists over time. Further, using the Australian banking industry as an empirical context, Roberts and Amit (2003) found that, firms which are very active and consistent with respect to their innovative activities are likely to reap significant financial performance benefits.

Consistent with these previous findings, Damanpoor et al. (2009) found that engaging in multiple innovation activities is positively related to organizational performance. Additional support for the link between innovation and performance has also been provided by Artz et al. (2010). Using data from US and Canadian publicly held companies, they (2010) found evidence that the firms' commitment to research and development can positively affect new product announcement and the financial performance of the firm.

These empirical findings highlight the importance of innovation to a firm. To gain competitive advantages, firms should engage actively in multiple innovation activities and new product development. In fact, innovation has been found to be one of the most significant sources of competitive advantage (e.g., Abidin et al. 2013; Damanpour et al. 2009) and, as such, it is important to understand the different definitions of the term.

Table 2.1. Selective summary of empirical studies that investigate the relationship between innovation and firm performance

Paper	Dimension	Performance Measure	Sample	Method
Calantone et al. (2002)	New Product Advantage	Return on Investment (ROI); Return on Assets (ROA); Return on Sales (ROS); and Firm's Overall Profitability	US Software Industry	Confirmatory Factor Analysis
Bayus et al. (2003)	New Product Introduction	Return on Investment (ROI)	US Personal Computer Industry	Time Series Regression Models
Roberts and Amit, (2003)	Innovative Activity	Return on Assets (ROA)	Australian Banks	Least-Square Regression
Artz et al. (2010)	New Product Development and Introduction	Return on Assets (ROA)	US and Canadian Publicly Held Companies	A Three-Stage Least Squares Analysis
Damanpour et al. (2009)	Innovation Types	Service Performance: Quantity of Outputs, Quality of Outputs, Efficiency, Formal Effectiveness, Equity, and Consumer Satisfaction.	UK Public Service Organizations	Time Series Regression Models

2.2.1. Definitions of Innovation

Definitions of innovation abound in the literature, each reflecting a different aspect of the term. The term usually encompasses concepts such as novelty, newness, change, commercialization, and/or implementation. For example, Thompson (1965: 2) defines innovation as "*the generation, acceptance and implementation of new ideas, processes, products, or services*". In the same vein, Wong et al. (2008) suggest that innovation is an effective application of processes and products new to the organization. Kimberly (1981), on the other hand, provides a definition that embraces three different forms of innovation. He (1981) describes innovation consisting of: (1) the innovation as a process; (2) the innovation as a discrete item including products, programs, or services; and (3) the innovation as an organizational attribute.

Some definitions suggest that innovation is tightly coupled to change (e.g., Damanpour, 1991). For example, Damanpour (1996) posits that innovation is a means of changing an organization, and it can include the introduction of a new product or service, a new process technology, a new organization structure including a new administrative system, or either a new plan pertaining to the members of the organization (Damanpour, 1996). Other definitions of innovation place emphasis on the degree of newness. For instance, Van de Ven et al. (1986) suggest that innovation is any idea perceived as new to the people involved in the process, even though, it may appear to others to be an imitation of something that already exists. These definitions give rise to a classification depending on the level or degree of novelty achieved. According to these classifications, innovation can be described as a change that involves, either an incremental improvement, or a radical change of a product, service, or organizational design (Goffin and Mitchell, 2010). More comprehensive definitions, describe innovation as an iterative process which starts with the conception of a new

idea and ends with the production and introduction of this idea to the market (Myers and Marquis, 1969; OECD, 2005). These definitions of innovation highlight two important distinctions. First, the innovation process consists of two stages: the invention of the product and the introduction of this product to the market. Second, given that the innovation process is iterative in nature, it should always include the initial introduction of the innovation as well as the re-introduction of an improved innovation (Garcia and Calantone, 2002).

Since definitions of innovation vary significantly, putting definitions into categories may help researchers to make sense of the subject. For this reason, the section below explains how different conceptualizations of innovation can be categorized.

2.2.2. Categories of Innovation

A close examination of the extant literature reveals that definitions of innovation can be organized into two categories: those that describe innovation as a process and those that describe innovation as an outcome (Crossan and Apaydin, 2010). This opens up the possibility for an innovation to be either a process, or the outcome of this process (Van de Ven, 1986; West and Farr, 1990). Innovation as a process, on the one hand, relates to activities that organizations undertake in order to develop innovations (Quintane et al., 2006). Definitions that describe innovation as a process answer the question *"how"* the innovation process starts and develops (Crossan and Apaydin, 2010) and as such, they allow researchers to identify the constituting activities of innovation (Greve and Taylor, 2000; Myers and Marquis, 1969). They involve concepts such as production and emergence (Gupta et al., 2007), development, solving

and implementation (Myers and Marquis, 1969), and discovery and creation (Dosi, 1988).

Innovation as an outcome, on the other hand, relates to new processes, products, and procedures (Greve and Taylor, 2000; Myers and Marquis, 1969; West and Farr, 1990). Definitions that describe innovation as an outcome answer the question *"what"* is the outcome of the innovation process (Crossan and Apaydin, 2010). Such definitions enable researchers to identify specific characteristics (Jaffe et al., 1993; Levitt, 1960; Utterback, 1971) and therefore, to classify innovations into different types.

The distinction between innovation as an outcome and innovation as a process is not always very clear. In fact, many empirical studies rarely distinguish between these two facets of innovation. The lack of clarity in separation may be problematic, since it does not allow researchers to classify innovations and therefore, it does not enable in-depth investigation of the links between different types of innovation (Sood and Tellis, 2005). For this reason, the sections below explain the most important dimensions pertaining to innovation as an outcome and innovation as a process as well as the different typologies of innovation based on these dimensions.

2.3. Innovation as an Outcome

2.3.1. The Object Dimension

The differentiation between product and process innovation is one of the most prominent categorization for the object of innovation that has emerged in the literature (Totterdell et al., 2002). This differentiation is based on the assumption that the object

of innovation can be either to create or improve a product or service, or to improve the process through which the products or services are produced. Process innovations, on the one hand, are defined as new factor combinations through which production of commodities can be achieved more effectively (Totterdell et al., 2002). As Schumpeter (1911) argued a process innovation is a way of handling a commodity that is not yet tested by experience in the branch of manufacture concerned. Therefore, a process innovation can be either technological or organizational. Technological innovations describe the introduction of new technological features that offer new functionalities, increase product quality, or allow for totally new areas of application (Baranano, 2003; Boer and During, 2001). On the contrary, organizational innovations describe the use of new managerial and working routines and practices (Damanpour, 1987) designed to affect the internal structures, culture, and systems as well as to provide a potentially positive impact on the financial performance of the firm (Totterdell et al., 2002). Process as a form of innovation outcome should not be considered as similar to innovation viewed as a process. Innovation as a process involves ideation and problem solving which in turn, is likely to result in an innovation outcome in the form of a new process (Crossan and Apaydin, 2010).

Product innovation, on the other hand, describes changes in the utilization of a product or a service in the market (Baranano, 2003). The aim of a product innovation is to improve the effectiveness of a product or a service and as such, to provide users with a new functionality, or existing functionality performed in a new way (Boer and During, 2001). A product innovation may be new to the world, or it may be new to the firm or country diffused. It can also be in the form of a purely tangible new good, or in the form of an intangible new service which is often consumed simultaneously to its

production, while it is capable of creating values that satisfy non-physical needs of the users (Boer and During, 2001).

2.3.2. The Degree Dimension

One prominent innovation typology proposed in the literature is the dichotomy of radical versus incremental innovation. A central criterion for this distinction has been the degree to which they incorporate technology that represents a clear and risky departure from existing practice (Duchesneau et al., 1979; Hage, 1980). Some innovations build simply on what is already there by modifying existing functions and practises, whereas other innovations make old things obsolete by changing the entire order of the things (Van de Ven et al., 1999). Tushman and Romanelli (1985: 174) claim that incremental innovations are those that include only minor changes encouraging the current status quo, while radical innovations are "*processes of reorientation wherein patterns of consistency are fundamentally reordered*".

More precisely, radical product innovations are those that include substantially different technologies and provide significantly higher customer, or user benefits when compared to previous products in the industry (Chandy and Tellis, 1998). A radical product innovator is the firm that commercializes a radical innovation (Ettlie and Rubenstein, 1987), while the incumbent firm is the firm that manufactured and sold the generation of products that preceded the radical product innovation (Henderson, 1993; Mitchell, 1991; Mitchell and Singh, 1993). A radical innovation can be a product, a process, or a service that induces unprecedented improvements in performance or costs efficiency and as such, it can transform an already established market or it can either introduce a new one. Herbig (1994) and Tushman and Anderson

(1986) argue that radical innovations may cause significant strategic changes in products/services, markets served, and technological breakthroughs. For this reason, they represent higher order innovations that serve to create new industries, products, or markets (Herbig, 1994; Meyer al., 1990). They involve also a high investment cost and high degree of risk for the innovator (Damanpour, 1991). Further, radical innovations might comprise so advanced technology that no increase in scale, efficiency, or design can make older technologies competitive (Tushman and Anderson, 1986). Hence, radical innovations are likely to make old products or ideas obsolete, alter the relationships between customers and suppliers, displace current products, introduce new product categories, and permit entire industries and markets to emerge, transform, or even disappear (Kaplan, 1999). As Henderson and Clark (1990: 9) argue radical innovations "*over time, augment, shift, and change a firm's technological processes and open up whole new markets and product applications"*. Examples of radical innovation include self-healing computers, commercial satellites, wireless Web, computerized tomography, magnetic resonance imaging, personal computers, pagers, and cellular.

Incremental innovation, on the other hand, "*builds squarely upon the established knowledge base used by incumbent firms, and it steadily improves the methods or materials used to achieve the firm's objective of profitably satisfying customer needs"* (Hill and Rothaermel, 2003: 258). As such, they attempt to meet the needs of the current customers or markets at a rate consistent with the current technological trajectory (Benner and Tushman, 2003; Gatignon et al., 2002). The strategic orientation of an incremental innovation is market dominated growth with diversification by improving and expanding current products and services within a short time (Ettlie et al., 1984; Taylor and Greve, 2006). For this reason, incremental

innovations depend primarily on the ability of the firm to reinforce, recombine, and take advantage of existing knowledge resources (Danneels, 2002; Subramaniam and Youndt, 2005). Examples of incremental innovation include video iPod, whitening toothpaste, and Microsoft vista operating system.

Stamm (2003) tried to summarize the most important differences between radical and incremental innovations. For this reason, he has introduced a comprehensive review that summarizes the focus of each innovation type. Table 2.2 presents this review by reporting nine characteristics that depict differences on the focus of radical and incremental innovations.

While the categorization of an innovation as either radical or incremental innovation is one of the most prominent in the innovation literature, Henderson and Clark (1990) suggest that this typology is incomplete and partially misleading because it neglects the effects of seemingly minor improvements on industry incumbents. To fill this gap, Henderson and Clark (1990) introduced two intermediate types of innovation: modular innovation and architectural innovation. This new typology has emerged from the notion that innovations are composed by hierarchically ordered subsystems and modules (Baldwin and Clark, 2000; Clark, 1985; Schilling, 2000; Tushman and Murmann, 1998), where the components and the knowledge of the system are distinct (Henderson and Clark, 1990). Henderson and Clark (1990) present incremental and radical innovations as the opposite extremes, while modular and architectural innovations are presented as two intermediate stages in between the two extremes (see figure 2.1).

According to Henderson and Clark (1990) radical innovation is the one that establishes a new dominant design that comprises of components linked together in a new architecture. Incremental innovation, on the other hand, refines and extends an

already existing design by introducing improvements associated with individual components, while the underlying core of the design and links between the components remain the same (Henderson and Clark, 1990). Modular innovation is the one that changes only the design concept of a technology without changing the architecture. In contrast, architectural innovation can be described as a type of innovation that reconfigures the architecture of the design by changing the links between the components, while leaving the components and the core design concepts unchanged (Henderson and Clark, 1990).

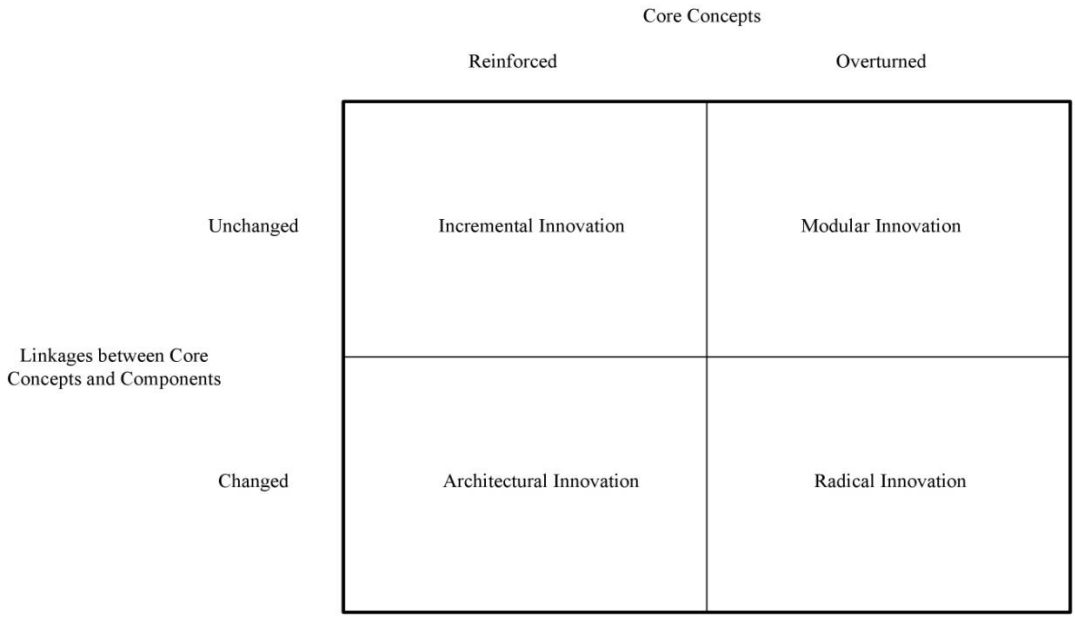


Figure 2.1. A framework for defining innovation

Source: Henderson and Clark (1990)

Table 2.2. Differences between incremental and radical innovation (Stamm, 2003)

Focus	Incremental Innovation	Radical Innovation
Time frame	Short term—6 to 24 months	Long term—usually 10 year plus
Development trajectory	Step after step from conception to commercialization, high levels of certainty	Discontinuous, iterative, set-backs, high levels of uncertainty
Idea generation and opportunity recognition	Continuous stream of incremental improvement; critical events large anticipated	Ideas often pop up unexpectedly, and from unexpected sources, slack tends to be required; focus and purpose might change over the course of the development
Process	Formal, established, generally with stages and gates	A formal, structured process might hinder
Business case	A complete business case can be produced at the outset, customer reaction can be anticipated	The business case evolves throughout the development, and might change; predicting customer reaction is difficult
Players	Can be assigned to a cross-functional team with clearly assigned and understood roles; skill emphasis is on making things happen	Skill areas required; key players may come and go; finding the right skills often relies on informal networks; flexibility, persistence and willingness to experiment are required
Development structure	Typically, a cross-functional team operates within an existing business unit	Tends to originate in R&D; tends to be driven by the determination of one individual who pursues it wherever he or she is
Resource and skill requirements	All skills and competences necessary tend to be within the project team; resource allocation follows a standardized process	It is difficult to predict skill and competence requirements; additional expertise from outside might be required; informal networks; flexibility is required
Operating unit involvement	Operating units are involved from the beginning	Involving operating units too early can again lead to great ideas becoming small

2.4. Innovation as a Process

2.4.1. The Openness Dimension

One prominent dimension that may help researchers to identify different types of innovation as a process, is the degree to which the innovation process is open and externally focused. Traditionally, most of the discussion on innovation has been around a single firm that develops and commercializes its own ideas by employing solely internal capabilities and by maintaining control over its own innovation activities. This type of innovation is known as the "closed innovation model".

Today, however, firms rarely innovate alone. Due to the increased mobility of knowledge workers and the growing availability of internet, the value of the closed innovation model has been undermined giving birth to a more interactive approach towards innovation (Chesbrough, 2003). In fact, the innovative efforts of the firms are usually organized in a collaborative manner that includes dense and heterogeneous networks. Collaborative arrangements between network actors occur based on mutual trust (Laursen and Salter, 2006; Scott and Brown, 1999). This approach towards innovation is called "open innovation model" (Chesbrough, 2003).

The basic argument of the open innovation model is that increased focus on internal R&D leads in declining novelty generation and innovation success (Chesbrough, 2003). As Chesbrough (2003b: 130) argues, firms that rely heavily on internal sources of knowledge tend to "*miss a number of opportunities because many will fall outside the organization's current business or will need to be combined with external technologies to unlock their potential"*.

Realizing the limitations of internal knowledge sourcing, innovating firms have shifted their focus to leveraging external sources of knowledge. The use of external

sources of knowledge has significantly reduced the R&D expenditures of firms, while increasing the firms' ability to innovate and gain performance advantages (Chesbrough, 2003a, 2003b). For some industries open innovation has been around for a long time. One very prominent example is the Hollywood film industry. Companies in this industry innovate by using an extensive network of external actors, including among others, production studios, directors, talent agencies, actors, and scriptwriters (Chesbrough, 2003). Today, the majority of the existing industries are in a transition phase moving from the closed to the open innovation paradigm (e.g., healthcare, computers, software, communications, banking, insurance, and consumer packaged goods).

In order enable easy comparison between the open and closed innovation paradigm, Chesbrough (2003) has introduced six contrasting principles. These principles are presented in table 2.3 and they build upon the following six elements: the location of expertise, the task of own R&D, the attitude towards research, the endeavour to be first on the market, the location of idea generation, and the handling of intellectual property. The basic difference between the models is that in the closed innovation paradigm firms adhere in the following philosophy: firms' boundaries should be kept systematically as impermeable as possible. On the contrary, the open innovation paradigm assumes that firm's boundaries should be systematically opened and kept permeable to outside knowledge influx.

No matter the type of a process innovation that firms adopt, new knowledge has long been considered as a crucial factor for improving their innovative activities (e.g., Cohen and Levinthal, 1990; Peteraf, 1993; Porter, 1991). Irrespective of whether innovation model is open or closed, the invention and commercialization of an innovation has been found to depend on the firm's ability to acquire new knowledge

(e.g., Cohen and Levinthal, 1990; Nelson and Winter, 1982). However, the process of identifying new knowledge requires that a firm deliberately search for and reach out new useful knowledge sources (Katila and Ahuja, 2002; Laursen and Salter, 2006). The following section describes some of the most important knowledge search strategies found in the literature.

Table 2.3. Contrasting principles of closed and open innovation

Closed Innovation Model	**Open Innovation Model**
The smart people in our field work for us.	Not all the smart people work for us. We need to work with smart people inside and outside our company.
To profit from R&D, we must discover it, develop it, and ship it ourselves	Eternal R&D can create significant value; internal R&D is needed to claim some portion of that value.
If we discover it ourselves, we will get it to market first.	We don't have to originate the research to profit from it.
The company that gets an innovation to market first will win.	Building a better business model is better than getting to market first.
If we create the most and the best ideas in the industry, we will win.	If we make the best use of internal and external ideas, we will win.
We should control our intellectual property, so that our competitors don't profit from our ideas.	We should profit from others' use of our intellectual property, and we should by others' intellectual property whenever it advances our own business model.

2.4.2. Local and External Search

It appears that high-technology firms rely heavily on innovation to increase their chances for survival and success. To boost the outcome of the innovation process, companies search for new knowledge. According to Huber (1991), innovation search is a learning process essential for technology improvements (Nelson and Winter, 1982), new skills development (Makadok and Walter, 1996), and organizational flexibility (Cyert and March, 1963). Alvarez et al. (2013) describe innovation search as an important dynamic capability that boosts problem solving and discovery of new opportunities. According to many scholars (e.g., Berends and Lammers, 2010; Kim and Rhee, 2009), search capability is essential for gathering, storing, and converting information into knowledge and therefore, it is beneficial for both exploitative and exploratory innovation.

For many years, the discussion was concentrated around "local search". Management of technology, organizational, and evolutionary scholars argued that "local search" is one of the most vital parts of the innovation activity (Stuart and Podolny, 1996). Local search refers to R&D activities that lie in the field of the firm's current expertise (Helfat, 1994; March and Simon, 1958; Nelson and Winter, 1982). Given that organisations rely heavily on their historical experience (March, 1988), the results of their past search efforts have been considered as the natural starting point of their new search efforts (Nelson and Winter, 1982). This argument is consistent with the assumption that the R&D activity of the firm is path dependent. This assumption has a very long tradition in the innovation literature (e.g., Cohen and Levinthal's, 1990; Peteraf, 1993; Porter, 1991). For example, Cohen and Levinthal (1990) argue that the "absorptive capacity" of the firm defined as the ability to recognize, assimilate, and integrate new technological knowledge is contingent upon the firm's previous R&D

activities. Along the same line, the resource-based view of the firm suggests that firm-specific competences and capabilities are the main source of competitive advantage (Barney, 1991; Peteraf, 1993; Porter, 1991; Wernerfelt, 1984). Several empirical studies have appeared in the past emphasize the effects of "local search" on innovation. In Martin and Mitchell (1998) account, it was found that local search is related to the introduction of designs that are similar to those incorporated into the existing products of the firm. Similarly, Stuart and Podolny (1996) have concluded that large semiconductor firms usually focus their exploration activity on closely related technological domains.

Whilst it is generally agreed that "local search" facilitates the development of firm-specific competences, many scholars agree that long-lasting competitive advantages depend heavily on the firms' ability to move beyond local search (e.g., Baldwin and Clark, 2000; Cassiman and Valentini 2015). Firms can decrease the risks of innovation by following what Nelson (1961) termed a "parallel-path strategy" (Cassiman and Valentini 2015; Hoang and Rothaermel, 2010). This perspective underlines the importance of utilizing a variety of different approaches to innovation. Similarly, Baldwin and Clark (2000) stress the importance of "multiple parallel searches" for innovation success.

Recent literature suggests that innovation cannot be seen as a purely internal matter (e.g., Laursen and Salter, 2006). Indeed, today the focus of many companies has shifted towards the development of their ability to generate, acquire, and integrate both internal and external sources of knowledge (Leonard-Barton1, 1995; Nonaka and Takeuchi, 1995; Simonin, 1997). Firms' external linkages can influence over time, both the innovation processes as well as their innovation outcomes (Powell et al., 1996; Rothwell et al., 1974; von Hippel, 1987). As many scholars argue (e.g., Rosenkopf and

Almeida, 2003; Rosenkopf and Nerkar, 2001) search for external knowledge can reduce the path dependence effects by facilitating the reconfiguring of the firm's knowledge base. Kogut and Zander (1992) termed this ability as "combinative capability". Teece et al. (1997) introduced the concept of "dynamic capability", while Henderson and Cockbur (1994) have used the term "architectural competence".

While local search, focus mainly on internally generated developments, moving beyond local search includes integrating developments generated by others. Past empirical evidence has been provided suggests that innovation success is closely related to search for knowledge in a broad variety of technological domains and geographic locations (e.g., Ahuja and Katila, 2004; Ahuja and Lampert, 2001; Katila and Ahuja, 2002; Laursen and Salter, 2006). For this reason, collaboration with external partners has become a central element of the innovation activity (Chesbrough, 2003a, 2003b). Further, the extent to which firms collaborate with external actors as well as the intensity of the use of different information sources, such as customers (von Hippel, 1978), suppliers (Leiponen, 2000) and research institutions have been found to be important determinants of the firm's ability to innovate (e.g., Ahuja and Katila, 2001; Laursen and Salter, 2006; Rosenkopf and Nerkar, 2001; Veugelers and Cassiman, 1999).

Past empirical findings (e.g., Cassiman and Valentini 2015; Hoang and Rothaermel, 2010; Laursen and Salter, 2006) have collectively emphasized the importance of a more interactive approach towards innovation called "open innovation model". As discussed earlier, this model has introduced a new innovation paradigm that deviates from the traditional approach known as "closed innovation model" in the sense that emphasizes the important role of external actors in the innovation activity. In the open innovation context, firms need to search more widely and deeply to

leverage valuable knowledge and information (Laursen and Salter, 2006). Therefore, external search has been found to be one of the major constituents of open innovation (e.g., Cassiman and Valentini 2015; Hoang and Rothaermel, 2010; Laursen and Salter, 2006). Detailed description of the open innovation model as well as explanations on why external search lies at the heart of the model are provided in the following section.

2.4.3. Defining Open Innovation

Research has frequently shown that knowledge is a key driver for innovation (Subramaniam and Venkatraman, 2001). As aptly remarked by Laursen and Salter (2006), knowledge creation and knowledge acquisition depends heavily on the firm's ability to screen the external environment and recognize and assimilate external knowledge (Laursen and Salter, 2006). The exploitation of external knowledge and the combination of external knowledge with knowledge resources available inside the firm have been recognized as critical dimensions for improving the firm's innovative performance (Chesbrough, 2003a).

The integration of external knowledge and expertise into the firm's internal innovation process has been termed as "open innovation". Chesbrough has introduced the term in his book published in 2003 and since then the concept has received unprecedented attention from practitioners and researchers. As opposed to the "traditional" or "closed innovation model" which describes the knowledge creation process as an internal firm-level activity without any external interference, open innovation model assumes that firms must interact with external actors and must be able to use both external and internal knowledge as well as internal and external paths to the market (Chesbrough, 2003a; Chesbrough, 2006a). Since valuable ideas may

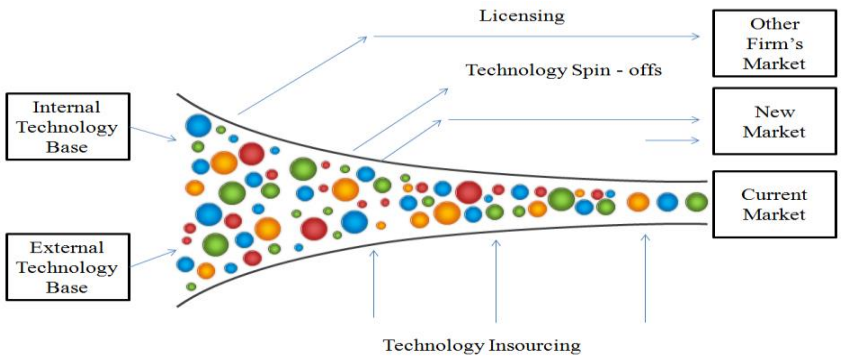
come and go to the market from both inside and outside the company, higher returns on the firm's innovative activities and intellectual property can be gained by loosening significantly the control over both (Chesbrough, 2003a). Chesbrough (2003) has identified four interconnected factors that led to the establishment of a more open innovation model: the increasing availability and mobility of skilled workers; a venture capital market that endows entrepreneurs with the necessary capital to compete; the external options for previously shelved ideas; and the increased capabilities of external suppliers.

Figure 2.2 presents graphically the open innovation model (see Chesbrough, 2004). According to the graph, the open innovation paradigm presents alternative ways for ideas to flow into the innovation process and flow out into the market, including strategic and managed exchanges of information and knowledge with external actors and integration of their resources and knowledge into the organization's innovation activities (Chesbrough, 2004). It suggests also that strategies for open innovation include commercializing external ideas through simultaneous exploitation of outside and in-house pathways to the market (Chesbrough, 2004).

This ambivalent activity represents a boundary spanning strategy that blares of the lines between the company and its surrounding environment. Firms that engage in this innovation paradigm should be able to become significantly porous and able to organize themselves in loosely coupled networks consisting of diverse actors (Laursen and Salter, 2006). Linkages with diverse external actors facilitate the introduction of new knowledge which in turn, boosts the firms' brainstorming activities and enables better commercialization of new ideas (Laursen and Salter, 2006). Recent examples of open innovation models such as Proctor & Gamble's OLAY Regenerative cream provide practical evidence on how linkages with external actors can contribute to the

successful generation and commercialization of new products (Huston and Sakkab, 2006). Proctor & Gamble adopted an innovation model that moved from a centralized approach to a network approach that emphasizes the opening to a wider range of knowledge sources and enables greater exploitation of external ideas. The central component of this innovation model is the assumption that external sources of ideas may often be more valuable than internal ones (Sakkab, 2002).

Since the open innovation model accentuates the great importance of external ideas, it has been repeatedly described in the literature as a search strategy for external knowledge (Laursen and Salter, 2006). External knowledge utilization activities and external linkages organizations engage in to fulfil their knowledge integration efforts, has become a major topic of empirical investigation (e.g., Huizingh, 2011; Van de Vrande et al., 2010). The following section discusses the dimensions of the external search strategy or open innovation strategy found in literature.



Source: Chesbrough, 2004

2.4.4. Dimensions of External Search

Prior literature has described the product development process as a problem-solving activity that requires the creation and recombination of new knowledge (Katila and Ahuja, 2002). The need for new knowledge is thought to be a major rationale behind search for external knowledge. The popularity of the external search strategies has

been stimulated from many empirical studies (e.g., Laursen and Salter, 2006; Zahra and Nielsen, 2002). According to the literature, external search strategies assume great importance since they represent the decisions that firms have to take so as to best exploit external knowledge (e.g., Laursen and Salter, 2006). They include direction and priorities for acquisition of external ideas, knowledge, and technologies and they encompass "*organization's problem-solving activities that involve the creation and recombination of technological ideas"* (Katila and Ahuja, 2002: 1184).

Laursen and Salter (2006) have proposed external search breadth and external search depth as two dimensions of the external search strategy. They define external search breadth as *"the number of different search channels that a firm draws upon in its innovative activities"* (135). Laursen and Salter (2006) emphasize the importance of external search breadth in the innovation process. They point out that external breadth strategy enables firms to take advantage of new ideas and technologies and as such, to increase their innovative performance. Their argument is based on the assumption that interaction between diverse actors can trigger the introduction of novel solutions and new combinations of diverse information (Katila and Ahuja, 2002) that facilitate problem solving (March, 1996) and recombination of internal knowledge (Fleming and Sorenson, 2001).

External search depth, on the other hand, is defined as the deepness or intensity of the interaction with external actors (Laursen and Salter, 2006). This strategy facilitates the endeavours of the firm to exploit external knowledge in different ways (Katila and Ahuja, 2002). It is a strategy that firms can employ in order to reduce the possibility of errors during the innovative process (Levinthal and March, 1981). Intense interaction with external actors can help firms to develop routines that increase the reliability of the innovation process (Levinthal and March, 1981). As Katila and

Ahuja (2002) argue repeated use of external knowledge contributes to the development of a good understanding of concepts involved in the innovation processes, enabling firms to adapt or either expand their competencies (Katila and Ahuja, 2002). In this context, external search depth is considered as a useful strategy that firms can employ in order to achieve the decomposition of the innovation activities in a logical and well demarcated sequence. Therefore, external search depth strategy can contribute towards the elimination of dispensable stages, increasing the dynamism of the innovative activity (Eisenhard and Tabrizi, 1995).

The importance of external search breadth and external search depth has been uncovered in many empirical studies that sought to prove the influence of the collaboration with external partners such as customers, suppliers, universities, consultants, competitors, non-profit organizations, public and private institutions on the firm's innovative performance (e.g., Becker and Dietz, 2004; Belderdos et al., 2004; Nieto and Santamaria, 2007). Table 2.4 summarizes empirical studies that examine the effects of external search strategies on the firm's innovative performance.

As reported by Stuart and Podolny (1996) firms that engage in external sourcing can easily reposition their technological base by utilizing different alliances and coalitions and by getting access to diverse sets of technologies. Similarly, Nagarajan and Mitchell (1998) suggest that external search is likely to result in technological change. A common agreement between these accounts is that spanning inter-firm boundaries generates innovative performance advantages through spanning the technological boundaries of the firm (Amara and Landry, 2005; Faems et al., 2005; Roper et al. 2008; Tether and Tajar, 2008).

In line with the previous argument, Kleinbaum and Tushman (2007) argue that groups of individuals embedded in networks that span social and group-level boundaries are more likely to demonstrate enhanced ability to brainstorm novel ideas. Kleinbaum and Tushman (2007) have provided evidence that loosely coupled networks can offer access to different sources of knowledge and alternative perspectives for problem solving, decision making, and creativity. Also, external linkages can have a considerable impact on the ability of the individuals to recognize available opportunities with regards to different parts of the organization. Along the same line, social capital theory (e.g., Burt, 1992) suggests that individuals having a broad network of contacts demonstrate greater capacity for knowledge sharing (Reagans and McEvily, 2003) and greater creativity than individuals whose network has been traditionally narrow (Hargadon, 2003).

To prove empirically these arguments, Tortoriello (2015) used sociometric data from scientists, researchers, and engineers of a large high-tech company. The results of this study confirmed that the generation of innovative solutions is directly linked to the linkages that firms develop with external actors. Tortoriello (2015) argues that collaboration with external actors provides great opportunities for recombining knowledge, facilitates the knowledge sharing and acquisition process, and offers easier access to internal talent and capabilities. Similarly, Singh et al. (2015) accentuate the importance of collaboration networks for the acquisition of "new knowledge" and "combinatory knowledge". They define 'new knowledge' as the knowledge that is unfamiliar to the focal inventor. This knowledge can be combined with internal knowledge towards the development of new innovations (Fleming, 2001; Rodan and Galuci, 2004). Combinatory knowledge, on the other hand, is defined as the ability of the firm to combine and reconfigure new knowledge highly tacit in nature (Singh et

al., 2015). This type of knowledge can positively affect the number of valuable innovations (Fleming, 2001; Henderson and Clark, 1990; Nonaka, 1994).

The basic assumption of the above arguments is that external knowledge should be combined with internal knowledge to unlock its potential. As Cassiman and Valentini (2015) claim inbound and outbound knowledge flows exert a complementary effect on the firm's innovative performance for a number of reasons. First, external sources of information are likely to decrease the transactional and cognitive costs of blocking patents that haven't been commercialized. Second, external sources of information can offer useful insights on the technology market, enabling firms to value external technologies more effectively (Cassiman and Valentini, 2015).

In line with the above arguments, Klevorick et al. (1995) and Arundel et al. (1995) have found that U.S and European companies increased their innovative performance by using ideas accessed through different knowledge sources. More precisely, their surveys have revealed that firms investing on several collaborative arrangements with firms operating in the same industry, customers, suppliers, academic research, and governmental research laboratories, and professional and technical societies are more likely to come up with useful innovations. Similarly, Leiponen and Helfat (2010) provide evidence that collaboration with external partners offers better access to complementary sources of knowledge (Kogut and Zander, 1992; Schumpeter, 1934) and as such, it can help firms to increase their innovative performance.

The intensity of collaboration with individual actors has been also found to be a significant predictor of the innovative performance of the firm. Many empirical studies uncovered the influence of individual sources of knowledge on the innovative

activities of the firm. For example, Tether (2002), in his account, emphasized the importance of working closely with customers and suppliers within the supply-chain. His main argument has been that customers and suppliers are likely to provide complementary knowledge such as users' technical know-how, insights on pricing issues and users' behaviours. Further, Tether (2002) suggests that collaboration with customers and suppliers is likely to enhance the chances of an innovation being accepted within the same user community. He argues, moreover, that the impact of collaboration with universities and government institutions can expand beyond the supply chain. Universities have shifted lately toward a closer collaboration with industry. This has contributed significantly to the shift in the universities' focus towards problem solving, spanning the boundaries of the traditional scientific knowledge (Tether, 2002).

In the same vein, Laursen and Salter (2004) argue that cooperative arrangements with universities are likely to increase the levels of creativity and innovation within the firm. Their empirical findings demonstrate that firms engaging in collaborative arrangements with universities tend to be more creative and therefore, more competitive. Further, Frenz and Ietto-Gillies (2009) found that cooperative agreements with external institutions can help firms to span their location boundaries and therefore, to gradually increase their innovative performance. Similarly, Mol and Birkinshaw (2009) accentuate the importance of market-based and professional sources of knowledge. As they point out, through intense collaboration with market-based and professional sources, firms can gain useful insights on organizational practises implemented in other settings. In turn, these insights can facilitate the introduction of new managerial routines and practices (organizational innovations) designed to improve the innovative performance of the firm.

In their seminal study, Laursen and Salter (2006) have sought to shed more light on the relationship between external search and innovative performance. They suggested, inter alia, that firms who search more broadly and deeply tend to be more innovative. However, they posit that the relationship between external search and innovative performance takes an inverted U-shape. They suggest that beyond some point of breadth, external search strategy is associated with three problems (Koput, 1997). First, the "absorptive capacity problem". This problem refers to the restricted ability of the firms to manage and choose among different ideas. Second, "the timing problem". This problem arises because many ideas might come at the wrong time and place. Third, "the attention allocation problem". This problem highlights the possibility of not taking some ideas seriously or at least not giving them the right level of attention (Koput, 1997). Similarly, Laursen and Salter (2006) argue that beyond some point, external depth requires a significant amount of resources and attention while it creates detrimental opportunity costs for the firm. For all these reasons, the effects of external search breadth and external search depth on the innovative performance of the firm are likely to be diminishing.

In line with Laursen and Salter (2006), many academics have exalted the positive effects of external search strategies on the innovative performance of the firm, recognizing also their limitations. For instance, Zahra and Nielsen (2002) suggest the development of internal capabilities is time-consuming and constrained by the firm's previous investments, organizational, and internal process inadequacies (Zahra and Nielsen, 2002). They suggest that firms can overcome these inadequacies by deploying external sources of knowledge. Such knowledge sources can accelerate the development of useful capabilities, increase operational flexibility, and decrease organizational costs. They argue, however, that external capabilities may not always

be compatible with internal management systems and processes (Leonard-Barton, 1995). Therefore, leveraging external sources may require significant changes in the production process and new personnel (Zahra and Nielsen, 2002). According to their analysis, too much focus on external sources might result in lower investments in internal capabilities. This opportunity cost can harm the competitive position of the firm (Zahra and Nielsen, 2002). In the same vein, Hoang and Rothaermel (2010), explain that external exploitation experience can increase R&D project performance by helping firms to develop tacit knowledge compatible with internal management processes. On the contrary, exploration experience imposes significant challenges since learning from external partners is a very difficult task (Hoang and Rothaermel, 2010).

The previous studies argue that no matter their limitations, external search strategies can exert positive influence on the firm's innovative performance. A few studies have found also that this positive influence might vary across different levels of novelty. Recall that a central criterion for categorizing different innovation outcomes has been the degree to which they incorporate technology that represents a clear and risky departure from existing practice (Duchesneau et al., 1979; Hage 1980). The next section builds upon this to present studies that investigate the effect of external search or open innovation on different types of innovation.

Table 2.4. Empirical studies that examine the effects of external search strategies on different aspects of innovation.

Author(s)	Open Innovation type	Sources of Knowledge	Unit of Analysis	Search Dimension	Key Findings
Becker and Diez (2004)	R&D cooperation	Suppliers Clients Competitors Universities	Firm	Breadth	✓ External sources of information influence positively the technological capabilities of the firm and therefore, the development of new or improved products. ✓ Assets, resources, and information leveraged from external sources influence positively the research efficiency of the firm and therefore, the total R&D turnover. ✓ The number of partners that cooperate efficiently with each other has a positive impact on new product development. ✓ Collaboration with external firms and institutions can make external resources usable because it facilitates knowledge transfers, resource exchange, and organizational learning.
Miotti and Sachwald (2003)	R&D cooperation	Suppliers of components Suppliers of equipment Clients Competitors Universities	Firm	Breadth	✓ The likelihood of cooperation on R&D is higher for R&D intensive firms. ✓ The likelihood of cooperation on R&D is higher for firms that use scientific resources to innovate, as

		Public Research Institutions			opposed to firms further away from the technological frontier. ✓ Vertical R&D co-operation is more frequent than horizontal co-operation with rival firms. ✓ Horizontal co-operation with rival firms is more frequent in technology intensive sectors. ✓ Co-operation with public research institutions is higher for firms that conduct R&D at the technological frontier.
Faems, Looy and Debackere (2005)	Collaboration	Suppliers Clients Competitors Universities Research Institutions Consultants Suppliers	Firm	Breadth	✓ The breadth of the firm's collaboration activities is positively related to the innovative performance of the firm. ✓ Collaboration with different types of partners coincides with different types of innovation outcomes.
Niento and Santamaria (2007)	Collaboration	Suppliers Clients Competitors	Firm	Breadth	✓ The breadth and the continuity of technological collaboration is positively related with product innovation.

		Universities Public Research Institutions Private Research Institutions Consultants			✓ The influence of collaboration breadth is greater for innovations with a greater degree of novelty. ✓ Greater experience in collaboration leads to greater innovation strategy success ✓ Greater diversity in the collaborative networks leads to higher degrees of novelty.
Belderbos, Carree and Lokshin (2004)	R&D cooperation	Suppliers Clients Competitors Universities	Firm	Breadth	✓ There is a positive relationship between the breadth of cooperation and the labour productivity growth. ✓ There is a positive relationship between the breadth of cooperation and the growth in sales of innovative products.
Tether and Tajar (2008)	Sources of Information	Customers Competitors Suppliers Standards and regulations Fairs and exhibitions Professional meetings or conferences Trade associations	Firm	Breadth	✓ Links with specialist knowledge providers tend to complement rather than substitute for a firm's own internal innovation activities and to complement firm's sourcing of information from other sources such as suppliers, customers and competitors. ✓ Different sources of information complement each other. ✓ Service firms are significantly more likely to have links with

		Trade or technical press (including computer databases) Other (non-research based) public sector organisations			consultants, and, with the important exception of technical service firms, are significantly less likely to have links with either private or public research organisations. ✓ Technical service firms' tend to have strong links with the public science-base. ✓ Private sources of knowledge and especially consultants are more widely used as a source of information or knowledge for innovation than public science-base.
Roper, Du and Lower (2008)	Sources of Knowledge	Clients suppliers consultants competitors Joint ventures Universities Industry operated labs or public labs	Firm	Breadth	✓ Internal R&D and backward knowledge sourcing have positive direct effects on product and process innovation ✓ Forward and horizontal knowledge sourcing have similar complementary effects with enterprises' other external knowledge sourcing activities but have a direct influence only on product innovation. ✓ Enterprises' public knowledge sourcing activities have no direct impact on innovation but have an indirect positive effect on innovation through their strong

					complementarity with other knowledge sourcing activities.
Tether (2002)	Joint R&D	Suppliers Clients Competitors Universities Public Research Institutions Private Research Institutions Consultants	Firm	Breadth	✓ Firms that develop more radical innovations are more likely to collaborate with external partners. ✓ The breadth of the external search depends on the type of the firm being considered and what is meant by innovation (incremental versus radical).
Amara and Landry (2005)	Sources of Information	Suppliers of equipment, material and components Clients Competitors Consultancy firms Research sources Universities and colleges Federal government agencies and research laboratories Provincial agencies and research laboratories Generally available sources	Firm	Breadth	✓ The impact of the variety of generally available sources of information has no significant relation to novelty of innovation in firms. ✓ Firms that can count on a larger variety of internal resources are more likely to introduce innovations. ✓ Firms that use a larger variety of research sources are more likely to develop radical innovations. ✓ The use of market sources of information decreases the likelihood of initiating radical innovations.

		Trade fairs and exhibitions Internet or computer based information networks Professional conferences, meetings and publications			✓ The level of government support programs and operation use in industries of high technological intensity is positively related with the novelty of innovation.
Rothaermel and Deeds (2006)	Alliances	Suppliers Clients Competitors Universities Public Research Institutions Private Research Institutions Consultants	Firm	Breadth	✓ There is a curvilinear relationship between external breadth and innovative performance. ✓ There are diminishing returns to high levels of alliance activity. ✓ The level of external collaboration experience positively influences the firm's innovative performance.
Laursen and Salter (2006)	Sources of Information	Suppliers Clients Competitors Universities Public Research Institutions Private Research Institutions Consulting Firms Professional Conferences	Firm	Breadth Depth	✓ External search depth is curvilinearly related to innovation performance. ✓ The more radical the innovation, the less effective external search breadth strategy will be in increasing innovative performance. ✓ The more radical the innovation, the more effective external search breadth will be in increasing innovative performance.

		Trade Associations Technical/Trade press Fairs, exhibitions Technical, healthy and safety and environmental Regulations			✓ The R&D intensity of the firm complements external breadth and depth strategies in shaping innovative performance. ✓ There is a substitution effect between external search activities and internal R&D.
Leiponen and Helfat (2005)	Sources of Knowledge	Suppliers Clients Competitors Universities Public Research Institutions Private Research Institutions Consulting Firms Scientific/Professional Conferences Patents Databases Trade fairs/exhibitions	Firm	Breadth	✓ External and internal knowledge sources are complementary. ✓ Greater breadth of innovation objectives and knowledge sources are associated with innovation success. ✓ Individual sources are not significant predictors of innovation success. ✓ There are increasing returns to a greater number of objectives and sources supporting the benefits of breadth.
Love, Roper and Vahter (2014)	Sources of Knowledge	Suppliers Clients	Firm	Breadth	✓ Past experience on managing external linkages has a positive effect on the relationship between current linkage breadth and

Competitors Joint Ventures Universities Industry-Operated Laboratories Government-Operated Laboratories	innovation, suggesting that there is a learning effect present in terms of innovation linkages. ✓ There is a statistically significant difference in the relationship between current openness and performance only for establishments that already have more than four different types of linkage in a previous period.

2.4.5. External Search and Different Degrees of Novelty

It is well documented in the literature that the degree of novelty associated with an innovation might vary significantly (e.g., Chiang and Hung, 2010; Garcia and Calantone, 2002; Jansen et al. 2006; Laursen and Salter, 2006). Innovation maybe graded on a scale from incremental to radical (Garcia and Calantone, 2002; Jansen et al. 2006; Laursen and Salter, 2006). Laursen and Salter (2006) and Chiang and Hung (2010) have found that external search breadth and external search depth exert asymmetric effects on radical and incremental innovation (e.g., Chiang and Hung, 2010; Laursen and Salter, 2006). However, their findings have been quite inconsistent.

For example, Laursen and Salter (2006) found that external search breadth exerts more positive influence on the incremental, while external search depth exerts more positive influence on the radical innovative performance of the firm. Their arguments were anchored in the product life cycle theory. Specifically, they suggested that radical innovation should rely upon a few external sources of information. Since radical innovations refer to products at early stages of diffusion, in-depth knowledge that stems from specific actors should be more valuable as compared to diverse but superficial knowledge. On the opposite direction, they argue that the development of an incremental innovation should require a much broader scope of interaction with external actors. Since incremental innovations represent minor improvements on an existing dominant design, they are likely to be inspired by many different sources of knowledge (Laursen and Salter, 2006).

Chiang and Hung (2010) challenge the former assumptions and suggest that Laursen and Salter's (2006) findings do not provide significant support for the relevant theoretical arguments. Specifically, they suggest that the product life cycle theory

dictates that hypotheses should have been tested by using either longitudinal data or specification of product development stages. To address this limitation, Chiang and Hung (2010) anchor their arguments in theories of inter-organizational knowledge flows. As opposed to Laursen and Salter (2006), they found that search breadth exerts more positive influence on the radical innovative performance. They suggest that search breadth can offer access to great amount and variety of new information and knowledge and as such, it can help firms to generate truly novel ideas (Chiang and Hung, 2010). Further, they provided evidence that external search depth exerts more positive influence on the incremental innovative performance of the firm. They posit that external depth offers restricted access to diverse information and knowledge and therefore, it may also restrict the generation of truly novel ideas. Their arguments draw on the assumption that different external knowledge strategies can induce different types of organization learning and as such, they can exert asymmetric effects on different types of innovation (Eisenhardt and Martin, 2000; Schulz, 2001). The next section discusses the relationship between external search strategies and organizational learning.

2.4.6. External Search and Organizational Learning

In the literature, search for external knowledge has been consistently described as an effective way to increase the level of external learning (e.g., Bierly et al., 2009; Cohen and Levinthal, 1990). In turn, external learning can induce the acquisition of two types of knowledge. First, knowledge unrelated to the firm's current areas of expertise and second, knowledge that advances the firm's existing technologies and products (Cohen and Levinthal, 1990). These two types of external learning have been linked,

respectively, with exploration and exploitation of external knowledge sources (Bierly et al., 2009).

According to March (1991), exploration can be described as the application of external knowledge to produce new products and technologies. Exploitation, on the other hand, is described as the application of the external knowledge to introduce incremental improvements on existing products and processes (March, 1991). Exploration, traditionally, involves experimentation with new alternatives. For this reason, it is associated with risk-taking, flexibility, and divergent thinking. On the opposite direction, exploitation refers to the refinement, routinization, and elaboration of existing ideas, paradigms, and technologies. Therefore, it is associated with convergent thinking and focus (March, 1991; Smith and Tushman, 2005).

The outcomes of exploration and exploitation have been described, respectively, as exploratory and exploitative innovations (e.g., Jansen et al., 2006; Smith and Tushman, 2005). The essence of exploration is the pursuit of new knowledge that leads to more variations and therefore, to new customer value (Chiang and Hung, 2010). The essence of exploitation, on the other hand, is refinement and deepening of existing knowledge and as such, exploitation can increase the current customer value (Chiang and Hung, 2010).

Recall that external search breadth is defined as *"the number of external channels from which the innovating company accesses knowledge"* (Laursen and Salter, 2006: 140). Therefore, by definition, external search breadth is a strategy that facilitates broader and more general knowledge search efforts (Chiang and Hung, 2010). Drawing on March (1991), firms that engage in external search breadth are likely to achieve a more exploratory learning. In turn, exploratory learning might help firms to expand their knowledge pools, increase their flexibility, adapt to unpredictable

changes, and produce really novel products that differ significantly from the existing ones, creating new customer value (Levinthal and March, 1993; March, 1991). Therefore, external search breadth strategy is likely to facilitate the introduction of radical innovations.

On the opposite direction, external search depth is defined as the extent to which firms draw ideas intensively from external sources (Laursen and Salter, 2006). Therefore, it is a search strategy that enables firms to draw ideas from a given knowledge source. Firms that engage in this strategy need to maintain strong and frequent interactions with particular knowledge sources (Leana and Van Buren, 1999). As the social networks and social capital literature suggests strong and frequent interactions with a particular knowledge source can help firms to leverage in-depth and fine-grained knowledge (Dyer and Nobeoka, 2000; Kang et al., 2007; Leana and Van Buren, 1999). This type of knowledge is more likely to induce well-defined solutions (Dyer and Nobeoka, 2000; Leana and Van Buren, 1999;), more certain outcomes, more predictable costs as well as the generation of more proximate customer benefits (Kang et al. 2007). As Schulz (2001) argues, these outcomes are the product of a more exploitative in nature learning and as such, they facilitate the introduction of more incremental innovations (Dewar and Dutton, 1986).

According to the ambidexterity literature, firms must be able to excel at both exploration and exploitation of knowledge in order to survive (Atuahene-Gima, 2005). Firms focusing only on exploitation are not able to adapt to evolving and turbulent environments (Bierly et al., 2009). Further, firms that focus only on exploration are usually less flexible in developing and refining existing competencies that enable them to compete in the current market (Bierly et al., 2009; March, 1991).

However, it has been consistently reported in the literature (e.g., Bierly et al., 2009; March, 1991) that there is a tension between exploration and exploitation due to constraints on resources and firm's strategic orientation. Exploration requires different knowledge management processes, including different organizational routines and practises than exploitation (Jansen et al., 2006; McGrath and Macmillan, 2000; Smith and Tushman, 2005). Therefore, to reap the benefits of the different external search strategies and thus, to gain long-term innovative performance advantages firms must be able to deal with important conflicts between the knowledge management processes that different external search strategies may entail.

Firms that employ external search strategies can benefit significantly by an increased understanding on how they can manage both exploration and exploitation (Levinthal and March, 1993; Tushman and O'Reilly, 1996). The literature on ambidexterity has provided some important insights on how firms can deal with the conflicts that derive from the simultaneous pursuit of exploration and exploitation. Tushman and O'Reilly (1996) were first to present structural mechanisms that enable firms to simultaneously exploit existing competencies and explore new opportunities.

An examination of the literature indicates that there are two alternative pathways to deal with tensions that stem from the simultaneous pursuit of exploration and exploitation. The first pathway is differentiation. The essence of differentiation is the separation of exploitative and explorative activities into distinct organizational units (Raisch et al., 2006). The proponents of this pathway argue that the conflicts between exploration and exploitation can be reconciled through the creation of structural ambidexterity (March, 1991). The second pathway is labelled as integration and it is described as a mechanism that enables organizations to address exploitative and explorative activities within the same organizational unit (Raisch et al., 2006). The

proponents of this pathway suggest that the creation of contextual ambidexterity is likely to enhance the behavioural capacity of employees to demonstrate alignment and adaptability across an entire business unit (Gibson and Birkinshaw, 2004). While structural ambidexterity involves top-down institutional policy, commercial infrastructure, organizational guidelines to support research commercialization, clear roles of stakeholders and more specialized skills, contextual ambidexterity creates a bottom-up, flexible context, which encourages individuals to be flexible and juggle their time between different roles (Chang et al., 2009).

While these insights can be very helpful in achieving integration between the knowledge processes of exploration and exploitation, they are not exhaustive neither enough to ensure that firms will reap the benefits of external search breadth and external search depth. It has been consistently reported (e.g., Cohen and Levinthal, 1989; Laursen and Salter, 2006) that firm's ability to acquire knowledge from its external environment is primarily contingent upon its absorptive capacity (Cohen and Levinthal, 1989). This conceptual construct is discussed and defined in the next section.

2.4.7. External Search and Absorptive Capacity

Absorptive capacity has been described a firm's ability to identify, value external knowledge, assimilate it, and commercially apply it (Cohen and Levinthal, 1990). Through their R&D activities, firms can develop organizational knowledge about certain areas of science and technology. They can also understand how these areas relate to different markets and offerings. This is what Cohen and Levinthal (1989) describe as a firm's ability to identify and value external knowledge. Further, firms develop, over time, routines and processes that facilitate internal knowledge sharing.

This is what Cohen and Levinthal (1990) describe as a firm's ability to assimilate external knowledge. In addition, the firm becomes skilled at using this knowledge to predict new technological trends, to create new products and markets, and to manoeuvre strategically. This is what Cohen and Levinthal (1990, 1994) describe as a firm's ability to commercially utilize external knowledge. Taken all together, these three processes constitute the absorptive capacity of the firm.

Absorptive capacity is important because it does not only help firms to exploit external knowledge, but also enables firms to predict more accurately the nature of potential technological advances (Cohen and Levinthal, 1990). Thus, absorptive capacity is directly linked with the establishment of diverse knowledge pools that facilitate problem solving and flexibility towards future environmental changes (Bowman and Hurry, 1993; March, 1991). Absorptive capacity is considered as a necessary requirement for more accurate future development predictions (Cohen and Levinthal, 1994). As such, it allow firms to engage in exploratory innovation activities through unpredictable of even rare combinations of resources (Jansen et al. 2006; Subramaniam and Youndt, 2005).

External sources of knowledge need to be identified, activated, and managed in order to unlock their potential benefits (Gottfredson et al. 2005; Stock and Tatikonda, 2004). Therefore, firm's absorptive capacity has been found (e.g., Grimpe and Sofkaa, 2009; Laursen and Salter, 2006) to be one of the most important constituents of success towards finding and recognising relevant external knowledge sources, transforming and assimilating external knowledge (Todorova and Durisin, 2007), and commercializing the rare combinations between external and internal resources and knowledge (Cohen and Levinthal, 1994; Jansen et al. 2006).

Absorptive capacity can be either inward-looking or outward-looking (Cohen and Levinthal, 1990). Inward-looking absorptive capacity, on the one hand, refers to the efficiency of the internal communication systems, while outward-looking absorptive capacity refers to the ability of the firm to assimilate and exploit information originating from the external environment (Cohen and Levinthal, 1990). According to Cohen and Levinthal (1990), both inward-looking and outward-looking absorptive capacity are essential for effective organizational learning because their coexistence enables firms to successfully link external and internal knowledge sources.

While the absorptive capacity of the firm can contribute significantly towards organizational learning and therefore, towards the success of the firm's external search activities, it has been found (e.g., Bergman et al., 2009; Lichtenthaler, 2011) that the firm's ability to reach and process internally new knowledge is also contingent upon new organizational practices and routines or in other words, organizational innovations. The next section discusses why organizational innovation can help firms to deal with potential limitations of external search, unlocking its potential impact on the firm's innovative performance.

2.4.8. Limitations of External Search: The role of Organizational Innovation

The positive relationship between external search strategies and innovation performance has been repeatedly documented in the literature (e.g., Chesbrough, 2003; Laursen and Salter, 2006). It has been acknowledged though that search for external knowledge has also limitations with regard to its positive effects on the firms' innovation performance (Laursen and Salter, 2006). Many empirical studies indicate that the relationship between the two concepts takes an inverted U-shaped (e.g., Katila

and Ahuja, 2002; Laursen and Salter, 2006; Rothaermel and Alexandre, 2009). Therefore, search for external knowledge is of major importance for firms' innovation activities but must not be taken as the sole remedy.

As remarked by Bergman et al. (2009), search for external knowledge requires new organizational practices, processes, and structures designed to improve the firm's ability to reach and process internally diverse sources of information. In this respect, Lichtenthaler and Ernst (2009b) suggest that research dealing with appropriate management for open innovation needs to be further emphasized. Lichtenthaler (2011) also points out that further insight into organizational practices is necessary since such practices may unlock the potential of open innovation. In the same vein, Brunswicker (2011) states that the role of organizational practices in the value creation and appropriation of the open innovation model is hardly investigated.

Although some studies attempt to fill this gap, empirical findings stem mainly from case studies. For example, using a case study, Sakkab (2002) found that the overall design of the open innovation model is contingent upon internal management processes. Furthermore, Huston and Sakkab (2006) indicate that the introduction of new managerial routines and processes is one of the most important determinants of open innovation success. Similarly, Chesbrough and Crowther (2006) found that implementation of open innovation as strategic and top-down initiative has been one of the key success factors when engaging in open innovation. More precisely, they have shown that successful innovators usually adopt their organizational routines, practices, structures, and processes to open innovation. Along the same line, Chiaroni et al. (2010) suggest that the open innovation model to be effective requires significant changes at the structural arrangements, the evaluation processes, and the knowledge management systems employed by the firm. Such organizational innovations can

contribute towards the elimination of organizational beliefs that may compromise the effectiveness of the external search activities of the firm such as the ‘not-invented-here’-syndrome’ (Lichtenthaler and Ernst, 2006).

In one of the few quantitative studies that examine the relationship between open innovation and organizational innovation, Foss et al. (2011) have found that organizational innovation moderates the relationship between external search and innovative performance. They argue that the success of the open innovation model depends on the firm’s ability to change critical organizational processes and aspects. Han et al. (1998), on the other hand, found that organizational innovation mediates the relationship between external search and organizational innovation. More precisely, they claim that organizations have to innovate across their entire business system in order to capture the benefits of external search. Finally, Mol and Birkinshow (2009) provide hard evidence that organizational innovations are likely to help firms engaging in external search activities to increase their innovative performance. They argue also that external search offers insights on organizational routines and practices successfully used in other settings and therefore, it can increase the likelihood of an organizational innovation brought inside the firm.

The above studies have considered organizational innovation as one of the most important requirements for unlocking the potential of open innovation and bringing successfully external knowledge inside the firm (e.g., Bergman et al. 2009; Lichtenthaler and Ernst, 2006). The next section focus on the concept of organizational innovation and explains its importance according to the literature.

2.5. Organizational Innovation

"But in capitalist reality as distinguished from its textbook picture, it is not… (price) competition which counts but the competition from the new commodity, the new source of supply, the new type of organization… competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits…of the existing firms but at their very lives. This kind of competition is as much more effective than the other as a bombardment is in comparison with forcing a door."

(Schumpeter 1943: 84)

The struggle that organizations face during periods of rapid technological change, irreducible uncertainty and intensified competition is well documented in the literature (e.g., Anderson and Tushman, 1990; Juan Li et al., 2008; Nicholls-Nixon1 and Woo, 2003). In response to these pressures, organizations have recognized innovation as fundamental constituent for survival and profitability (Goffin and Mitchell, 2010; Rubera and Kirca, 2012). The need for innovation is imperative (Tidd et al., 2005) not just for firms that seek to strengthen their competitive position (Cooper, 2005; Hamel and Prahalad, 1994; Kaplan and Norton, 1992) but also for public organisations that seek to improve their services and better manage their activities (Hartley, 2005; Mulgan and Albury, 2003). As aptly remarked by Coopers, "*it's war: Innovate or die*" (Cooper, 2005a, p: 4).

On the one hand, innovation can be the introduction of new products and services. This type of innovation depends on the firm's ability to sense market opportunities and establish commercial relationships that generate performance advantages (Tidd et al., 2008). On the other hand, the real challenge is to move beyond the introduction of new products and services by changing the nature of management within the organization and by introducing new routines and processes as well as new ways to work on

established markets (Vaccaro et al., 2012). This challenge calls researchers and practitioners to better understand the process through which organizational innovation occurs (Mol and Birkinshaw, 2009).

Despite its importance, until recently organizational innovation has not received much consideration from practitioners as opposed to product, service, and process innovation. Further, past innovation literature contributes little to improve our understanding of the phenomenon (Mol and Birkinshaw, 2009). Most of the scientific research in the field focus on the examination of various aspects of technological or product innovation (e.g., Henderson and Clark, 1990; Utterback, 1994), service innovation (e.g., Gallouj and Weinstein, 1997), strategic innovation (e.g., Hamel, 1998; Markides, 1997), process innovation (e.g., Pisano, 1996), strategic innovation (e.g., Hamel, 1998; Markides, 1997), and business model innovation (e.g., Casadesus-Masanell and Zhu, 2013; Markides, 1997).

The majority of the previous empirical work centred mainly on understanding how different types of innovation should be managed productively to support long term organizational success (Birkinshaw et al., 2008). In the past few years, however, there has been an increasing interest from academics in organizational innovation as empirical evidence have revealed not only potential benefits with regards to the success of the organization, but also opportunities relating to the dissemination of new ideas that may influence the structure of the industrial landscape (e.g Chandler, 1962; Mol and Birkinshaw, 2009). Table 2.5 summarizes empirical studies that investigate the impact of organizational innovation on the firm's performance.

Prior empirical research has generated important insights that advanced our understanding on the importance of organisational renewal for the firms' competitive edge (e.g., Albach, 1989; Cooper, 2001; Wheelwright and Clark, 1992). In fact, the

positive link between organizational innovation and firm performance has been documented in the literature (e.g., Birkinshaw and Mol, 2006; Hamel, 2006; Teece, 2007). Organizational innovation is considered as the use of new managerial and working routines and practises (Damanpour, 1987). These managerial and working routines and practises are context specific and therefore, very hard to replicate. As such, they are likely to create sustainable competitive advantages (Birkinshaw and Mol, 2006; Hamel, 2007; Teece, 2007). Hamel (2006) suggests that organizational innovation has become the most important source of competitive advantage. He argues (2006) that today's unprecedented shifts in competitive advantage have come, not as a result of technology innovation, but as a result of innovation in managerial and working routines and practises. These innovation elements are inimitable and as such they create sustainable competitive advantages and long lasting organizational success (Birkinshaw and Mol, 2006; Hamel, 2007; Teece, 2007).

As mentioned in the previous sections, innovation can increase the competitive edge and performance of the firm (Walker, 2004). Many studies that focus on the link between innovation and performance provide empirical evidence on this relationship. According to their findings, innovativeness may influence positively the performance of the firm (Calantone et al., 2002; Damanpour and Evan, 1984; Dos Santos and Peffers, 1995). As opposed to studies that find evidence for a positive link between innovations and firm performance, some studies reveal a negative relationship or no relationship at all (e.g., Chandler and Hanks, 1994, Subramanian and Nilakanta, 1996). Generally speaking, firms seek technological innovation in anticipation of gaining competitive advantages (Miller, 2001). However, technological innovation usually requires organizational innovation, given that the more the challenge is in the new products, services or operations, the more changes in organizational structures,

processes, and procedures will be required to successfully capture the benefits of the innovation process (Miller, 2001).

So far, most research has centred on a single type of innovation rather than considering many types of innovation. Technological and product innovations are the most common innovation types examined. For instance, Li and Atuagene-Gima (2001) and Subramanian and Nilakanta (1996) focus merely on product innovation while Hill and Rothaermel (2008) and Rogers (1995) focus on process innovations. The effects of organizational innovation have remained relatively unexplored in the management research. A few studies on innovation capabilities, however, indicate that organizational innovations are equally essential to the growth and effective operation of the firm (e.g., Damanpour and Evan, 1984, Damanpour 1991). Some studies also (e.g., Guan and Ma, 2003; Hult and Ketchen, 2001; Ravichandran, 2000) reveal that high performing innovators place more emphasis on organizational techniques and processes since technological innovation usually requires changing the very approach to managing the organization (Baldwin and Johnson, 1996). In this respect, Lin and Chen (2007) examined the relationship between organizational innovation and firm's performance. Their results confirmed that organizational innovation influences more positively the performance of the firm than technological innovation. In the same vein, Oke (2007) found that innovative performance is the combination of the overall organizational achievements. Performance advantage is the product of renewal and improvement efforts done considering various aspects of firm innovativeness, i.e. processes, products, organizational structure. Furthermore, Han et al. (1998) suggest that innovation is a synergetic combination of technical and organizational achievements. Such combination may contribute significantly to the growth and profitability of the firm. According to Damanpour and Evan (1984), both technical and

administrative changes incorporated into the organizational structure can increase the firm's innovative performance. Renewal of administrative mechanisms, production processes, and new products are likely to help firms to increase their operational flexibility and decrease their costs by facilitating the dissemination of knowledge and the coordination of internal mechanisms that support innovation (Koufteros and Marcoulides, 2006).

The macro-economic importance of organizational innovation has been also reported in the literature (e.g., Ahlstrom 2010; Coriat and Weinstein, 2002). Following, Schumpeter's ideas on the macro-economic importance of innovations, Ahlstrom (2010: 11) suggests that organizational innovations "*generate growth and deliver important benefits to an increasingly wide range of the world's population*". Organizational innovation may also play a critical role in managing information and knowledge (Coriat and Weinstein, 2002). It may include the introduction of new learning processes and the coordination of conflicting interests that come up during events of change. Therefore, decisions on the innovation management systems represent important strategic choices that might influence the competitive position of the firm (Coriat and Weinstein, 2002).

Nonetheless, a number of researchers have been critical of organizational innovation. Part of them suggest that the faith in organizational innovation is good for nothing (e.g., Chandler, 1962; Hamel, 2006; Tichy and Standstrom, 1974), while others understand organizational change as a way to reaffirm control over the workers (Knights and McCabe, 2002) or as a fashion that influence positively the consultants that promote organizational changes (Staw and Epstein, 2000). However, many examples of world leading companies such as General Electric, Visa, Linux, Procter & Gamble etc have shown that organizational innovation can be the more fundamental

reason for organizational success (Chandler, 1962). Considering the importance of organizational innovation, management scholars have started to investigate how specific organizational innovation tools can influence the innovative performance of the firm.

The first solid theoretical and empirical foundation for the use of a vast array of innovation theories in management has been set from the R&D literature in the 1980s (Cooper and Kleinschmidt, 1986). Since then a variety of innovation concepts have been adopted and applied in real business practice. For instance, several organizational innovation tools (von Hippel, 2001) such as toolkits (Pru¨gl and Schreier, 2006) and networked organizational structures that enabled advanced information processing (Bavelas, 1950; Connoly, 1977; Tushman, 1979) have been introduced and extensively used by small to medium-sized enterprises (SMEs) and large organizations. To offer a better understanding of the subject, the next section of this chapter presents the definitions of organizational innovation found in the literature and describes the theoretical foundations of the concept.

Table 2.5. Empirical studies that investigate issues around organizational innovation

Author(s)	Definition of Organizational Innovation	Theoretical Foundations	Research methods	Research Questions	Key Findings
Damanpour et al. (2009)	New approaches and practices initiated to motivate and reward organizational members, devise strategy and structure of tasks and units, and modify the internal management processes.	Socio-technical system theory	Panel data analysis	What is the influence that different types of innovation (service, technological process, and administrative process) exert on the firm's performance?	Adopting a specific type of innovation every year is detrimental, consistency in adopting the same composition of innovation types over the years has no effect, and divergence from the industry norm in adopting innovation types could possibly be beneficial to organizational performance.
Birkinshaw and Mol (2006)	The implementation of new management practices, processes and structures that represent a significant departure from current norms.		Historical analysis	What are the stages of organizational innovation process and how key individuals influence the shape of management innovations?	The role of external change agents such as academics, consultants, management gurus and ex-employees is more significant for management innovation than for technological innovation. The process of organizational innovation implementation is more diffused and gradual than in technological innovation. The organizational innovation model has four main stages: (1) dissatisfaction with the status quo, (2) inspiration from other

					sources, (3) invention, and (4) internal and external validation. Internal and external actors play different roles in each stage.
Birkinshaw et al. (2008)	The generation and implementation of a management practice, process, structure, or technique that is new to the state of the art and is intended to further organizational goals.	Intrafirm evolutionary Theory	Conceptual	What is the role of internal and external change agents in the motivation, invention, implementation and theorization/ labelling phase of organizational innovation?	Organizational innovation has three different sets of consequences: (1) the impact on various performance metrics inside the innovating firm; (2) the impact on the performance and legitimacy of subsequent adopters of the innovation; and (3) the benefits of management innovation to society as a whole, in terms of improvements of such things as productivity or quality of work life.
Mol and Birkinshaw (2009)	The introduction of management practices that are new to the firm but they could be implemented elsewhere in the past and intended to enhance firm performance.	Organizational reference group theory, behavioral theory, resource based theory, institutional theory	Survey data analysis	What are the conditions under which firms introduce new management practices and what is the effect on future productivity growth?	Organizational innovation relates to productivity improvements. The use of market-based sources is positively related with the introduction of new management practices. The use of professional sources is positively related with the introduction of new management practices.

2.5.1. Definitions and Theoretical Foundations of Organizational Innovation

Many studies (e.g., Birkinshaw et al., 2008; Hamel 2006) have contributed significantly to our broader understanding of organizational innovation by providing several conceptualizations of the term. However, there is no consensus on the definition of organizational innovation. In addition, a range of different terms such as "management", "managerial", and "administrative" have been used interchangeably in the past (Birkinshaw and Mol, 2006; Damanpour and Aravid, 2012). Generally speaking, there are two streams of literature. For the first stream of literature, organizational innovation is considered as an innovation without any known precedent. It is usually described as a practice of structure new-to-state-of-the art (e.g., Chandler, 1962). For the second stream of literature, organizational innovation is something that is totally new for the firm. This definition does not preclude the possibility of being already implemented in a different context (e.g., Zbaracki, 1998).

Birkinshaw et al. (2008: 829) define organizational innovation as "*the generation and implementation of a management practice, process, structure, or technique that is new to the state of the art and is intended to further organizational goals*". In this definition, "newness" is related to organizational innovation at large. Organizational innovation may facilitate novel organizational structures such as human resource practices, work routines, ways to manage relationships, and changes in non-structural aspects such as the web of organizational norms, values and behaviours. In the same vein, Vaccaro et al. (2012) posit that organizational innovation relates to practices, processes, and structures that are new for the company and they may contribute towards the fulfilment of the organizational goals. For both definitions, novelty is the predominant criterion for categorization.

Hamel, however, (2006: 75) describes organizational innovation as "a *marked departure from traditional management principles, processes, and practices or a departure from customary organisational forms that significantly alters the way the work of management is performed"*. Similarly, Damanpour (1987) defines organizational innovation as the use of new managerial and working routines and practises. Organizational innovation, therefore, addresses important facets of organizational reinvention and renewal such as directions setting, decision making, people motivation, and activities coordination (Hamel, 2006).

Different bodies of innovation management literature also employ different units of analysis. There is one body of literature that focuses mainly on specific organizational practices or structures such as M-Form structure (e.g., Chandler, 1962). The focus of this stream of literature is to analyse the patterns of innovation diffusion across firms, industries or countries (e.g., Cole, 1985; Guillen, 1994; Kogut and Parkinson, 1993). There is a second body of literature that deals mainly with the "why" and "how" certain organizational practices become popular (e.g. Benders and Van Veen, 2001; Huczynski, 1993) and it seeks to understand how organizational fashions emerge (e.g., Abrahamson, 1991, 1996). Last but not least, there is one stream of literature that seeks to identify the organizational, individual, and institutional factors that influence the firms' propensity to introduce new organizational practices. This stream of literature is not interested in analysing specific organizational innovation processes and practices. In fact, it focuses primarily on specific features of the firm that may facilitate a wider range of innovation practices (e.g., Damanpoor, 1987, 1991; Kimberly and Evanisko, 1981; Mol and Birkinshaw, 2009).

Birkinshaw et al. (2008) identifies in the literature four different perspectives on organizational innovation: the institutional, fashion, cultural, and rational

perspective. The institutional perspective takes a macro level, and it focuses on socioeconomic conditions in which organizational ideas and perspectives take shape (e.g., Guillen, 1994). For instance, Guillen (1994) has proposed a range of institutional factors that may influence the introduction of novel organizational ideologies and techniques in different countries. Kossek (1987) also suggests that firm level factors such as normative believes, as well as industry level factors such as long Kondratieff waves of economic change are interrelated and they can both influence human resource management innovation. Cole (1985), on the other hand, identifies three mutually interrelated factors that influence organizational innovation namely, labour market incentives, strength of industry associations, and the predisposition of organized labour.

In contrast, fashion perspective focuses on the dynamic interplay between users and providers of organizational ideas (e.g., Abrahamson, 1996). This perceptive apart from describing what are the characteristics of managers that buy into these fashions (e.g., Gill and White, 1993; Huczynski, 1993, Jackson, 1986), it also provides a detailed analysis on the strategies that fashion setters develop to disseminate their ideas (e.g., Clark, 2004; Kieser, 1997; Mazza and Alvarez, 2000). Fashion approach, however, does not address the origins of organizational fashions and as such, it does not provide explanation on why some innovation become fashions while others do not.

Cultural perspective strives to analyse how organizations react to the introduction of a new organizational practice (e.g., Zbaracki, 1998). The main focus of this perspective is the meso-level. Central part of the cultural perspective is the analysis of how individual attributes influence the introduction of organizational innovation in the organizational level. According to the cultural perspective, organizational innovation includes both rhetorical and technical components. For this reason, the

success or failure of an organizational innovation is quite unpredictable (Birkinshaw et al., 2008).

Finally, the rational perspective strives to span the micro-macro levels of analysis by focusing on how organizational innovations and individuals who drive organizational innovations deliver improvements that may increase the effectiveness of the organization (e.g., Chandler, 1962). This perspective claims that the introduction of an organizational innovation is problem driven. Managers come up with new ideas in attempt to deal with specific problems (Burgelman, 1983; Howel and Higins, 1990). According to Birkinshaw et al. (2008), there is also a related body of literature concerned with the subsequent diffusion of organizational innovations across firms, industries, or countries (e.g., Guler et al., 2002).

Despite the evolution of the academic discourse towards the analysis of organizational innovation, a broader and more holistic approach has yet to be developed by academics. With very few exemptions (e.g., Birkinshaw et al., 2008), academic research has little to say about the generative mechanisms by which organizational ideas are first created and put into practice (Birkinshaw et al., 2008). Birkinshaw et al. (2008) attempted to address this gap by providing a systematic and grounded process theory that explains how organizational innovation transpires. Birkinshaw et al. (2008) begin by providing an operational definition for the term. Their definition builds upon three core questions: What exactly is being innovated? How new does an innovation have to be? And, what is the purpose of organizational innovation?. Based on these questions, four organizational elements can be innovated: organizational practises, organizational processes, organizational techniques, and organizational structures (Alange et al., 1988; Guillen, 1994). The innovation has to be new to the state of the art, and the purpose of innovation would be the fulfilment of

the organizational goals. According to their view, human agency is considered to have a central role in the innovation process.

Further, to offer a more a holistic organizational innovation theory, Birkinshaw et al. (2008) provide an in-depth description of the organizational innovation process. They suggest that organizational innovation is a four-phase process that includes: (1) The motivation stages during which several motivational factors may influence the individuals and make them think that they would like to develop their own organizational innovations; (2) the invention stage during which an initial act of experimentation is taking place and it can lead to the introduction of new hypothetical organizational practices; (3) the implementation stage that is described as the technical process of establishing the value of a new organizational innovation and (4) the theorization and labelling stage that is the social process through which individuals both inside and outside the organization make sense, validate, and build the legitimacy of the organizational innovation (Birkinshaw et al., 2008).

Changes in motivation usually result in variations in the organizational routines. These variations contribute to the invention. During the implementation stage some of these variations are internally selected and retained through theorization and labelling (Birkinshaw et al., 2008; Zollo and Winter, 2002). Theorizing and labelling refers to what managers are doing with the organizational innovation and why they do it (Birkinshaw et al., 2008). This step occurs when organizational innovation is applied broadly to internal situations and therefore, it becomes explicit and deeply embedded in the organization (Birkinshaw et al., 2008). In this sense, the last step resembles the notion of retention, which is frequently used in the context of organizational learning (Zollo and Winter, 2002).

Gebauer (2011) suggests that the four steps through which organizational innovations emerge build on the evolutionary perspective as well as on the internal learning processes. The utilization of organizational innovation might be driven by internal agents that experiment with and implement organizational innovations. Nonetheless, according to the knowledge-base perspective on strategic change, changes driven by internal agents might be more incremental and restricted close to current routines since minor changes are more resource efficient than radical changes (Gebauer, 2011). Such a restriction can be lifted by searching externally for organizational innovations through external change agents such as communities of experts, consultants, or academics (Birkinshaw, 2006; Birkinshaw et al., 2008; Gebauer, 2011).

Although, organizational routines have been linked to organizational innovation, the terms can be easily perceived as antithetical. Organizational routines are considered as a primary means by which organizations accomplish much of what they do (March and Simon, 1958; Nelson and Winter, 1982) and as such, they are well known as a source of inertia (Hannan and Freeman, 1984). The following section explains why organizational routines can be a source of change instead of a source of inertia.

2.5.2. Organizational Innovation and Organizational Routines

In the literature, organisational routines are closely linked to the notion of organizational innovation (Pavitt, 2002; Webster, 2004). Although the terms can be perceived as antithetical, the literature on performativity of routines has claimed a

positive relationship between the two concepts (e.g., Nelson and Winter, 1982). This perspective builds on the understanding of organizational routines as a source of organisational change and renewal (e.g., Nelson and Winter, 1982). In the past, management scholars used to consider organizational routines as a source of organisational stability. This understanding of organizational routines is in line with the social theory and the writings on bureaucracy (Merton, 1940; Selznick, 1949; Weber, 1947).

Nevertheless, the literature on routines as performances opens up the possibility of understanding organizational routines as subject to a more active agency and therefore, as source of a more intentional organizational design. From this perspective, organizational routines are likely to trigger more radical organisational transformations. This is a very dynamic understanding of organizational routines that has been acknowledged within the literature on dynamic capabilities (Teece et al., 1997; Teece and Pisano, 1994; Winter, 2003). For instance, Zollo and Winter (2002: 340) define dynamic capabilities as "*learned and stable patterns of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness"*. This definition perceives organizational routines as a directed learning process and as such, it highlights their role as a more active and deliberate agent of change.

According to this perspective, organizational routines are likely to involve through adapting to contexts that require idiosyncratic or continuous changes and they may reflect on the meaning of actions for future realities (Feldman and Pentland, 2003). In this context, organizational routines link directly with organizational innovation. However, organizational innovation might occur also beyond the level of

organizational routines. The next section presents different levels of organizational innovation found in the literature.

2.5.3. Levels of Organizational Innovation

Organizational innovation can occur at the abstract level of management ideas or a more detailed level of management practices, processes, structures, and techniques (Birkinshaw and Mol, 2008). The first level of management ideas refers to organizational rules, assumptions, and principles, which relate to the notion of an organizational ideology (Birkinshaw and Mol, 2008). Examples include concepts relating to total quality management, learning organization, customer orientation, or lean management. Organizational ideology is associated with the management values and attitudes toward organizational change or renewal. The second level can be described as the innovation of management routines (Birkinshaw and Mol, 2008). On this level, organizational innovation can be defined as the "*invention and implementation of a management practice, process, structure, or technique that is new to the state of the art and is intended to further organizational goals"* (Birkinshaw et al., 2008: 825).

This study focuses on the second level of organizational innovation using organizational innovation as a synonym for new managerial and working routines and practises (Damanpour, 1987). In the present empirical context, organizational innovations may include new chain management routines, business re-engineering, new knowledge management routines, lean production, new quality management routines, first use of a new system of employee responsibilities, new team work routines, decentralisation, integration or de-integration of departments, new

education/training systems, first use of alliances, partnerships, outsourcing or sub-contracting, etc. Such organizational innovations are part of the strategic routines of the organization that constitute dynamic capabilities (Gruber and Niles, 1974; Teece, 2007) and they may refer to internal innovations, external innovations or both (Garud and Kumaraswamy, 1995). The next section discusses the different dimensions of organizational innovation and their relationship with the absorptive capacity of the firm.

2.5.4. Dimensions of Organizational Innovation and Absorptive capacity

Garud and Kumaraswamy (1995) posit that organizational innovation has two dimensions: internal and external. Internal organizational innovation refers to internal innovation such as the introduction of new business practices and the introduction of new methods of organizing work (Garud and Kumaraswamy, 1995). External management innovation, on the other hand, refers to external innovation such as the introduction of new methods of organizing external relationships (Garud and Kumaraswamy, 1995). Organizational innovation creates formal and informal (internal) structures that can be powerful influences in the innovation activities of the firm (Teece, 1996). Both internal and external organizational innovations can be equally important for the innovative performance of the firms. This is because innovators collaborate often with external actors to come up with novel ideas that help them to develop new products and technologies.

Cohen and Levinthal (1990) argue that internal organization can influence the absorptive capacity of the firm. Recall that the absorptive capacity of the firm is the firm's ability to identify, assimilate, and exploit external knowledge (Cohen and Levinthal, 1990). Absorptive capacity might be "inward-looking" when it refers to the

ability of the firm to achieve efficiency on internal communication or "outward-looking" when it refers to the firm's points of contact with external sources of knowledge (Cohen and Levinthal, 1990). Organizational innovation also can be either inward-looking (internal) or either outward-looking (external). Internal organizational innovation includes the introduction and use of new practices that enhance the efficiency of the internal communication systems while external organizational innovation includes new practices that facilitate the establishment of contact with external sources of knowledge (Foss et al., 2011). As such, organizational innovation can enhance significantly both the "inward-looking" and the "outward-looking" absorptive capacity of the firm.

As discussed earlier, absorptive capacity can contribute significantly towards the success of the firm's external search activities. Since organizational innovation is likely to enhance the absorptive capacity of the firm, it seems that it is likely also influence positively search for external knowledge. The introduction of organizational innovations, however, is contingent upon creative insights available inside the firm. As Mol and Birkinshaw (2009) argue firms engaging in external search are more likely to gain insights into organizational practices and routines that have been successfully used in other settings (Mol and Birkinshaw, 2009). Therefore, organizational innovation can reinforce external search and vice versa. To put it differently, external search and organizational innovation seem to reinforce each other and therefore, to exert a complementary effect on the firm's performance. The next section discusses the theory of complementarity.

2.6. Complementarity

The topic of interaction among different organizational activities has received considerable attention in the economics and management literatures (e.g., Levinthal, 1997; Milgrom and Roberts, 1990a; Porter, 1996). Many scholars argue that systems of tightly interconnected activities are a major source of competitive advantage (Milgrom and Roberts, 1995; Rivkin, 2000).

The concept of complementarity among choices has a long heritage in the literature (e.g., March and Simon, 1958; Thompson, 1967). Many scholars (e.g., Baumol et al., 1988; Ichniowski et al., 1997; Cassiman and Valentini 2015) claim that the joint implementation of several practices can create significant economies of scope. Also, in the past, many empirical studies investigated the complementary relationship between different activities. For example, Ichniowski et al. (1997) explored the complementary relationship between human resource practices and firm strategy (Ichniowski et al., 1997). Arora and Gambardella (1994) investigated the complementary relationship between internal R&D and external technology sourcing. More recently, Cassiman and Valentini (2015) provided evidence on the complementary effect of in-bound and outbound knowledge flows on the firm's innovative performance.

In these studies, organizational performance is understood through the lens of a more holistic perspective that captures the effect of organizational activities that complement each other. According to Milgrom and Roberts (1995) two organizational activities are complementary if they can mutually reinforce each other. If two activities are complementary then the impact of their system will be greater than the sum of its parts because of the complementary effects of bundling these two activities together. The following mathematical theory presents the necessary conditions for two activities to be complementary:

Suppose there are 2 activities A1 and A2, each activity can be done by the firm (Ai = 1) or not (Ai = 0) and i ∈{1, 2}. The function Π (A1, A2) is supermodular and A1 and A2 are complements only if:

$$\Pi (1, 1) - \Pi (0, 1) \geq \Pi (1, 0) - \Pi (0, 0),$$

i.e. adding an activity while already performing the other activity has a higher incremental effect on performance (Π) than when doing the activity in isolation.

2.7. Chapter Summary

This chapter presented an overview of previous theories related to the concepts of the thesis. The findings of this review when considered together reveal that organizational innovation in the form of new managerial and working routines and practices (Damanpour, 1987) enables firms to achieve efficiency on internal communication and better management of points of contact with external channels of knowledge (Cohen and Levinthal, 1990). This, in turn, should foster both exploration and exploitation of external ideas and knowledge (Teece, 2007), increasing the innovative performance of the firm. Further, the theory reveals that one major benefit of external search is that it helps firms to gain important insights into organizational practises and routines successfully used in other settings (Mol and Birkinshaw, 2009). These insights can increase the firm's ability to introduce organizational innovations (Abrahamson and Fairchild, 2001; Abrahamson and Rosenkopf, 1993). In turn, organizational innovations are likely provide operational flexibility, decrease the operational costs, and facilitate the dissemination of knowledge and coordination of the innovation

activities inside and outside the firm, increasing the firm's innovative performance (Koufteros and Marcoulides, 2006).

Drawing on previous theory, these arguments provide evidence that external search and organizational innovation can mutually reinforce each other for the purposes of innovation and therefore, they are complementary activities. However, the theory also reveals that different external search strategies may induce different types of organizational learning and therefore, the join occurrence of external search and organizational innovation may exert asymmetric effects on the innovative performance of the firm. These arguments are considered in more detail in the following chapter.

Chapter 3: Conceptual Background and Hypothesis Development

3.1. Chapter Overview

The purpose of this chapter is to present the conceptual framework of the thesis and to explain why search for external knowledge and organizational innovation are hypothesized to be complementary, as well as how decisions on the direction and the extent to which organizations collaborate with some actors can have considerable implications for this relationship. Further, in this chapter I explain why different innovation outcomes are not equally affected by the joint occurrence of external search breadth and organizational innovation. Derived from the existing literature, the proposed relationships are discussed and hypotheses related to (a) external search breadth, (b) external search depth, (c) organizational innovation and (f) innovative performance are developed.

3.2. Conceptual Background

Knowledge sources external to a firm have long been recognized as an important determinant of its ability to innovate (Cohen and Levinthal, 1990; Kafouros and Forsans, 2012; Rosenkopf and Nerkar, 2001). Consistent with this recognition, a new approach to innovation labelled as “open innovation” has given a comprehensive perspective that emphasises the distributed and interactive character of the innovation process (Chesbrough, 2003). In the literature, open innovation has been repeatedly described as a search strategy for external knowledge (Laursen and Salter, 2006). External knowledge utilization activities and linkages that organizations engage in to

fulfil their knowledge integration efforts has become a major topic of empirical investigation (Huizingh, 2010; Trott and Hartmann, 2009; Van de Vrande et al., 2010). Prior literature has described the product development process as a problem-solving activity that requires the creation and recombination of new knowledge (Katila and Ahuja, 2002). The need for creation and recombination of new knowledge is thought to be a major rationale behind search for external knowledge. Von Hippel (1988) argues that organizations build their inventories of knowledge by developing networks of contacts. New knowledge and novel ideas may stem from a diverse set of contacts such as users, suppliers, universities, other institutions, and companies in the same industry (Levinthan and March, 1993). Hence, choices on search strategies or in other words, decisions on the direction and extent to which organizations should collaborate with different actors can have considerable implications for innovative performance in terms of magnitude and degree of innovativeness.

A major contribution to the fast growing open innovation research is the seminal study of Laursen and Salter (2006) about the effects of search strategies for external knowledge on the firm's innovative performance. Drawing on Katila and Ahuza (2002), Laursen and Salter (2006) have proposed two critical components of search named "external search breadth" and "external search depth". They defined (2006) "external search breadth" as *"the number of external sources or search channels that firms rely upon in their innovative activities"* (Laursen and Salter, 2006: 4) and "external search depth" as *"the extent to which firms draw deeply from the different external sources or search channels"* (Laursen and Salter, 2006: 5). The first component is usually described as the diversity of a firm's search activities. It is a stage of trial and error that includes multiple interactions with diverse actors (Laursen and Salter, 2006) and provides organizations with a comprehensive overview of available

opportunities (Chiang and Hung, 2010; Sofka and Grimpe, 2008). The knowledge which is necessary to achieve competitive advantages is broadly distributed in the network of the organization. Laursen and Salter (2006) suggest that through interaction with a broad range of diverse actors, organizations can gain a better understanding of the norms, habits, and routines of different external channels of knowledge. Further, such interactions enable access to new ideas and different technologies which in turn, facilitate problem solving (March, 1996) and development of novel solutions, new combinations of diverse information (Katila and Ahuja, 2002), as well as recombination of internal knowledge (Fleming and Sorenson, 2001).

At the individual level, different sources of knowledge and alternative perspectives for problem solving and decision making are likely to impact on the ability of the employees to recognize available opportunities related to different parts of the organization (Kleinbaum and Tushman, 2007). The exposure to diverse pieces of knowledge boosts the capacity for knowledge sharing (Reagans and McEvily, 2003) and the creativity of the individuals within the organization (Hargadon, 2003). At the same time, as Cassiman and Valentini (2015) argue the transactional costs of the firm may decrease due to significant learning effects (Cassiman and Valentini, 2015). Broad interaction with external actors may offer access to complementary sources of knowledge (e.g., Kogut and Zander, 1992; Schumpeter, 1934) and hence, it is likely to enable inter-firm capabilities transfer that strengthen the innovative performance of the firm (Hamel, 1991; Simonin, 1997, 1999).

The second component of search for external knowledge, which is termed as "external search depth" has been described as the number of external partners that are deeply integrated into the organisation's innovation activities. While external search breadth is associated with scanning a wide range of external resources, external search

depth calls for in-depth collaboration and sustainable patterns of interaction over time (Laursen and Salter, 2006). This process of in-depth interaction with external actors has been viewed as an important strategy that facilitates the endeavours of the firm to exploit external knowledge in different ways (Katila and Ahuja, 2002). Katila and Ahuja (2002) suggest that the repeated use of knowledge sources results in the development of a good understanding of the concepts involved in the innovation processes. As such, it facilitates the development of routines while it increases the reliability of the innovation process (Levinthal and March, 1981). At the same time, in-depth collaboration with other partners enables firms to adapt or expand their competencies (Katila and Ahuja, 2002). This is mostly because it provides complementary knowledge including users' technical know-how, insights on pricing issues and users' behaviours while it enhances the chances of the innovation being accepted within the same user community (Tether, 2002). Further, learning effects that derive from in-depth interactions with diverse actors can trigger the decomposition of the innovation activities in a logical and well demarcated sequence eliminating the dispensable stages and increasing the dynamism of the innovation activity (Eisenhard and Tabrizi, 1995). Hence, it is likely to reduce the possibility of errors in the innovation process (Levinthal and March, 1981).

For all these reasons collectively, both external search breadth and external search depth strategies have been considered as salient predictors of the firm's innovative performance (Laursen and Salter, 2006). While these strategies have received considerable attention in many studies (e.g., Laursen and Salter, 2006), organizational innovation has also been found to exert significant influence innovative performance (Hamel, 2006). The term organizational innovation refers to the use of new managerial and working concepts and practices (Damanpour, 1987; Damanpour and Evan, 1984).

Prior empirical research has generated important insights that advanced our understanding on the importance of such an innovation activity for the firms' competitive edge (e.g, Albach, 1989; Cooper, 2001; Wheelwright and Clark, 1992). Organizational innovation has stimulated the interest of academics because empirical evidence has revealed not only potential benefits with regards to the success of the organization, but also opportunities associated with the dissemination of new ideas (e.g, Chandler, 1962; Mol and Birkinshaw, 2009). Hamel (2006) suggests that organizational innovation has become the most important source of competitive advantage. Today's unprecedented shifts in competitive advantage have come, not as a result of technology innovation, but as a result of innovation in organizational practices and processes. Since these elements are very hard to replicate, they can offer sustainable competitive advantages and long lasting firm success (Birkinshaw and Mol, 2006; Hamel, 2007; Teece, 2007). Many empirical studies that focus on the links between innovation and performance have provided empirical evidence on the contribution of organizational innovation. Especially studies on innovation capabilities have consistently indicated that organizational innovation is equally beneficial to the growth and operations of the firm (e.g., Damanpour and Evan, 1984, Damanpour 1991). They also reveal that high performing innovators usually place more emphasis on organizational practices since technological innovation usually requires changing the very approach to managing the organization (Baldwin and Johnson, 1996; Guan and Ma, 2003; Hult and Ketchen, 2001; Ravichandran, 2000). At the same time, organizational innovation has been found to exert more positive influence on the firm performance than technological innovation (Lin and Chen, 2007). As Oke (2007) suggests innovative performance is the combination of overall organizational achievements and therefore, renewal and improvement efforts should be done by

considering various aspects of firm innovativeness, i.e. practices, processes, products, organizational structure. Similarly, Han et al. (1998) suggest that innovations are a synergetic combination of technical and organizational achievements. Such combinations contribute significantly to the growth and profitability of the firm since the renewal of the administrative practises and production processes along with the development of new products enable operational flexibility and significant decrease in operational costs. The major contribution of these administrative practises and production processes is that they are likely to support the dissemination of knowledge and coordination of activities within the organization (Koufteros and Marcoulides, 2006). The importance of organizational innovation for the management of knowledge and dissemination of new ideas has been reported also in previous literature. Coriat and Weinstein (2002) suggest that organizational innovation may include the introduction of new learning processes and the coordination of conflicting interests that come up during events of change. Hence, it plays a critical role in managing information and knowledge.

With a few exceptions (e.g., Foss et al., 2011; Han et al., 1998; Mol and Birkinshaw, 2009) previous quantitative studies have investigated the impact of organizational innovation and search for external knowledge as if they had independent effects. In this thesis, I claim that these activities have a complementary effect on the firm's innovative performance, in the sense that returns from search for external knowledge are expected to be greater for firms that concurrently engage in organizational innovation, and vice versa. More specifically, I contend that external search and organizational innovation are complementary activities meaning that adding the one activity while the other activity is already being performed has a higher incremental effect on innovative performance. I further argue that the effect of the joint

occurrence of search for external knowledge and organizational innovation varies significantly depending on what is the external search strategy that firms follow and the degree of novelty achieved. I build my arguments on the following operational definition of complementarity of Milgrom and Roberts (1990):

> *Let us suppose there are two activities, A1 and A2. Each activity can be performed by the firm (Ai=1) or not (Ai=0) and i € {1, 2}. Then the function Π(A1, A2) is supermodular and A1 and A2 are complements if Π(1, 1)−Π(0, 1)≥Π(1, 0)−Π(0, 0).*

3.3. The Complementarity between Search for External Knowledge and Organizational innovation

There are a number of reasons to believe that search for external knowledge and organizational innovation should be complementary activities. In this section, I explain how engaging in one activity may increase the returns achievable through the other.

Firms consider external knowledge utilization as a fundamental way to increase their innovative performance. For this reason, they have recently shifted to an "open innovation" model that exploits the knowledge of a wide range of external actors (Chesbrough, 2003). Organizations seek out relationships with external organizations to gain access to new ideas and critical resources, such as raw materials, labor, specialized skills, and diverse capabilities. Indeed, many empirical studies seem to confirm the assumption that innovation success is closely related to innovation inputs from external sources like customers, suppliers, competitors or universities (e.g., Katila and Ahuja, 2002; Laursen and Salter, 2006). Such innovation inputs have been conceptualised as the main elements of a firm's external search strategy (Laursen and Salter, 2006).

The effect of external search on the firm's ability to innovate have been uncovered in many studies (e.g., Chesbrough, 2003; Laursen and Salter, 2006). As reported by Stuart and Podolny (1996) firms that employ external search strategies can easily reposition their technological base by utilizing different alliances and coalitions and by getting access to diverse sets of technologies. Similarly, Tortoriello (2015) has found that diverse networks of actors can provide opportunities for recombining knowledge. Laursen and Salter (2006) argue that firms who establish in-depth interactions with external actors are more likely to understand the norms, habits, and routines of different external channels of knowledge and to access new ideas and different technologies (March, 1996).

However, the extent to which firms can recognize, absorb, and integrate external knowledge is determined by their "absorptive capacity" that is the firms' ability to acquire and utilise external knowledge internally (Cohen and Levinthal, 1990). Prior literature has discussed the positive influence of absorptive capacity on the firm's ability to internalize external knowledge (e.g., Cohen and Levinthan, 1990). Essentially, absorptive capacity consists of the identification, assimilation, and exploitation of potentially useful external knowledge (Cohen and Levinthan, 1990). Therefore, it goes beyond the external ties of the firm including the ability to remove external knowledge from its original point of entry, transferring it across and within different subunits, and applying it to commercial ends (Cohen and Levinthan, 1990). As Nonaka (1991) argues firms create knowledge through a dynamic process of conversion between explicit and tacit knowledge. To leverage knowledge from external channels firms must be able to externalize tacit knowledge by converting it into explicit and then internalize it by converting it into tacit (Nonaka, 1991). This process lies at the core of organizational learning and requires two important elements

which are indicative of the absorptive capacity of the firm (Cohen and Lavinthal, 1990): an existing knowledge base or competence and the intensity of effort or commitment (Nonaka, 1991).

The importance of the absorptive capacity for the firm's search strategy has been also aptly acknowledged by Laursen and Salter (2006). In their seminal study, they (2006) have found, inter alia, that the relationship between external search and innovative performance takes an inverted U-shape since over-search is associated with increased exposure to new ideas. After a certain point of exposure, there may be too many ideas for the firm to handle, evaluate, and choose between (Laursen and Salter, 2006). Indeed, it is particularly difficult as well as costly for firms to overcome their narrow search horizons (Teece, 2007). As Henderson (1994) points out many technology-intensive firms fall into the trap of becoming imprisoned by their deeply ingrained assumptions, information filters, as well as problem-solving strategies, turning their competitive advantages into strategic straitjackets.

Past empirical evidence suggests that in order to overcome the inertias that inhibit innovation, firms should go beyond external search by introducing completely radical strategies (e.g., Davidow and Malone, 1992; Handy, 1990). Teece (2007) indicates that these strategies encourage change through the implementation of organizational innovation, i.e., new organizational routines that facilitate creative action and enable the perpetual shedding of established assets and routines that no longer yield value. Further, Cohen and Levinthal (1990) point out that internal re-organization and adaptation may influence the firm's ability to identify, assimilate, and exploit external knowledge. More specifically, they distinguish between "inward-looking" absorptive capacity, that is the ability of the firm to achieve efficiency on internal communication,

and “outward-looking” absorptive capacity, which is the ability of the firm to achieve efficiency on the points of contact with external sources of knowledge.

While Cohen and Levinthal (1990) do not address directly the joint effect of organizational innovation and external search strategy, the aforementioned distinction opens up new avenues for explaining the role of new organizational routines for the successful use of external knowledge for the purposes of innovation. New organizational routines may have inward-looking or either outward-looking orientation as they can both include new practices that enhance the efficiency of the internal communication systems and new practices that facilitate the establishment of contact with external sources of knowledge (Foss et al., 2011). More precisely, organizational innovation may include the introduction of new delegation, internal and external communication, and incentives systems (Foss et al., 2011), new administrative mechanisms (Koufteros and Marcoulides, 2006) or new learning processes and coordination activities that balance conflicting interests that come up during events of change (Coriat and Weinstein, 2002). These organizational innovations when implemented can enhance the operational flexibility, the dissemination of knowledge, and the effectiveness of the coordination mechanisms within (Koufteros and Marcoulides, 2006) and outside the firm (Foss et al., 2011). They help firms also to deal with previous investments, organizational, and internal process inadequacies (Zahra and Nielsen, 2002), while at the same time contribute towards the elimination of the “not-invented-here” syndrome (Lichtenthaler and Ernst, 2006), which may compromises the ability of the firm to incorporate external knowledge into its own, internal knowledge stocks. Therefore, organizational innovation is likely to increase the firm’s ability to recognize, absorb, integrate, and

commercialize new knowledge as it engages in higher levels of external search (Cohen and Levinthan, 1990).

From the arguments above, it is obvious that the ability to identify and draw knowledge successfully from external sources is deeply grounded in the organizational processes and routines. To put it differently, the creative process lies inside the firm itself and not inside the external environment of the firm. As Leonard-Barton (1995) argues external knowledge may not always be compatible with internal management routines. Therefore, innovating firms should have the ability to implement complementary organizational innovations needed to support the exploration and the internal exploitation of external knowledge (Teece, 2007). This ability has been directly linked with the successful commercialization of external knowledge inputs (Foss et al., 2011).

To summarize, firms which are actively involved in external search activities while at the same time implement new organizational practices to support the exploration, assimilation, and commercialization of new knowledge are more likely to establish successful patterns of interaction with external partners and to achieve better exploration of diverse information as well as better management and exploitation of a wide range of new ideas (Koput, 1997). In turn, all these should positively influence their innovative performance (Katila and Ahuja, 2002).

Yet the introduction and therefore, the benefits achievable through organizational innovation depend on the amount of creative insights available to the firm (Mol and Birkinshaw, 2009). These creative insights may increase positively through search for external knowledge. Mol and Birkinshaw (2009) explain that firms having external ties are more likely to gain broader and deeper insights into organizational practices and

routines that have been successfully used in other settings (Mol and Julian Birkinshaw, 2009). Many empirical studies indicate that external knowledge can successfully reinforce organizational innovation (e.g., Birkinshaw et al., 2008; Kaplan, 1998). This is mostly because firms that engage in external search activities are able to observe a huge variety of successful organizational routines as well as the mechanisms that support their implementation (Mol and Birkinshaw, 2009). According to Hargadon (2002), as the insights gained from external search increase, the ability to recombine these insights in valuable for the firm ways increases proportionally. Firms that engage in search activities experience the diversity of ideas in different domains. In turn, these ideas enable firms to identify valuable combinations of resources and transform their past knowledge into new organizational routines and processes (Hargadon, 2002).

Further, in the fashion literature, it has been explicitly described how the interaction with particular sources of knowledge, like market-based sources, can impact on the successful introduction of new organizational routines and practices. Competitors' management practices that appear progressive as well as insights from specialized consultants, customers, users or suppliers can be critical success factors in the implementation of organizational innovation because they increase the ability of the managers to introduce something, which is useful for the firm (Abrahamson and Fairchild, 2001; Abrahamson and Rosenkopf, 1993). Thus, the general assessment here is that engaging in search for external knowledge will increase the ability of the firm to introduce successfully organizational innovations, which will ultimately lead to greater operational flexibility, lower operational costs, better dissemination of knowledge and coordination of activities within the organization, and therefore, higher innovative performance (Koufteros and Marcoulides, 2006).

These arguments suggest that not only external search strategies and organization innovation should increase the innovative performance of the firm, but also they are complementary activities, in the sense that the contribution of external search is greater for firms that simultaneously engage in organizational innovation, and vice versa.

3.4. Anticipated Differences in the Complementary Effects

Recall that Laursen and Salter (2006) have proposed two critical components for external search strategy, namely "external search breadth" and "external search depth". These external search strategies represent decisions that firms have to take so as to best explore and exploit external knowledge (Laursen and Salter, 2006). While external search and organizational innovation seem to be complementary activities for increasing the firm's innovative performance, decisions on the direction and the extent to which organizations should collaborate with external actors can have considerable implications for this relationship.

As Mol and Birkinshaw (2009) argue, the introduction of an organizational innovation depends on the amount of creative insights available in the firm. However, the implementation of an organizational innovation is contingent upon internal levels of resistance against organizational changes (Nelson and Winter, 1982). Because external search breath and external search depth are facilitated by different organizational structures, firms that engage in these external search strategies may experience different pressures from organizational inertia (Nelson and Winter, 1982). The organizational properties that enable firms to search broadly or deeply for external sources of knowledge can also promote or either inhibit organizational innovation.

Since external search and organizational innovation can only complement each other if organizational innovation is effectively implemented, the confirmation of their link is only useful if we are able to distinguish how organizational innovation and different external search strategies relate, and recognize the asymmetry of their facilitating mechanisms (March, 1991). The general assumption here, is that the organizational mechanisms that facilitate external search breadth and external search depth can also influence the complementary relationship between external search and organizational innovation by rendering the implementation of an organizational innovation either productive or counterproductive. In the following two sections, the relevant hypotheses are thoroughly discussed.

3.4.1. The Complementary Effect of External Breadth and Organizational Innovation on the Firm's Innovative Performance

By definition external search breadth strategy entails infrequent and shallow interactions with external channels of knowledge (Burt, 1992; Dittrich and Duysters, 2007; Granovetter, 1973; Hansen, 1999). Because firms do not rely upon direct experience with these channels of knowledge, they should devote extensive effort and time to build up an understanding of their norms, habits, and routines (Laursen and Salter, 2006). Firms who engage in external breadth have to go through a period of experimentation in order to learn how to gain knowledge from external sources (Laursen and Salter, 2006). This process is subject to considerable uncertainty and risk (Laursen and Salter, 2006). Such a pattern of collaboration corresponds to March's (1991) notion of exploration. According to He and Wong (2004) and March (1991),

exploration favours organic structures that promote search, variation, risk taking, and experimentation.

The importance of organizational structure as a contextual factor that affects the probability that learning and organizational change will occur has been aptly acknowledged in the management literature (e.g., Hrebiniak and Joyce, 1984; Starbuck et al., 1978). According to Morgan and Ramirez (1983), a mechanistic structure tends to reinforce past behaviours, while an organic structure tends to allow shifts in organizational beliefs and actions. Zammuto and O'Connor (1992) argue that organic structures provide the best chance for successful implementation of an organizational innovation. Indeed, an organic structure can enhance adaptation to environmental changes by increasing variance in organizational routines (McGrath, 2001) and by supporting reorientations (Levinthal, 1997) that enable firms to implement new routines and practises (Rosenkopf and Nerkar, 2001). In turn, the implementation of new routines and practices is likely to increase the efficiency of the internal communication systems as well as the efficiency of points of contact with external channels of knowledge (Foss et al., 2011). To put it differently, organic structures do not only enable firms to search broadly for external information and knowledge, but they also reinforce organizational change. Therefore, they enable organizational innovation to complement other innovation activities, such as external search, in order to incrementally increase the innovative performance of the firm. Hence, I hypothesize that:

Hypothesis 1: External search breadth and organizational innovation have a complementary effect on the firm's innovative performance.

3.4.2. External Depth and Organizational Innovation

External search depth, on the other hand, involves deep use of key sources of knowledge and therefore, it occurs through recurrent interactions with external channels (Laursen and Salter, 2006). Firms who engage in recurrent interactions with selected groups of partners tend to rely on existing arrangements made to facilitate access and transfer of knowledge already prevailing in the network (Lavie and Rosenkopf, 2006). This type of interaction can improve the flow of knowledge and efficiency of collaboration (Verspagen and Duysters, 2004). As such, it corresponds to March's (1991) notion of exploitation.

He and Wong (2004) and March (1991) argue that exploitation favours mechanic structures that promote organizational stability (He and Wong 2004; March, 1991). Functional organizations may be efficient but are less likely to accept organizational change (Hrebiniak and Joyce, 1984; Vancil, 1978). As Birkinshaw et al. (2008) point out the implementation of something new to the state of art entails a great level of uncertainty that stems from the fear that innovation will have negative consequences for the organization (Birkinshaw et al., 2008). In fact, as companies become deeply embedded within collaborative arrangements, the already established routines of interaction and assimilation of knowledge may result in automatic organizational activities that create strong resistance against organizational changes (Nelson and Winter, 1982). Since these internal activities represent templates that facilitate and smooth operations, they can generate strong internal pressures against radical changes from the current status quo (Hannan and Freeman, 1984). Hence, it is expected that these pressures will render the implementation of organizational innovation counterproductive, and as such, they will also erode any potential complementarity

between organizational innovation and other innovation activities such as external search. Therefore, I hypothesize that:

Hypothesis 2a: External search depth and organizational innovation do not have a complementary effect on the firm's innovative performance.

As discussed earlier, recurrent interactions with external channels of knowledge might hinder the implementation of organizational innovation in the form new management and working routines and practices (Hannan and Freeman, 1984). However, this might not apply to contexts where search is planned or intentional. Such a type of search usually targets for access to information and knowledge on premeditated interventions intended to modify specific aspects of an organization which are widely seen as dysfunctional (Lippitt, 1958). In this context, managers and employees alike are more likely to put faith in external ideas than in internal ones. This is because, external ideas are usually considered as neutral and therefore, useful in understanding new threats and opportunities associated with changing certain aspects of the organization (Mol and Birkinshaw, 2008). Therefore, through establishing recurrent interactions with external channels of their choice, firms are more likely to capture what is happening beyond the firm boundaries and what actually works in the world of practice, while they can also acquire rich information on how, why, and which new management and working routines and practices can yield value, establishing the cognitive legitimacy needed for the organizational innovation to be accepted inside the firm (Mol and Birkinshaw, 2008). Such a cognitive legitimacy might render the implementation of new management and working routines and practices productive, enabling them to

complement other innovation activities such as external search and therefore, to further increase the innovative performance of the firm. Therefore, I hypothesize that:

Hypothesis 2b: External search depth and organizational innovation have a complementary effect on the firm's innovative performance.

3.4.3. External Search breadth, Organizational Innovation and Different Degrees of Novelty

Hypothesis 1 stated that external search breadth and organizational innovation have a complementary effect on the firm's innovative performance. There is a reason to believe, however, that not all types of innovation outcomes are equally affected by the joint occurrence of external search breadth and organizational innovation.

Innovations vary significantly in the degree of novelty. An innovation can be either radical, if it represents a revolutionary departure from existing practice (Ettlie, 1983) or incremental, if it initiates minor improvements or simple adjustments in current technology (Freeman and Soete, 1997; Henderson and Clark, 1990; Laursen and Salter, 2006; Munson and Pelz, 1979). While incremental innovation refers to minor technical changes, radical innovation is associated with technological breakthroughs and intense technological discontinuities (e.g., Anderson and Tushman, 1990). Foster (1986) points out that managing through technological discontinuity necessitates more skill transitions. Hence, radical innovations tend to create greater knowledge demands for firms than incremental innovations (Duchesneau, 1979). Firms using a wide range of knowledge domains are more likely to generate cutting-edge ideas and new combinations of knowledge components (Taylor and Greve, 2006). They are also more

likely to capture new information about technological and market opportunities for their radical innovation (Chesbrough, 2003). Therefore, external breadth is more likely to stimulate radical innovation.

Incremental innovation, on the other hand, requires less knowledge resources in the organization for development or support (Dewar and Dutton, 1986). Firms that target incremental innovations need to keep abreast of developments which may improve their current operations (Webster, 1970). As Allen (1970) and Utterback (1974) argue improving current operations necessitates frequent exposure to innovation through in-depth interaction with external actors. Therefore, external breath is less likely to foster incremental innovation.

It has been reported, though, that without sufficient synthesis and utilization efforts, ideas stimulated by diverse knowledge touch on shallow surfaces rather than drill down to the essence of an emerging breakthrough (e.g., Laursen and Salter, 2006). As such, they are likely to favour incremental instead of radical innovation (Laursen and Salter, 2006). Exposure to diverse knowledge often calls firms to adopt new routines and practices in order to sufficiently synthesize and capitalize on new ideas (Nord and Tucker, 1987). These routines and practices coordinate the efforts of actors operating across different parts of the organization (Dougherty 1992, Jelinek and Schoonhoven, 1990). They also provide the flexibility needed for people throughout an organization to productively transform their new ideas and efforts into novel products (Bartel and Garud, 2009). Thus, external search breadth creates the need for organizational innovations.

To summarize, firms that engage in external breadth search while at the same time implement organizational innovations to facilitate the synthesis and utilization of

external ideas are more likely to exhibit higher radical than incremental innovative performance.

On the other hand, firms that engage in external search breadth are able to observe a huge variety of organizational routines and practices implemented elsewhere (Mol and Birkinshaw, 2009). Therefore, these firms are more likely to introduce organizational innovations (Mol and Birkinshaw, 2009). However, an organizational innovation should be successfully implemented to release its benefits. As discussed earlier, external search breadth is facilitated by organic structures. Morgan and Ramirez (1983) argue that organic structures enable shifts in organizational beliefs and actions. Hence, the organizational property that allows firms to search broadly for external knowledge facilitates also the implementation of an organizational innovation. Thus, the general assessment here is that engaging in external search breadth will increase the ability of the firm to introduce and implement successfully organizational innovations, which will ultimately facilitate the productive transformation of new ideas into radical innovations (Bartel and Garud, 2009). Taken all arguments together, I hypothesise that:

Hypothesis 3: The complementary effect of external search breadth and organizational innovation is stronger for the firm's radical than for the firm's incremental innovative performance.

3.4.4. External Search depth, Organizational Innovation and Different Degrees of Novelty

Hypothesis 2b stated that external search depth and organizational innovation have a complementary effect on the firm's innovative performance. However, there are several reasons to believe that not all types of innovation are equally affected by the joint occurrence of external search depth and organizational innovation. As discussed earlier, radical innovation requires a wider range of knowledge domains for development and support when compared to incremental innovation. While radical innovation creates greater knowledge demands, incremental innovation requires continuous monitoring of specific knowledge domains which are likely to improve the firm's current operations (Webster, 1970). For this reason, external search depth is more likely to stimulate incremental rather than radical innovation. However, knowledge on specific domains can be well integrated inside the firm, allowing for ongoing incremental improvement, only if new management practices and routines that facilitate the development of tighter intraorganizational linkages and streamline the handoffs between the innovation processes are put in place (Dean and Snell, 1996). In other words, to release its benefits, knowledge accessed through external search depth requires organizational innovation.

To summarize, firms that engage in external search depth while at the same time implement organizational innovations to facilitate the development of tighter intraorganizational linkages and to streamline the handoffs between the innovation processes are more likely to exhibit higher incremental than radical innovative performance.

Further, firms that engage in external search depth are more likely to gain deeper insights into new management routines and practices implemented in other settings (Mol and Birkinshaw, 2009). These insights are not only likely to facilitate the development of a better understanding on how and why specific organizational

innovations can yield value (Mol and Birkinshaw, 2008), but they can also provide the cognitive legitimacy required for the organizational innovation to be accepted and therefore, to be successfully implemented inside the firm (Mol and Birkinshaw, 2008). Therefore, the general assessment here is that engaging in external search depth will increase the ability of the firm to introduce and implement successfully organizational innovations, which will ultimately facilitate the productive transformation of new ideas into incremental innovations. Taken all arguments together, I hypothesize that:

> *Hypothesis 4: The complementary effect of external search depth and organizational innovation is stronger for the firm's incremental than for the firm's radical innovative performance.*

3.5. Summary of the Hypotheses of the Thesis

In this chapter three hypotheses have been introduced and arguments regarding the complementary effect of external search and organizational innovation on the firm's innovative performance have been developed. In more details, I asked:

What is the effect of the joint occurrence of search for external knowledge and organizational innovation on the firm's innovative performance?

I argued that search for external knowledge necessitates new organizational routines that facilitate creative action, enable the perpetual shedding of established assets and routines that no longer yield value, and support the exploration and the internal exploitation of external knowledge (Teece, 2007). I suggested that organizational innovation may increase the effectiveness of external search. I also claimed that the introduction of an organizational innovation is directly linked to the amount of creative

insights inside the firm. As Mol and Birkinshaw (2009) point out creative insights can be gained through search for external knowledge. These arguments suggest that not only external search and organization innovation should increase the innovative performance of the firm, but also they are complementary activities, in the sense that the contribution of external search is greater for firms that simultaneously engage in organizational innovation, and vice versa.

Next, I differentiated search for external knowledge along two critical component: 'external search breadth' and 'external search depth' (Laursen and Salter, 2006). According to March (1991), the former component is typically associated with the exploratory activities of the firm. Therefore, it entails organic structures of collaboration that increase the amount of experimentation and adaptation and enable the introduction of more radical organizational and operational improvements (He and Wong, 2004). Conversely, the latter component relates to the exploitative activities of the firm (March, 1991). Hence, it is facilitated by mechanic structures of collaboration that strive to maintain stability while increasing organizational and operational efficiency (He and Wong, 2004; March, 1991). Drawing on these arguments, I claimed that the complementary relationship between external search and organizational innovation on the innovative performance is more likely to exist for those firms that engage in search breadth rather than search depth external sourcing. I anchored this argument in the assumption that companies deeply embedded within collaborative arrangements may appear reluctant to change the already established internal routines and practises (Nelson and Winter, 1982). However, I also recognized the possibility that the coexistence of external search depth and organizational innovation might be productive, if search for external knowledge is more intentional or planned, targeting access to information and knowledge on premeditated interventions intended to

modify specific aspects of an organization which are widely seen as dysfunctional (Lippitt, 1958). Further, I attempted to explain how the joint occurrence of external search breadth and organizational innovation and the joint occurrence of external search depth and organizational innovation can impact on innovations associated with different degrees of novelty. More specifically, I asked:

Are all the innovation outcomes equally affected by the joint occurrence of external search breadth and organizational innovation?

I suggested that the complementary effect of external breadth and organizational is stronger for the radical than for the incremental innovative performance of the firm. Specifically, I explained that external breadth is more likely to stimulate radical innovation than to foster incremental innovation (Robert et al., 1986). I acknowledged, though, that firms need organizational innovations in order to synthesize and manage their innovative efforts. Otherwise, ideas that stem from external search breadth are likely to touch on only shallow surfaces favouring incremental instead of radical innovation (Laursen and Salter, 2006). I claimed also that through external search breadth firms can gain access to creative insights that foster organizational innovations (Mol and Birkinshaw, 2009). Further, I pointed out that the organizational structure (organic structure) that allows firms to search broadly for external knowledge facilitates also the implementation of organizational innovations and as such, it enables firms to synthesize creative ideas and manage their innovative efforts in order to introduce radical innovations. In the same vein, I also asked:

Are all the innovation outcomes equally affected by the joint occurrence of external search depth and organizational innovation?

To answer this question, I develop arguments on why external search depth is more likely to stimulate incremental than to foster radical innovation. I also explain how organizational innovation facilitates the development of tighter intraorganizational linkages and the streamlining of the handoffs between the innovation processes, promoting the development of increment improvements. Last, I explain why external search depth can help firms to establish the cognitive legitimacy needed for the successful implementation of organizational innovation.

Table 3.1 summarizes the three hypotheses of the study. The next chapter presents the research methodology including the philosophical underpinnings of the study, data and sample, measures for the variables used as well a brief discussion on quantitative methods applied for investigating the proposed hypotheses.

Table. 3.1. Summary of the proposed hypotheses

Hypotheses	
H1	*External search breadth and organizational innovation have a complementary effect on the firm's innovative performance.*
H2a	*External search depth and organizational innovation do not have a complementary effect on the firm's innovative performance.*
H2b	*External search depth and organizational innovation have a complementary effect on the firm's innovative performance.*
H3	*The complementary effect of external search breadth and organizational innovation is stronger for the firm's radical than for the firm's incremental innovative performance.*

H4	*The complementary effect of external search depth and organizational innovation is stronger for the firm's incremental than for the firm's radical innovative performance.*

Chapter 4: Research Methodology

4.1. Chapter Overview

The purpose of the following chapter is to describe the research methodology of the study. The second section presents the philosophical underpinnings of the study. Following, the data and the sample used for the analysis of the hypothesized relationships are described. Next, the measures for the variables of the study are presented. Last, the econometric methods applied for the investigation of the proposed hypotheses are briefly discussed.

4.2. Philosophical Underpinnings

The choice of a research method is driven chiefly by the philosophical perspectives, which frame the researcher's reference. Developing a philosophical perspective requires that the researcher makes several distinct assumptions on the nature of reality (ontology) and knowledge of the reality (epistemology) (Guba and Lincoln, 1994). Together, ontological and epistemological assumptions make up a paradigm. Indeed, all social science is based on paradigmatic thinking and theorizing is dominated by a paradigm mentality.

The term paradigm was first introduced by Thomas Kuhn (1962) in his book, titled *"The structure of Scientific Revolutions"*. A paradigm, according to Kuhn (1962), is a certain way of viewing the world which is taken for granted by the scientific community. When scientists that use the prevalent paradigm fail to solve certain puzzles, they tend to lose their confidence in this paradigm and therefore, they try to

replace it in a so-called paradigm-shift. This process is what Kuhn (1962) describes as a scientific revolution.

Traditionally, two major paradigms were dominant in social research: the qualitative and quantitative approaches. Both of them encompass a range of ontological and epistemological approaches. Quantitative approaches' ontological position is that there is only one truth, an objective reality that exists independent of human, while epistemologically, the investigator and the investigated are independent entities. This approach to research is called positivist, or positivist-empiricist. Positivism was first introduced by the French philosopher August Comte and it is logically connected to natural sciences and pure scientific laws. It is based on the logic of deduction, beginning from accepted theories or premises and testing them rationally. Its central claim is, that no truth can be known if it not empirical verified.

Quantitative research is also associated with the post-positivist stance. Just as positivism, post-positivism complies with deductive scientific principles, while acknowledging a single reality that can only be approximated. As such, it espouses theory falsification over theory verification. According to theory verification, which comes from Karl Popper, observational evidence can never prove that any general theories or scientific hypothesis are true, but it can only falsify them. Causality is the main concern of post-positivist research methods, and is established by research design, statistical hypothesis testing, and assessment of alternative possible explanations for research findings.

As opposed to the quantitative, the qualitative paradigm is associated with interpretivism (Altheide and Johnson, 1994; Kuzel and Like, 1991) and constructivism (Guba and Lincoln, 1994). Interpretivism and constructivism are rooted in the thinking of Immanuel Kant, John Dewey and William James, Jean Piaget, and Thomas Kuhn.

Ontologically speaking, these approaches argue that there are multiple realities or multiple truths which are shaped by the individual's construction of reality. Therefore, the world is considered as socially constructed and understood (Blaikie, 2000), and therefore, it is in a constant flux. On an epistemological level, there is no access to reality independent of peoples' minds, and no external referent by which to compare claims of truth (Smith, 1983). Therefore, the investigator and the object of study are interactively intertwined in such a way, that findings are created mutually within the context of the situation that molds the inquiry (Denzin and Lincoln, 1994; Guba and Lincoln, 1994). The process of qualitative research is inductive in that, the researcher builds abstractions, concepts, hypotheses, and theories from details (Merriam, 1988). This research approach emphasizes thick description while, utilizing the researcher as the focal instrument in data gathering and analysing data (Van Manen, 1990).

From the above discussion, it is clear that different traditions have their roots in different kinds of paradigmatic thinking. Further, different approaches introduce different world-views that guide the choice of research approach, theories, methodology, and methods. Guba and Lincoln (1994) argue that constructivism has failed to treat the rich complexity of social life because of its major flow. Constructivism assumes a relativist ontological position (Guba and Lincoln, 1994) according to which, each view of the reality is not possible to be compared with other views. This is mostly, because each view of the reality is considered to be equally important. According to Guba and Lincoln (1994), such an assumption is likely to hamper significantly the scientific progress. Ultimately, because of this assumption, qualitative research has failed in understanding causal processes, replicating observations (reliability), obtaining correct answers, and correcting impressions of the phenomenon under investigation (validity) (Kirk and Miller, 1986).

Agreeing with the thoughts of August Comte, the ontological position of the thesis is in compliance with the post-positivist paradigm. As such, this study focuses on understanding and interpreting the causal processes and factors that exert complementary effects on the innovative performance of the firm. The hypothesized relationships of the thesis will be tested by using empirical evidence. The aim of this work is to provide recommendations, and further refinement of the prior theory in the fields of innovation and strategy. The emphasis of this thesis is to clarify the relationships between different variables (Saunders et al., 2007). I commence research by deducing hypotheses from theory and literature. Next, I examine these hypotheses by using quantitative data and methods of analysis. In the following section, the data, variables, and methods used to test the hypothesized relationships of the study are described.

4.3. Data and Sample

The data used in this study is obtained by the Community Innovation Survey (CIS). The CIS was conducted by Eurostat in sixteen European Union member states covering the period from 2006 to 2008. The CIS is a microdata questionnaire that measures innovation activities at firm level. The CIS questionnaire can be found in appendix A. The questions and measures used in CIS are described in the Oslo Manual (OECD, 2005). The CIS data has been used successfully in over 60 recent academic articles from various disciplines, e.g. economics (Belderbos et al., 2004a; Veugelers and Cassiman, 1999) and strategic management (Laursen and Salter, 2006; Leiponen and Helfat, 2010). 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, I assume that all measurements are both highly reliable and valid.

The survey among other things sought to generate insights into search for external knowledge, organisational innovation, and firms' innovative performance. The CIS questionnaire includes questions regarding the breadth and depth of the firm's reliance on external knowledge sources, the introduction of organizational innovation, and firm's R&D investments. One major advantage of the CIS is that it is "subject-oriented". In other words, the survey asks firms directly whether they were able to produce an innovation. This approach of measuring innovative performance is a useful complement to traditional measures of innovative performance like patent statistics (Mairesse and Mohnen, 2002) because it provides direct measure of success that traditional measures cannot capture (Leiponen and Helfat, 2003). Since all innovative output is not necessarily patented, and all patents will not necessarily lead to innovation, the number of patents granted can be considered primarily as a proxy for the firms' appropriability strategy rather than a proxy for the firms' innovative performance (Laursen and Salter, 2006).

All survey questions regarding external search strategies and organizational innovation refer to the average of a three year period from 2006 to 2008. The innovation performance, however, is evaluated only for the last year of that period. By doing so, I attempt to temporally separate the independent from the dependent variables and therefore, to account for time lags between innovation activities and innovation outcomes. This also adds to overcoming potential common method bias concerns (Rothaermel and Alexandre, 2009).

The CIS 2008 includes 127,690 responding firms. Yet, because of missing values in key variables of interest, I performed econometric analysis using a sample of 46,862 European firms that expand in twelve CIS countries: Bulgaria (BG), Belgium (BE), Cyprus (CY), Czech Republic (CZ), Germany (DE), Estonia (EE), Spain (ES), Hungary (HU), Italy (IT), Portugal (PT), Romania (RO), and Slovakia (SK).

4.4. Variables and Measures

The following section describes the variables and measures used. First, the measures for the innovative performance of the study are described. Next, the three independent variables (external search breadth, external search depth, and organizational innovation) are introduced. The section concludes with the description of the control variables of the study.

4.4.1. Dependent Variables

Following Laursen and Salter (2006), I use two different types for innovative performance: radical and incremental. To measure radical innovative performance, I use the percent of total firm sales revenues that derive from new or significantly improved goods and services that are new to the market (INNWORLD). In order to measure incremental innovative performance, I use the percent of total firm sales revenues that derive from new or significantly improved goods and services that are only new to the firm (INNFIRM).

4.4.2. Independent Variables

To examine the potential complementary relationship between organizational innovation and external search, I test separately the complementary effect of the former innovation activity with the two components of the external search strategy. Following Laursen and Salter's (2005) seminal study, first, I measure external search breadth and external search depth as a combination of 9 sources of knowledge. The three sub-dimensions of knowledge include (1) market (i.e., suppliers of equipment, materials, components, or software; clients or customers; competitors; consultants; commercial laboratories/R&D enterprises), (2) institutional (i.e., universities or other higher education institutes; government research organizations or public research institutions), (3) other (i.e., conferences; trade affairs, exhibitions; scientific journals and trade/technical publications; professional and industry associations).

To measure external breath (BREADTH), I coded the variable as binary with 0 being no use and 1 being use of the given knowledge source. The total external breath was estimated by calculating the sum of the knowledge sources being in use. Accordingly, I measured depth (DEPTH) by using the same 9 sources of knowledge mentioned above. I coded the depth variable with 1 when the respondent firm reports the source is used to a high degree and 0 in case of either no, low, or medium use of the given source of knowledge. The total measure of external depth was estimated by calculating the sum of the knowledge sources used to a high degree. After measuring external search breadth and external search depth respectively, I coded them as dummy variables. Both variables take the value of 1 when their score is equal or higher than 1 or 0 otherwise. The last step was essential in order to run the "productivity" regression which is one of the most prominent econometric tests for exploring complementarities (see Milgrom and Roberts, 1990). More information on the econometric technique used can be found in the following section of the thesis.

With respect to organizational innovation, CIS asks respondents to indicate whether they introduced three different organizational innovations. More specifically, responding firms are asked to indicate if they have introduced new methods of organising external relations with other firms or public institutions; new business practices for organising procedures; and new methods of organising work responsibilities and decision making. The variable organizational innovation (ORGANIZATIONAL INNOVATION) takes the value of 1 when the firm indicates that it has introduced at least one of these organizational innovation activities or 0 otherwise (see Milgrom and Roberts, 1990).

Next, following Cassiman and Veugelers (2006), I assessed whether external search breadth and organizational innovation, as well as external search depth and organizational innovation are complementary activities by creating four exclusive dummy variables for each hypothesized relationship. These dummies indicate firm innovation activities with respect to its external search strategies and organizational innovation and they distinguish the following mutually exclusive cases (Milgrom and Roberts, 1990):

Complementary effect of external search breadth and organizational innovation

1. No external search breadth, no organizational innovation
2. Only external search breadth
3. Only organizational innovation
4. External search breadth and organizational innovation

Complementary effect of external search depth and organizational innovation

1. No external search depth, no organizational innovation
2. Only external search depth

3. Only organizational innovation
4. External search depth and organizational innovation

4.4.3. Control Variables

I control for the size of the perceived product market (GEOMARKET). The variable captures whether the largest market of the firm is perceived to be local, regional, national, or international and it takes the values from 0 to 3, with 0 corresponding to 'local' and 3 corresponding to 'international'. I control also for the use of lead users in innovation (USER). The variable takes the value of 1 when the firm indicates that it uses clients or customers to a high degree as sources of information and knowledge for innovation activities, and 0 otherwise.

The use of cross-sectional data poses the concern that firm characteristics may correlated with organizational innovation and knowledge sources affecting innovative performance. To mitigate this concern, the analysis includes variables that control for important firm characteristics. In particular, I control for R&D intensity (RDINT), number of employees (EMP), and engagement in collaboration activities (COLLAB). The variable RDINT is measured by dividing firm R&D expenditure by firm sales. The variable EMP captures the firm size class and it takes the values from 0 to 2, with 0 corresponding to <50 employees, 1 corresponding to 50-249 employees, and 2 corresponding to >=250 employees. COLLAB takes the value of 1 when the firm indicates that it is engaged in collaboration arrangements on innovation activities and 0 otherwise. I control also for external financial support (SUPPORT). The variable takes the value of 1 when the firm indicates that it has received external financial support and 0 otherwise.

Finally, I include 12 country dummies and 13 industry dummies to control for country and industry effects. The industry dummies were identified based on the NACE-codes provided by the Oslo Manual (OECD, 2005). I made a distinction between: (1) food, drink and tobacco; (2) textiles; (3) wood, paper and printing; (4) chemicals, plastics and non-metallic minerals; (5) basic metals and fabricated metal products; (6) electrical, machinery and transport equipment; (7) furniture and repair of equipment; (8) electrical and gas; (9) water supply, sewerage, and waste management; (10) construction; (11) transport; (12) information and communication and (13) other. In the following section, descriptive insights on the variables used in this study are presented.

4.5. Descriptive Statistics

Table 4.1 summarizes the variables used in this study, and presents their descriptive statistics. Note that the four variables created for assessing whether or not external search and organizational innovation are complementary activities are not presented in table 4.1. Given the nature of these variables (dummies that capture complementary effects), calculating their means does offer any important insights. The mean and standard deviations of the dependent, and control variables, as well as the means and standard deviations of “BREADTH”, “DEPTH”, and “ORGANIZATIONAL INNOVATION”, are presented in order to offer insights on the characteristics of the sample. Further, table 4.2 breaks down the industries on the basis of the technological intensity. The sample includes firms form both low, medium, and high technology and knowledge intensive industries.

Table 4.1. Description and descriptive statistics of the main variables of the thesis

Variable	Description	Mean	S.D.
BREADTH	The sum of the knowledge sources being in use.	5.178699	2.978568
DEPTH	The sum of the knowledge sources being in use to a high degree.	0.9106933	1.178945
ORGANIZATIONAL INNOVATION	Dummy that takes the value of 1 if a firm indicates that it has introduced at least one organizational innovation.	0.5687032	0.4952627
RDINT	R&D expenditure divided by firm sales.	0849246	2.519388
EMP	The firm size class. It takes the values from 0 to 2, with 0 corresponding to <50 employees, 1 corresponding to 50-249 employees, and 2 corresponding to >=250 employees.	0.6654147	0.7303411
COLLAB	Dummy that takes the value of 1 if a firm indicates that it is engaged in collaboration arrangements on innovation activities and 0 otherwise.	0.3226564	0.4674975
SUPPORT	Dummy that takes the value of 1 if a firm indicates that it has received external financial support and 0 otherwise.	0.2556283	0.4362185
USER	Use of lead users in innovation. The variable takes the value of 1 when the firm indicates that it uses clients or customers to a high degree as sources of information and knowledge for innovation activities, and 0 otherwise.	0.2636734	0.440629
INNWORLD	Logarithm of the percent of total firm sales revenues that derive from new or significantly improved goods and services that are new to the market.	- 0.1014149	1.109958
INNFIRM	Logarithm of the percent of total firm sales revenues that derive from new or significantly improved goods and services that are only new to the firm.	0.2669982	1.154522

Table 4.2. Industry breakdown

Industry	Industry Group
Food, drink and tobacco	Low-technology
Textiles	Low-technology
Wood, paper, publishing and printing	Low-technology
Chemicals, plastics and non-metallic minerals	Medium-high-technology
Basic metals and fabricated metal products	Medium-high-technology
Electrical, machinery and transport equipment	Medium-high-technology
Furniture and repair of equipment	Low-technology
Electrical and gas	Medium-high-technology
Water supply, sewerage, and waste management	Medium-high-technology & Low knowledge intensive
Construction	Medium-high-technology
Transport	Low-technology & Low knowledge intensive
Information and communication	High-technology & Knowledge intensive
Other	Medium-high-technology

Table 4.3 presents descriptive insights on the characteristics of the sample. More specifically, it describes the level of external search breadth and depth across different industries, the level of R&D intensity, and the percentage of radical and incremental innovators in each industry. Overall, information and communication have the highest level of external breadth, indicating that firms in medium to high technology intensive industries search broadly. On the other hand, firms in low technology and knowledge

intensive industries such as transport exhibit the lowest levels of external search breadth.

By definition external depth is less common than external breadth (Laursen and Salter, 2006). On average, firms draw deeply from almost one source of knowledge. As expectable, firms exhibit high external depth in high technology intensive industries, such as information and communication. Firms in electrical and gas industry, demonstrate the highest level of external search depth. It is noteworthy that firms in industries with the highest R&D intensity exhibit the highest levels of external search depth.

Table 4.3. External breadth and depth by industry

	No. of firms	**Percentage of firms that introduced a product new to the market**	**Percentage of firms that introduced a product new to the firm**	**Average R&D intensity**	**Breadth mean**	**Depth mean**
Food, drink and tobacco	3812	46.93	63.64	0.00985	5.21	0.88
Textiles	2055	43.74	65.35	0.009376	4.87	0.82
Wood, paper and printing	2251	35.45	50.21	0.0074	4.58	0.86
Chemicals, plastics and non-metallic minerals	5746	49.28	64.41	0.033	5.52	0.93
Basic metals and fabricated metal products	3548	41	58.38	0.018	5.06	0.83
Electrical, machinery and transport equipment	6725	55.53	70.06	0.047	5.78	1.01
Furniture and repair of equipment	2630	46.34	63.87	0.018	5.03	0.81

Electrical and gas	357	23.80	36.13	0.052	4.62	0.75
Water supply, sewerage, and waste management	977	27.32	43.25	0.062	4.66	0.82
Construction	1332	28.97	40.69	0.018	4.86	0.89
Transport	1219	29.20	51.68	0.0031	4.34	0.77
Information and communication	2281	51.68	84.52	0.1758	5.88	1.05
Other	13614	39.76	55.42	0.19	3.15	0.58
Average		39.92	57.50	0.049	4.88	0.84

Table 4.4 provides information on the importance of each source of knowledge. The results indicate that clients and customers are the most important sources of information, followed by suppliers of equipment, materials, components, and software. Competitors or other enterprises in the sector, are the third most important source of information, while government and public research institutes along with professional and industry associations, and universities or other higher education institutions are the least important sources of information.

Table 4.4. Sources of information and knowledge for innovation activities in European firms (n = 46,862)

Type	Knowledge source	Percentages			
		Not used	**Low**	**Medium**	**High**
Market	Suppliers of equipment, materials, components, or software	21	21	37	21
	Clients or customers	26	17	31	26
	Competitors or other enterprises in your sector	32	26	31	11
	Consultants, commercial labs, or private R&D institutes	50	24	19	7
Institutional	Universities or other higher education institutions	66	19	11	4
	Government or public research institutes	67	18	11	4
Other	Conferences, trade fairs, exhibitions	35	25	30	10
	Scientific journals and trade/technical publications	39	29	26	6
	Professional and industry associations	50	27	19	4
Average		43	23	24	10

Table 4.5 presents descriptive insights on the level of organizational innovation across different industries. The results indicate that on average 55% of the sample has introduced at least one organizational innovation. Firms in information and communication industry, demonstrate the highest while firms in textiles industry exhibit the lowest level of introduction of organizational innovation. As expected, there are no important differences between firms in low and high technology intensive industries. This finding confirms the assumption that, organizational innovation is important for all firms that seek to improve their services and better manage their activities (e.g., Hartley 2005, Mulgan and Albury, 2003).

Table 4.5. Introduction of organizational innovation by industry

	No. of firms	**Percentage of firms that implemented at least one organizational innovation**
Food, drink and tobacco	3812	53
Textiles	2055	45
Wood, paper and printing	2251	49
Chemicals, plastics and non-metallic minerals	5746	54
Basic metals and fabricated metal products	3548	55
Electrical, machinery and transport equipment	6725	58
Furniture and repair of equipment	2630	51
Electrical and gas	357	59

Water supply, sewerage, and waste management	977	52
Construction	1332	59
Transport	1219	56
Information and communication	2281	65
Other	13614	62
Average		55

4.6. Methods

To verify empirically the complementarity relationship between external search and organizational innovation, I implement the "productivity" approach proposed by Cassiman and Veugelers (2006). This approach draws on the theory of supermodularity (see Milgrom and Roberts, 1990), which assumes that if two activities are complementary then adding one activity while the other has already being performed has higher incremental effect on performance than implementing the same activity in isolation (Cassiman and Valentini, 2015). The main advantage of the "productivity" approach over the frequently used "correlational" approach is that it uses lattices that allow researchers to identify substantial interdependencies among different variables. According to the "productivity" approach, two activities are complementary if the distribution of the first activity is supermodularly dominated by the other and vice versa (Cassiman and Veugelers, 2006). A distribution is supermodularly dominated by another if and only if one can go from the former to the latter by a sequence of two-dimensional elementary transformations that increase the probability of homogeneous outcomes and reduce the portability of heterogeneous ones for the two corresponding variables, with each transformation affecting the probabilities of only four

adjustment points (a square) in the support of the distributions. The "productivity" approach is a purely algebraic method that handles both invisibilities and non-concave maximands and therefore, it allows for sharp comparative statics results (e.g., Wald test) that provide an extra formalization of complementarities. In this respect, the method highlights the conditions under which a set of maximizers moves monotonically with changes in one or more parameters, making the analysis of complementarities easily tractable. The supermodular ordering is characterized by a list of inequalities (see inequality 1, page 26) that help researchers examine if the differences between any pair of distributions (seen as vectors in an appropriate space) satisfy these inequalities (Cassiman and Veugelers, 2006).

Further, because the dependent variables of the study (INNWORLD & INNFIRM) are conditioned on values between 0 and 100, I use a Tobit model to adjust their coefficient estimates (Greene, 2003). Tobit censored regression models assume that the data are normally distributed. Further, the dependent variables are highly skewed. For this reason, I performed a logit transformation of the data. This treatment is consistent with prior studies (e.g. Laursen and Salter, 2006; :Leiponen and Helfat, 2010).

4.7. Summary of the Chapter

This chapter presented the methods applied to test the hypotheses of the thesis. The first section of the chapter, explained the philosophical underpinnings of the study. Next, the data and the advantages of the questionnaire used in this thesis were reported. Following, an extensive description of the variables and measures used to test the hypotheses of the study was provided. Further, descriptive statistics on the characteristics of the sample were presented. Finally, the methods used to test the

hypothesized relationships of the thesis were briefly discussed. The analytical approach used, the results of the study, and several econometric models that examine whether these results are robust to alternative specifications are presented in the following chapter.

Chapter 5: Hypotheses Testing and Results

5.1. Chapter Overview

This chapter presents the results of the thesis. First, I explain the results of the main analysis of the thesis with respect to the hypothesized complementary relationships of external search strategies and organizational innovation. Next, I run several econometric models to test whether these results are robust to a number of alternative specifications. The correlation tables for each respective analysis can be found in Appendix B.

5.2. Econometric Analysis

5.2.1. Productivity Approach for Complementarity Testing: Stage 1 – Mean Comparison

I posit that external search breadth and organizational innovation are complementary activities for increasing the firm's innovative performance (H1). Further, I suggest that there is no significant difference between the innovative performance of firms that engage in both external search depth and organizational innovation, and the innovative performance of firms that do not (H2). Last, I claim that the complementary effect of external search breadth and organizational innovation is greater for the firm's radical than for the firm's incremental innovative performance (H3).

In order to detect whether these assumptions are valid, I test separately the complementary effect between the main components of external search (i.e., external search breadth and external search depth) and organizational innovation on the firm's

radical and incremental innovative performance. Hence, I study possible complementarity between external search breadth and organizational innovation, as well as external search depth and organizational innovation. In order to confirm the presence or absence of complementarity between these activities, I follow different empirical approaches. I begin by implementing the "productivity" approach proposed by Cassiman and Veugelers (2006). Drawing upon the theory of supermodularity (see Milgrom and Roberts, 1990), this approach assumes that if two activities are complementary then adding one activity, while the other has already being performed, has higher incremental effect on performance than implementing the same activity in isolation (Cassiman and Valentini, 2015). Based on this assumption, I use four mutually exclusive cases for each relationship to calculate the following equations that should hold, if external search breadth and organizational innovation, as well as external search depth and organizational innovation, respectively, are complementary activities:

(1) No external search breadth, no organizational innovation; (2) only external search breadth; (3) only organizational innovation; (4) external search breadth and organizational innovation

External search breadth and organizational innovation are complementary activities if:

Innovative performance (external search breadth & organizational innovation) - innovative performance (only external search breadth) ≥ innovative performance (only organizational innovation) - innovative performance (no external search breadth & no organizational innovation).

(1) No external search depth, no organizational innovation; (2) only external search depth; (3) only organizational innovation; (4) external search depth and organizational innovation

External search depth and organizational innovation are complementary activities if:

Innovative performance (external search depth & organizational innovation) - innovative performance (only external search depth) ≥ innovative performance (only organizational innovation) - innovative performance (no external search depth & no organizational innovation).

Table 5.1. Average value of the firms' innovative performance for each of the four mutually exclusive categories

	(5.1a) Radical Innovative performance	**(5.1b) Incremental innovative performance**
External search breadth & organizational innovation	11.994	16.658
Only external search breadth	8.952	16.041
Only organizational innovation	4.371	8.831
No external search breadth & no organizational innovation	4.059	7.688
External search depth & organizational innovation	12.611	17.147
Only external search depth	9.623	15.877

Only organizational innovation	10.245	15.06
No external search depth & no organizational innovation	7.105	13.843

The average values of innovative performance for each of the four mutually exclusive cases are presented in table 5.1. The results indicate that while engaging in external search breadth and organizational innovation in isolation increases both radical and incremental innovative performance, engaging in both activities simultaneously seems to provide additional benefits for both radical and incremental innovative performance. Similarly, the benefits for radical and incremental innovative performance from engaging in external search depth and organizational innovation seem to be greater than the benefits from engaging in each activity in isolation. Finally, the results suggest that engaging in external search breath and organizational innovation has greater benefits for incremental rather than radical innovative performance. Although these results provide some initial insights into the examined interrelationships, all hypotheses are formally tested in the following section (i.e., empirical verification of the productivity approach).

5.2.2. Productivity Approach for Complementarity Testing: Stage 2 - Empirical Verification

In order to verify empirically the above results, I use a Tobit model to regress the firm's radical and incremental innovative performance on the four mutually exclusive cases. Since the dependent variables of the study (INNWORLD and INNFIRM) reflect the

percentage of sales from products with different degrees of novelty, they are conditioned on values between 0 and 100. Hence, both variables are left-censored and right-censored. In such cases, standard ordinary least squares regression using censored data will typically result in coefficient estimates that are biased (Tobin, 1958). Following other researchers, the most appropriate method to adjust the coefficient estimates would be a Tobit model (Greene, 2003). Tobit censored regression models assume that the data are normally distributed. In this case, the dependent variables are both highly skewed, and therefore, the underlying assumption of normality is violated. To solve this problem, I performed a logit transformation of the data. This treatment is consistent with prior studies (e.g. Laursen and Salter, 2006; Leiponen and Helfat, 2010). Two models have been estimated for each hypothesis. One model for radical innovative performance (INNWORLD) and one model for incremental innovative performance (INNFIRM), as the dependent variable. More specifically, the following models have been estimated:

Complementary effect of external search breadth and organizational innovation:

$\text{INNWORLD}_i = \beta_{00}\text{No external search breadth no organizational innovation}_i + \beta_{10}\text{Only external search breadth}_i + \beta_{01}\text{Only organizational innovation}_i + \beta_{11}\text{external search breadth \& organizational innovation}_i + \gamma\mathbf{X}i + \varepsilon i$

$\text{INNFIRM}_i = \beta_{00}\text{No external search breadth no organizational innovation}_i + \beta_{10}\text{Only external search breadth}_i + \beta_{01}\text{Only organizational innovation}_i + \beta_{11}\text{external search breadth \& organizational innovation}_i + \gamma\mathbf{X}i + \varepsilon i$

Complementary effect of external search depth and organizational innovation:

$INNWORLD_i = \beta_{00}$No external search depth no organizational innovation$_i + \beta_{10}$Only external search depth$_i + \beta_{01}$Only organizational innovation$_i + \beta_{11}$external search depth &organizational innovation$_i + \gamma \mathbf{X}i + \varepsilon i$

$INNFIRM_i = \beta_{00}$No external search depth no organizational innovation$_i + \beta_{10}$Only external search depth$_i + \beta_{01}$Only organizational innovation$_i + \beta_{11}$external search depth &organizational innovation$_i + \gamma \mathbf{X}i + \varepsilon i$

where **X** is a vector of control variables, INNWORLD is the radical innovative performance of the firm, INNFIRM is the incremental innovative performance of the firm, and ε is the error term. If external search breadth and organizational innovation, as well as if external search depth and organizational innovation are complementary activities, the parameter estimate of the strategy that combines external search breadth and organizational innovation and external search depth and organizational innovation, respectively, are expected to be positive and significant. In addition, the following inequality should hold:

$$\beta_{11} - \beta_{10} \geq \beta_{01} - \beta_{00} \qquad (1)$$

Following the suggestions of Davidson and MacKinnon (1993), I control for potential heteroscedacity by running the Tobit regression with robust errors. To run the analysis, I use the firms that do none of these activities as base cases, leaving them out from the respective models. Table 5.2 reports the results of the Tobit regression models.

With regards to the firm's radical innovative performance, model 5.2b suggests that the parameter estimates of "breadth & organizational innovation" and "depth &

organizational innovation" have a positive and highly significant effect on radical innovative performance. Further, the parameter estimate of "only organizational innovation" is not significantly different from zero. In addition, while the parameter estimate of "only breadth" is positive and significant, it is much smaller than the parameter coefficient of "breadth & organizational innovation". The one-sided Wald test for the differences of the parameters presented in inequality (1) suggests that the existence of complementarity is accepted at the 1% level of significance. These results indicate that breadth and organizational innovation are complementary activities for increasing the firm's radical innovative performance. Model 5.2c suggests that the parameter estimates of "only depth" and "only organizational innovation" are marginally and highly significant, respectively. The results also indicate that the inequality (1) is not supported, since the one-sided Wald test does not reject the null of equality. Therefore, according to these results, depth and organizational innovation are not complementary activities for the firm's radical innovative performance.

With regards to the firm's incremental innovative performance, Model 5.2e and model 5.2f suggest that the parameter coefficients of "only breadth" and "only organizational innovation", as well as "only depth" and "only organizational innovation" are both positive and significant. The inequality (1) is not supported and the one-sided Wald test does not reject the null of equality for both cases. Thus, results indicate that breadth and organizational innovation have no complementary effect on the firm's incremental innovative performance. Further, according to these results, depth and organizational innovation have no complementary effect on the firm's incremental innovative performance.

In the light of the collective results presented in the previous two paragraphs, H1 is partially confirmed, while H2a is fully confirmed and H2b and H4 are rejected.

Finally, there is evidence in support of H3 that the complementary effect of external breadth and organizational innovation is stronger for the firm's radical than for the firm's incremental innovative performance. More specifically, the Wald test in Model 5.2b shows that the null hypothesis of equality for the radical innovative performance is rejected (i.e., presence of complementarity). On the contrary, model 5.2e shows that Wald test of equality for the incremental innovative performance is supported (i.e., absence of complementarity).

Table 5.2. Results of innovative performance regressions

	(5.2a) INNWORLD	(5.2b) INNWORLD	(5.2c) INNWORLD	(5.2d) INNFIRM	(5.2e) INNFIRM	(5.2f) INNFIRM
EMP	0.081***	0.043*	0.041*	0.001	-0.018	-0.020
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
RDINT	-0.001	-0.001	-0.001	-0.016*	-0.017*	-0.016*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
GEOMARKET	0.220***	0.200***	0.209***	0.043*	0.023	0.037
	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
SUPPORT	0.577***	0.490***	0.545***	0.186***	0.095***	0.163***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
USER	0.551***	0.399***	0.446***	0.481***	0.323***	0.383***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)
COLLAB	0.688***	0.551***	0.598***	0.295***	0.182***	0.239***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
ONLY BREADTH		0.886***			1.280***	
		(0.07)			(0.05)	
ONLY ORGANIZATIONAL INNOVATION		0.088			0.249**	
		(0.12)			(0.09)	
BREADTH & ORGANIZATIONAL INNOVATION		1.446***			1.509***	
		(0.07)			(0.05)	

ONLY DEPTH			0.110*			0.138***
			(0.04)			(0.03)
ONLY ORGANIZATIONAL INNOVATION			0.624***			0.341***
			(0.04)			(0.03)
DEPTH & ORGANIZATIONAL INNOVATION			0.673***			0.423***
			(0.04)			(0.03)
_CONS	-2.286***	-3.257***	-2.562***	-0.714***	-1.902***	-0.872***
	(0.11)	(0.12)	(0.11)	(0.08)	(0.10)	(0.08)
COMPLEMENTARITY TEST:		ACCEPTED			REJECTED	
BREADTH & ORGANIZATIONAL INNOVATION - ONLY BREADTH > ONLY ORGANIZATIONAL INNOVATION – NO BREADTH & ORGANIZATIONAL INNOVATION		*F(1, 46747) = 16.74* *Prob > F = 0.0000*			*F(1, 46747)= 0.02* *Prob > F = 0.8852*	
COMPLEMENTARITY TEST:			REJECTED			REJECTED
DEPTH & ORGANIZATIONAL INNOVATION - ONLY DEPTH > ONLY ORGANIZATIONAL INNOVATION – NO DEPTH & ORGANIZATIONAL INNOVATION			*F(1, 46747) = 1.09* *Prob > F = 0.2960*			*F(1, 46747) = 2.04* *Prob > F = 0.1529*
INDUSTRY DUMMIES	YES	YES	YES	YES	YES	YES
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
NO. OF OBSERVATIONS	46862	46862	46862	46862	46862	46862
NO. OF LEFT-CENSORED OBS	27518	27518	27518	20245	20245	20245

NO. OF RIGHT-CENSORED OBS	613	613	613	1575	1575	1575
NO. OF UNCENSORED	18730	18730	18730	25041	25041	25041
LOG LIKELIHOOD	-58702.262	-58196.271	-58413.377	-69277.326	-68573.169	-69136.186
PSEUDO R2	0.048	0.056	0.052	0.032	0.042	0.034

Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

5.3. Robustness Tests

To test whether the results are driven by a number of alternative explanations, I run a number of robustness tests. Chesbrough (2012) argued that internal R&D is critical for the success of external search, since it creates absorptive capacity (Cohen and Levinthan, 1990). Further, internal R&D enables companies to develop new organizational structures that streamline the innovation process (Dahlander and Gann, 2010; Henderson and Cockburn, 1996). Due to the importance of internal R&D for the success of both external search and organizational innovation, I test the model on a sub-sample of firms that perform internal R&D activities excluding those firms that do not. Relevant results are presented in table 5.3. Based on the one-sided Wald test, the previous findings are confirmed, however, the hypothesis that breadth and organizational innovation have a complementary effect on the firm's radical innovative performance is not supported this time (H1, H2b, and H4 are rejected, while H2a is confirmed). Further, H3 is rejected since the one-sided Wald test does not reject the null of inequality (1) for both radical (see model 5.3b) and incremental innovative performance (see model 5.3e). These results are probably due the fact that the success of external search and the development of new organizational structures do not rely solely on the existence of internal R&D activities, but also on the intensity of these activities.

Table 5.3. Results of innovative performance regressions for firms that perform internal R&D activities

	(5.3a) INNWORLD	(5.3b) INNWORLD	(5.3c) INNWORLD	(5.3d) INNFIRM	(5.3e) INNFIRM	(5.3f) INNFIRM
EMP	-0.49*	-0.072***	0.075***	-0.002	-0.020	-0.021
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
GEOMARKET	0.141***	0.142***	0.140***	-0.045	-0.045	-0.046
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
SUPPORT	0.184***	0.192***	0.193***	-0.094***	-0.088***	-0.090***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
USER	0.271***	0.220***	0.251***	0.173***	0.139***	0.130***
	(0.03)	(0.03)	(0.04)	(0.02)	(0.02)	(0.03)
COLLAB	0.337***	0.269***	0.559***	0.132***	0.086***	0.096***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
ONLY BREADTH		0.981***			0.590***	
		(0.17)			(0.14)	
ONLY ORGANIZATIONAL INNOVATION		0.309			0.348	
		(0.28)			(0.022)	
BREADTH & ORGANIZATIONAL INNOVATION		1.360***			0.882***	
		(0.17)			(0.04)	
ONLY DEPTH			-0.050			0.038
			(0.06)			(0.05)
ONLY ORGANIZATIONAL INNOVATION			0.370***			0.306***

			(0.05)			(0.04)
DEPTH & ORGANIZATIONAL INNOVATION			0.371***			0.341***
			(0.05)			(0.04)
COMPLEMENTARITY TEST:		**REJECTED**			**REJECTED**	
BREADTH & ORGANIZATIONAL INNOVATION - ONLY BREADTH > ONLY ORGANIZATIONAL INNOVATION – NO BREADTH & ORGANIZATIONAL INNOVATION		*F(1, 19545) = 0.06* *Prob > F = 0.8030*			*F(1, 19545) = 0.06* *Prob > F = 0.8031*	
COMPLEMENTARITY TEST:			**REJECT**			**REJECTED**
DEPTH & ORGANIZATIONAL INNOVATION - ONLY DEPTH > ONLY ORGANIZATIONAL INNOVATION – NO DEPTH & ORGANIZATIONAL INNOVATION			*F(1, 19545) = 0.66* *Prob > F = 0.4171*			*F(1, 19545) = 0.00* *Prob > F = 0.9649*
INDUSTRY DUMMIES	YES	YES	YES	YES	YES	YES
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
NO. OF OBSERVATIONS	19575	19575	19575	19575	19575	19575
NO. OF LEFT-CENSORED OBS	8495	8495	8495	6364	6364	6364
NO. OF RIGHT-CENSORED OBS	325	325	325	466	466	466
NO. OF UNCENSORED	10757	10757	10757	12757	12757	12757
LOG LIKELIHOOD	-29016.195	-28888.155	-28930.549	-30442.518	-30347.434	-30368.515
PSEUDO R2	0.019	0.024	0.022	0.015	0.018	0.017

Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

Taking into consideration the importance of R&D intensity, I run the same Tobit regression models on the observations with the highest R&D intensity. According to the results presented in table 5.4, the parameter estimates of “breadth & organizational innovation” and “depth & organizational innovation” have a positive and significant effect on radical as well as incremental innovative performance. The parameter estimate of “only organizational innovation” in model 5.4a is not significantly different from zero, while the parameter estimate of “only breadth” is positive and significant, but smaller than the parameter coefficient of “breadth & organizational innovation”. Furthermore, the one-sided Wald test shows that the existence of complementarity is accepted at the 1% level of significance. These results confirm the main finding that breadth and organizational innovation are complementary activities for increasing the firm’s radical innovative performance.

In addition, the parameter estimates of “only depth” and “only organizational innovation” in model 5.4b are marginally significant, while the parameter coefficient of “depth & organizational innovation” is both higher and significant. At the same time, the one-sided Wald test indicates that the existence of complementarity is accepted at the 1% level of significance. With respect to the complementary relationship between breadth and organizational innovation on the firm’s incremental innovative performance, the results in model 5.4c show that the parameter coefficient of “only organizational innovation” is not significantly different from zero, while the parameter coefficient of “only breadth” is significant, but smaller that the parameter coefficient of “breadth & organizational innovation”. The Wald test also indicates, once again, that the existence of complementarity is accepted at the 1% level of significance. These results, as opposed to the main analysis, indicate that the complementary relationship between depth and organizational innovation on the firm’s

radical innovative performance, as well as that the complementary relationship between breadth and organizational innovation on the firm's incremental innovative performance are supported for those firms that have high R&D intensity. However, in model 5.4d, the results remain qualitatively the same as in the main analysis and they indicate that the hypothesis that depth and organizational innovation have a complementary effect on the firm's incremental innovative performance, is not supported.

Further, the coefficient of "breadth & organizational innovation" in model 5.4a is higher than the respective coefficient in model 5.4c, showing that the complementary effect of external breadth and organizational innovation is greater for the firm's radical than for the firm's incremental innovative performance. Therefore, with regards to H3, the results remain qualitatively the same as in the main analysis.

Table 5.4. Results of innovative performance regressions for firms that have the higher R&D intensity

	(5.4a) INNWORLD	(5.4b) INNWORLD	(5.4c) INNFIRM	(4.4d) INNFIRM
EMP	-0.078***	-0.062	-0.182***	-0.169
	(0.02)	(0.15)	(0.02)	(0.17)
GEOMARKET	0.149***	0.168	-0.056***	-0.038
	(0.02)	(0.09)	(0.02)	(0.09)
SUPPORT	0.395***	0.382**	0.120***	0.113
	(0.03)	(0.13)	(0.03)	(0.12)
USER	0.117***	- 0.024	0.110***	0.058
	(0.03)	(0.15)	(0.02)	(0.16)
COLLAB	0.146***	0.176	0.115***	0.145
	(0.03)	(0.15)	(0.03)	(0.15)
ONLY BREADTH	9.020***		7.596***	
	(0.2)		(0.02)	
ONLY ORGANIZATIONAL INNOVATION	0.000		0.000	
	(0.00)		(0.00)	
BREADTH & ORGANIZATIONAL INNOVATION	9.321***		8.312***	
	(0.3)		(0.03)	
ONLY DEPTH		0.676*		0.479
		(0.32)		(0.32)
ONLY ORGANIZATIONAL INNOVATION		0.617*		1.014***

		(0.26)		(0.26)
DEPTH & ORGANIZATIONAL INNOVATION		0.735**		0.998***
		(0.26)		(0.26)
_CONS	-10.846***	-2.232**	-6.630***	0.637
	(0.04)	(0.79)	(0.04)	(0.45)
COMPLEMENTARITY TEST:	ACCEPTED		ACCEPTED	
BREADTH & ORGANIZATIONAL INNOVATION - ONLY BREADTH > ONLY ORGANIZATIONAL INNOVATION – NO BREADTH & ORGANIZATIONAL INNOVATION	F(1, 683) = 206.51 Prob > F = 0.0000		*F(1, 683) = 1148.71* *Prob > F = 0.0000*	
COMPLEMENTARITY TEST:		ACCEPTED		REJECTED
DEPTH & ORGANIZATIONAL INNOVATION - ONLY DEPTH > ONLY ORGANIZATIONAL INNOVATION – NO DEPTH & ORGANIZATIONAL INNOVATION		F(1, 658) = 2.91 Prob > F = 0.0884		*F(1, 658) = 2.42* *Prob > F = 0.1204*
INDUSTRY DUMMIES	YES	YES	YES	YES
COUNTRY DUMMIES	YES	YES	YES	YES
NO. OF OBSERVATIONS	681	681	681	681
NO. OF LEFT-CENSORED OBS	188	188	185	185
NO. OF RIGHT-CENSORED OBS	8	8	8	8
NO. OF UNCENSORED	485	485	488	488
LOG LIKELIHOOD	-999.139	-1000.659	-982.138	-982.886
PSEUDO R2	0.051	0.050	0.083	0.082

Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

5.4. Endogeneity Test

Another possible concern is whether there is reverse causality between external search and organizational innovation. To successfully remove the problem of unobserved reverse causality, we require drivers of the adoption decision of the innovation activities that do not affect the innovative performance of the firm directly and a good explanatory power for the adoption decision associated with these activities. Maddala (1983) suggests that if the prediction of one of the adoption decisions is poor, the noise will contaminate the estimation of the innovation strategy coefficients. To eliminate this possibility, we find a theoretical driver that might possibly affect the adoption of organizational innovation when firms engage in external search. If after including this variable in the model the innovation strategy remains significant in explaining differences in innovative performance, the effect can be attributed to intrinsic complementarity between external search and organizational innovation (Maddala, 1983).

From a theoretical point of view, it has been reported that when firms having ties with a variety of knowledge sources fail to compete successfully, they may introduce new organizational practices to cope with failure (e.g., Udagawa, 1995; Mol and Birkinshaw, 2009). Therefore, the lack of complementarity between the innovation strategies obtained from the results in the main analysis may be due to the fact that firms who introduced an organizational innovation were low performing before doing so, and as such, they have introduced an organizational innovation to increase their performance. To mitigate this concern, I control for past performance in the Tobit regression by using the turnover of the first year of the period covered by the data. Albeit, a proper treatment of endogeneity requires longitudinal data, this solution can

help to purify the error terms from possible correlations with the innovation strategies (Cassiman and Valentini, 2015).

Relevant results are presented in table 5.5 and they are qualitatively similar to those in the main analysis, as the Wald test is accepted only for the hypothesis that there is a complementary relationship between breadth and organizational innovation on the firm's radical innovative performance. However, when I run the same analysis by keeping only the observations with the highest R&D intensity, as per table 5.4, interestingly enough, the results (see table 5.6) confirm the hypothesis of complementarity between breadth and organizational innovation for both radical and incremental innovative performance (H1). At the same time, the results support the hypothesis that there is no significant difference in the radical or incremental innovative performance of firms engaging in both external depth and organizational innovation simultaneously and those that do not (H2a). Therefore, H2b and H3 are both rejected. Further, the results also support H3 in that the complementary effect of external breath and organizational innovation is higher for the firm's radical rather than for the firm's incremental innovative performance.

Table 5.5. Results of innovative performance regressions that control for endogeneity

	(5.5a) INNWORLD	(5.5b) INNWORLD	(5.5c) INNFIRM	(5.5d) INNFIRM
EMP	0.036*	0.033	-0.028*	-0.032*
	(0.02)	(0.02)	(0.01)	(0.01)
RDINT	-0.001	-0.001	-0.017*	-0.015*
	(0.01)	(0.01)	(0.01)	(0.01)
GEOMARKET	0.201***	0.209***	0.022	0.036
	(0.03)	(0.03)	(0.02)	(0.02)
SUPPORT	0.491***	0.544***	0.095***	0.160***
	(0.03)	(0.03)	(0.02)	(0.02)
USER	0.402***	0.449***	0.324***	0.381***
	(0.03)	(0.03)	(0.02)	(0.03)
COLLAB	0.546***	0.592***	0.180***	0.235***
	(0.03)	(0.03)	(0.02)	(0.03)
TURNOVER 2006	0.000***	0.000***	0.000***	0.000***
	(0.00)	(0.00)	(0.00)	(0.00)
ONLY BREADTH	0.848***		1.239***	
	(0.27)		(006)	

ONLY ORGANIZATIONAL INNOVATION	0.087		0.254**	
	(0.12)		(0.09)	
BREADTH & ORGANIZATIONAL INNOVATION	1.412***		1.469***	
	(0.7)		(0.05)	
ONLY DEPTH		0.098*		0.125***
		(0.04)		(0.03)
ONLY ORGANIZATIONAL INNOVATION		0.621***		0.331***
		(0.04)		(0.03)
DEPTH & ORGANIZATIONAL INNOVATION		0.667***		0.414***
		(0.04)		(0.03)
_CONS	-3.203***	-2.532***	-1.849***	-0.842***
	(0.12)	(0.11)	(0.10)	(0.08)
COMPLEMENTARITY TEST:	ACCEPTED		REJECTED	
BREADTH & ORGANIZATIONAL INNOVATION - ONLY BREADTH > ONLY ORGANIZATIONAL INNOVATION – NO BREADTH & ORGANIZATIONAL INNOVATION	F(1, 46269) = 15.84 Prob > F = 0.0001		F(1,46269) = 0.07 Prob > F = 0.7985	
COMPLEMENTARITY TEST:		REJECTED		REJECTED
DEPTH & ORGANIZATIONAL INNOVATION - ONLY DEPTH > ONLY ORGANIZATIONAL INNOVATION – NO DEPTH & ORGANIZATIONAL INNOVATION		F(1, 46269) = 1.09 Prob > F = 0.2971		F(1, 46269) = 1.13 Prob > F = 0.2873

INDUSTRY DUMMIES	YES	YES	YES	YES
COUNTRY DUMMIES	YES	YES	YES	YES
NO. OF OBSERVATIONS	46862	46862	46862	46862
NO. OF LEFT-CENSORED OBS	46862	46862	20245	20245
NO. OF RIGHT-CENSORED OBS	27518	27518	1575	1575
NO. OF UNCENSORED	613	613	25041	25041
LOG LIKELIHOOD	-57589.663	-57790.017	-67849.251	-68365.535
PSEUDO R2	0.055	0.052	0.041	0.033

Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 5.6. Results of innovative performance regressions that control for endogeneity for firms that have the higher R&D intensity

	(5.6a) INNWORLD	(5.5b) INNWORLD	(5.6c) INNFIRM	(5.6d) INNFIRM
EMP	-0.105***	-0.090	-0.162***	-0.154
	(0.02)	(0.15)	(0.02)	(0.17)
GEOMARKET	0.183***	0.198*	-0.061***	-0.044
	(0.02)	(0.09)	(0.02)	(0.10)

SUPPORT	0.331***	0.324*	0.135***	0.130
	(0.03)	(0.13)	(0.03)	(0.13)
USER	0.084**	-0.020	0.110***	0.059
	(0.03)	(0.15)	(0.03)	(0.16)
COLLAB	0.165***	0.193	0.123***	0.143
	(0.03)	(0.15)	(0.03)	(0.15)
TURNOVER 2006	0.000***	0.000	- 0.000*	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
ONLY BREADTH	8.947***		7.576***	
	(0.2)		(002)	
ONLY ORGANIZATIONAL INNOVATION	0.000		0.000	
	(0.00)		(0.00)	
BREADTH & ORGANIZATIONAL INNOVATION	9.226***		8.401***	
	(0.3)		(0.03)	
ONLY DEPTH		0.552		0.469
		(0.33)		(0.35)
ONLY ORGANIZATIONAL INNOVATION		0.547*		1.108***
		(0.26)		(0.28)
DEPTH & ORGANIZATIONAL INNOVATION		0.632*		1.104***
		(0.26)		(0.28)
_CONS	-10.652***	-2.050*	-6.781***	0.489
	(0.04)	(0.81)	(0.04)	(0.47)
COMPLEMENTARITY TEST:	ACCEPTED		ACCEPTED	
BREADTH & ORGANIZATIONAL INNOVATION - ONLY BREADTH >				

ONLY ORGANIZATIONAL INNOVATION – NO BREADTH & ORGANIZATIONAL INNOVATION	F(1, 683) = 174.24 Prob > F = 0.0000		*F(1, 683) = 1411.06* *Prob > F = 0.0000*	
COMPLEMENTARITY TEST:		**REJECTED**		**REJECTED**
DEPTH & ORGANIZATIONAL INNOVATION - ONLY DEPTH > ONLY ORGANIZATIONAL INNOVATION – NO DEPTH & ORGANIZATIONAL INNOVATION		F(1, 658) = 1.96 Prob > F = 0.1615		*F(1, 658) = 1.88* *Prob > F = 0.1706*
INDUSTRY DUMMIES	YES	YES	YES	YES
COUNTRY DUMMIES	YES	YES	YES	YES
NO. OF OBSERVATIONS	681	681	681	681
NO. OF LEFT-CENSORED OBS	188	188	185	185
NO. OF RIGHT-CENSORED OBS	8	8	8	8
NO. OF UNCENSORED	485	485	488	488
LOG LIKELIHOOD	-999.139	-1000.659	-982.138	-982.886
PSEUDO R2	0.051	0.050	0.083	0.082

Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

As a next step for the endogeneity test, I examine whether external search and organizational innovation are influenced by the firm's past low performance. If these innovation strategies have an endogenous nature then past low performance should influence their adoption. To investigate this possibility, I run two ordered probit regression models with external search breadth and external search depth respectively, as dependent variables, as well as a bivariate probit regression with organizational innovation as a dependent variable. I control also for the size of the use of lead users in innovation (USER), engagement in collaboration activities (COLLAB), number of employees (EMP), and external financial support (SUPPORT), as well as industry and country effects.

The results are presented in Table 5.7. The coefficient of the "turnover" is not significantly different from zero in all cases. This indicates that turnover does not have any significant influence on both external search strategies and organizational innovation and it is a good indication that reverse causality is not an issue here.

Table 5.7. Results of probit regression analysis of Breadth, Depth, and Organizational Innovation

	(5.7a) BREADTH	(5.7b) DEPTH	(5.7c) ORGANIZATIONAL INNOVATION
EMP	0.131***	-0.011	0.158***
	(0.01)	(0.01)	(0.01)
COLLAB	0.496***	0.388***	0.385***
	(0.01)	(0.01)	(0.01)
SUPPORT	0.458***	0.263***	0.107***
	(0.01)	(0.01)	(0.01)
USER	0.084**	-0.020	0.110***
	(0.03)	(0.15)	(0.03)
TURNOVER 2006	0.000***	0.000*	0.000***
	(0.00)5.8	(0.00)	(0.00)
-CONS	-1.067***	0.499***	0.231***
	(0.02)	(0.02)	(0.02)
INDUSTRY DUMMIES	YES	YES	YES
COUNTRY DUMMIES	YES	YES	YES
NO. OF OBSERVATIONS	46862	46862	46862
LOG LIKELIHOOD	-99073.565	-49590.359	-49590.359
PSEUDO R2	0.048	0.177	0.049

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

To further confirm the results of the previous analysis, moderated Tobit regression analyses were conducted to check the significance of the interaction effects of external search breadth and organizational innovation as well as the significance of the interaction effects of external search depth and organizational innovation on the radical and incremental innovative performance. Table 5.8 presents the results of this analysis. In models 5.8c and 5.8f, the interaction terms of breadth and organizational innovation are both positive and highly significant, indicating that breadth and organizational innovation have a complementary effect on the firm's radical as well as on the firm's incremental innovative performance (H1). On the opposite direction, the interaction terms of depth and organizational innovation are both insignificant, providing evidence that depth and organizational innovation do not have a complementary effect on the firm's radical as well as on the firm's incremental innovative performance (H2a). Last, the parameter of the interaction term of the external search breadth and organizational innovation is higher for INNWORLD than for INNFIRM (see models 5.8c and 5.8f), indicating that the complementary effect of external search breadth and organizational innovation is greater for the firm's radical than for the firm's incremental innovative performance (H3). Taken all together, these results indicate that H1, H2a, and H3 are confirmed, while H2b and H4 are rejected.

Table 5.8. Results of Togit regression analysis: interaction effects

	(5.8a) INNWORLD	(5.8b) INNWORLD	(5.8c) INNWORLD	(5.8d) INNFIRM	(5.8e) INNFIRM	(5.8.f) INNFIRM
EMP	0.991***	0.842***	0.789***	0.832**	0.793**	0.787**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
RDINT	-0.024	-0.025	-0.025	-0.039	-0.042	-0.052
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
GEOMARKET	0.497***	0.453***	0.425***	0.052**	0.047**	0.038**
	(0.06)	(0.06)	(0.06)	(0.02)	(0.02)	(0.02)
SUPPORT	1.184***	0.871***	0.858***	0.025***	0.021***	0.018***
	(0.07)	(0.07)	(0.07)	(0.04)	(0.04)	(0.04)
USER	1.309***	0.874***	0.840***	0.542***	0.521	0.503
	(0.06)	(0.08)	(0.06)	(0.02)	(0.03)	(0.02)
COLLAB	2.236***	1.733***	1.579***	0.623***	0.612***	0.579***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)
BREADTH		1.001***	0.934***		0.897***	0.743***
		(0.04)	(0.04)		(0.05)	(0.05)
DEPTH		0.274*	0.278*		0.128***	0.102***
		(0.04)	(0.06)		(0.06)	(0.06)
ORG		0.634**	0.528**		0.253***	0.187***
		(0.04)	(0.04)		(0.04)	(0.04)
BREADT*ORG			0.485***			0.365***
			(0.05)			(0.05)
DEPTH*ORG			0.127			0.159
			(0.01)			(0.01)
INDUSTRY DUMMIES	YES	YES	YES	YES	YES	YES
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
NO. OF OBS	46862	46862	46862	46862	46862	46862
NO. OF LEFT-CENSORED OBS	27518	27518	27518	20245	20245	20245
NO. OF RIGHT-CENSORED OBS	613	613	613	1575	1575	1575
LOG LIKELIHOOD	-84486.688	-83631.552	-83460.700	-90243.613	-83524.941	-80419.627
CHI-SQUARE	5366.447	7076.720	7418.424	5798.365	6749.876	6985.784
PSEUDO R2	0.031	0.041	0.043	0.037	0.043	0.048

5.5. Investigation of the Complementary Relationship of External Search and Organizational Innovation across different Levels of Breadth and Depth

Recall that the results in table 5.6 indicate that there is a complementary effect between breadth and organizational innovation on the firm's radical and incremental innovative performance. On the opposite direction, the complementary effect between depth and organizational innovation is not supported. In order to gain a deeper understanding of these relationships, I investigate the same effects across different levels of external search breadth and depth.

To enable easy comparisons, I capture the complementary effects of external search strategies and organizational innovation for three subgroups of the sample. The first subgroup includes firms that draw knowledge from either 0 or 1-3 external sources of information (low levels of information search). The second subgroup includes firms that draw knowledge from either 0 or 4-6 external sources of information (medium levels of information search), while the third subgroup includes firms that draw knowledge from either 0 or 7-9 external sources of information (high levels of information search). The aim of this analysis is to examine the effects of the coexistence of external search and organizational innovation on the innovative performance of the firm for "low", "medium", and "high" levels of external breadth and depth, respectively. To achieve that, I estimate a separate model for each of the three subgroups and set firms that draw knowledge from "0 sources of information" as reference category in each of these models. This particular analysis was replicated both for radical and incremental innovative performance. Note, that I follow this particular analytical strategy, because the productivity approach for testing complementarities requires that inequality (1) should be confirmed. This necessitates comparisons between observations that engage in a certain activity (in this case, external search)

and observations that do not. Tables 5.9 and 5.10 present relevant results, while table 5.11 summarizes the main findings of this analysis.

The results reveal that the complementary effect of external search breadth and organizational innovation on the firm's radical innovative performance is supported across all three levels of external breadth, while a similar effect on the firm's incremental innovative performance is supported only for "high" levels of external breadth. Further, the complementary effect of external depth and organizational innovation on the firm's incremental innovative performance is rejected across all three levels of external depth. Interestingly enough, the complementary effect of external depth and organizational innovation on the firm's radical innovative performance is supported only for "high" levels of external depth.

Table 5.9. Results for innovative performance regressions across different levels of external breadth

	(5.9a) INNWORLD (Low search)	(5.9b) INNWORLD (Medium search)	(5.9c) INNWORLD (High search)	(5.9d) INNFIRM (Low search)	(5.9e) INNFIRM (Medium search)	(5.9f) INNFIRM (High search)
EMP	0.160**	0.014	0.037	-0.076	-0.031	0.137**
	(0.05)	(0.03)	(0.02)	(0.04)	(0.02)	(0.05)
RDINT	0.139	-0.002	-0.005	-0.079	-0.013	-0.039***
	(0.12)	(0.01)	(0.01)	(0.08)	(0.01)	(0.00)
GEOMARKET	0.286***	0.181***	0.199***	0.144**	0.098**	0.233***
	(0.07)	(0.04)	(0.03)	(0.05)	(0.03)	(0.05)
SUPPORT	0.616***	0.292***	0.376***	0.073	-0.006	-1.379***
	(0.09)	(0.05)	(0.03)	(0.07)	(0.04)	(0.08)
USER	0.796***	0.333***	0.266***	0.569***	0.277***	-0.031
	(0.11)	(0.05)	(0.03)	(0.08)	(0.04)	(0.07)
COLLAB	0.453***	0.333***	0.524***	-0.001	0.082*	-0.058
	(0.09)	(0.05)	(0.03)	(0.07)	(0.04)	(0.08)
ONLY BREADTH	0.149	0.114	1.166***	0.663***	1.361***	2.528***
	(0.11)	(0.08)	(0.07)	(0.08)	(0.06)	(0.06)
ONLY ORGANIZATIONAL INNOVATION	0.047	0.114	0.066	0.278*	0.239**	-11.310
	(0.15)	(0.12)	(0.11)	(0.11)	(0.09)	(0.01)

BREADTH & ORGANIZATIONAL INNOVATION	0.656***	1.595***	1.613***	0.792***	1.520***	3.404***
	(0.11)	(0.08)	(0.07)	(0.08)	(0.06)	(0.08)
COMPLEMENTARITY TEST:	***ACCEPTED***	***ACCEPTED***	***ACCEPTED***	***REJECTED***	***REJECTED***	***ACCEPTED***
BREADTH & ORGANIZATIONAL INNOVATION - ONLY BREADTH > ONLY ORGANIZATIONAL INNOVATION – NO BREADTH & ORGANIZATIONAL INNOVATION	*F(1, 14118) = 7.51*	*F(1, 18955) = 13.29*	*F(1, 22848) = 11.23*	*F(1, 14118) = 1.49*	*F(1, 18955)= 0.69*	*F(1, 22848) = 46130.26*
	Prob > F = 0.0061	*Prob > F = 0.0003*	*Prob > F = 0.0008*	*Prob > F = 0.2224*	*Prob > F = 0.4056*	*Prob > F = 0.00*
CONS	-10.327***	9.031***	4.526***	0.432*	0.834*	4.524**
	(0.04)	(0.04)	(0.09)	(0.75)	(0.62)	(0.09)
INDUSTRY DUMMIES	YES	YES	YES	YES	YES	YES
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
NO. OF OBSERVATIONS	14118	18955	19545	14118	18955	19545
NO. OF LEFT-CENSORED OBS	10744	11996	12614	8469	8895	9881
NO. OF RIGHT-CENSORED OBS	118	228	286	618	619	642
NO. OF UNCENSORED	5063	6763	9980	5063	9473	12357
LOG LIKELIHOOD	-28972.997	-21784.998	-28972.477	-17089.428	-26470.495	-30368.515
PSEUDO R2	0.078	0.070	0.078	0.071	0.065	0.017

Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Table 5.10. Results for innovative performance regressions across different levels of external depth

	(5.10a) INNWORLD (Low search)	(5.10b) INNWORLD (Medium search)	(5.10c) INNWORLD (High search)	(5.10d) INNFIRM (Low search)	(5.10e) INNFIRM (Medium search)	(5.10f) INNFIRM (High search)
EMP	0.043*	0.122***	0.122***	-0.019	-0.013	-0.021
	(0.02)	(0.03)	(0.03)	(0.01)	(0.02)	(0.02)
RDINT	0.004	-0.001	0.007	-0.009	-0.014*	-0.015
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
GEOMARKET	0.216***	0.211***	0.220***	0.040*	0.053	0.064*
	(0.03)	(0.04)	(0.04)	(0.02)	(0.03)	(0.03)
SUPPORT	0.542***	0.641***	0.657***	0.174***	0.210***	0.197***
	(0.03)	(0.05)	(0.05)	(0.02)	(0.04)	(0.04)
USER	0.446***	-0.048	2.175	0.439***	-0.015	-0.345
	(0.03)	(0.20)	(1.50)	(0.03)	(0.22)	(0.71)
COLLAB	0.593***	0.717***	0.723***	0.247***	0.317***	0.339***
	(0.03)	(0.04)	(0.05)	(0.02)	(0.04)	(0.04)
ONLY DEPTH	0.108*	0.975***	4.117	0.140***	-0.459	-0.778
	(0.04)	(0.24)	(1.62)	(0.03)	(0.25)	(0.74)
ONLY ORGANIZATIONAL INNOVATION	0.625***	0.603***	0.606***	0.339***	0.336***	0.336***
	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)

DEPTH & ORGANIZATIONAL INNOVATION	0.651***	1.757***	1.953***	0.427***	-0.121	-0.302
	(0.04)	(0.19)	(1.48)	(0.03)	(0.21)	(0.70)
COMPLEMENTARITY TEST:	***REJECTED***	***REJECTED***	***ACCEPTED***	***REJECTED***	***REJECTED***	***REJECTED***
DEPTH & ORGANIZATIONAL INNOVATION - ONLY DEPTH > ONLY ORGANIZATIONAL INNOVATION – NO DEPTH & ORGANIZATIONAL INNOVATION	*F(1, 45792) = 2.60* *Prob > F = 0.1070*	*F(1, 45792) = 0.84* *Prob > F = 0.3590*	*F(1, 23093) = 4.76* *Prob > F = 0.0291*	*F(1, 45792) = 1.85* *Prob > F = 0.1742*	*F(1, 23748) = 0.00* *Prob > F = 0.9937*	*F(1, 23093) = 0.08* *Prob > F = 0.7788*
CONS	-10.212***	-0.262***	5.731***	0.562*	0.982*	0.436**
	(0.04)	(0.63)	(0.07)	(0.81)	(0.67)	(0.67)
INDUSTRY DUMMIES	YES	YES	YES	YES	YES	YES
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
NO. OF OBSERVATIONS	45792	45792	23093	45792	18955	23093
NO. OF LEFT-CENSORED OBS	27073	23748	15001	19657	23748	11417
NO. OF RIGHT-CENSORED OBS	559	308	270	1532	919	906
NO. OF UNCENSORED	18192	8302	7854	24635	11116	10802
LOG LIKELIHOOD	-56855.701	-27180.482	-26030.687	-67598.047	-33270.037	-32283.367
PSEUDO R2	0.052	0.065	0.062	0.035	0.042	0.044

Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Table 5.11. Summary of the results of the innovative performance regressions across different levels of external search

Level of External Search	Radical Innovative Performance	Incremental Innovative Performance
BREADTH	**COMPLEMENTARITY WITH ORGANIZATIONAL INNOVATION**	**COMPLEMENTARITY WITH ORGANIZATIONAL INNOVATION**
Low	Supported	Rejected
Medium	Supported	Rejected
High	Supported	Supported
DEPTH	**COMPLEMENTARITY WITH ORGANIZATIONAL INNOVATION**	**COMPLEMENTARITY WITH ORGANIZATIONAL INNOVATION**
Low	Rejected	Rejected
Medium	Rejected	Rejected
High	Supported	Rejected

5.6. Summary of the Results

This chapter presented a detailed description of the empirical approaches followed, in an attempt to confirm the presence or absence of complementarity between different external search strategies and organizational innovation. First, I implemented the "productivity" approach, proposed by Cassiman and Veugelers (2006). Next, I ran additional econometric models to test whether the results of the main analysis are robust to alternative specifications. Finally, to gain a deeper insight into the proposed relationships, I investigated the complementary effect of external search and organizational innovation across different levels of breadth and depth.

Table 5.12 summarizes the hypotheses that are supported and the ones rejected based on the different analytical approaches implemented in this chapter.

Table 5.12. Summary of the hypotheses testing based on the different analytical approaches implemented

Hypothesis	Main analysis (presented in Table 5.2)	Innovative performance regressions for firms that perform internal R&D activities (presented in Table 5.3)	Innovative performance regressions for firms that have the higher R&D intensity (presented in Table 5.4)	Innovative performance regressions that control for endogeneity for firms that have the higher R&D intensity (presented in Table 5.6)
H1: Complementarity between breadth and organizational innovation	**Dependent Variable** / INNWORLD: Accepted; INNFIRM: Rejected; **Collectively: Partly Confirmed**	**Dependent Variable** / INNWORLD: Rejected; INNFIRM: Rejected; **Collectively: Rejected**	**Dependent Variable** / INNWORLD: Accepted; INNFIRM: Accepted; **Collectively: Confirmed**	**Dependent Variable** / INNWORLD: Accepted; INNFIRM: Accepted; **Collectively: Confirmed**
H2a: Absence of complementarity between depth and organizational innovation	**Dependent Variable** / INNWORLD: Accepted; INNFIRM: Accepted; **Collectively: Confirmed**	**Dependent Variable** / INNWORLD: Accepted; INNFIRM: Accepted; **Collectively: Confirmed**	**Dependent Variable** / INNWORLD: Rejected; INNFIRM: Accepted; **Collectively: Partly Confirmed**	**Dependent Variable** / INNWORLD: Accepted; INNFIRM: Accepted; **Collectively: Confirmed**
H3: Complementarity between breadth and organizational innovation is higher for radical than incremental	**Confirmed** **H2b and H4: Rejected*	**Rejected** **H2b and H4: Rejected*	**Confirmed** **H2b: Partially Confirmed; H4: Rejected*	**Confirmed** **H2b and H4: Rejected*

Innovative performance regressions across different levels of external search breadth and depth (presented in Tables 5.8 and 5.9, respectively)

Levels of External Search	INNWORLD	INNFIRM
Breadth	**Complementarity with organizational innovation**	**Complementarity with organizational innovation**
Low	Confirmed	Rejected
Medium	Confirmed	Rejected
High	Confirmed	Confirmed
Depth	**Complementarity with organizational innovation**	**Complementarity with organizational innovation**
Low	Rejected	Rejected
Medium	Rejected	Rejected
High	Confirmed	Rejected

Recall that in H1, it has been implicitly assumed that external search breadth and organizational innovation complement each other to incrementally increase both the radical and the incremental innovative performance of the firm.[1] The main analysis reveals that this assumption is partly supported, in the sense that external search breadth and organizational innovation have a complementary effect on the firm's radical, but not on the firm's incremental innovative performance. Consequently, these findings provide also support for the assumption that the complementary effect of external search breadth and organizational innovation is greater for the firm's radical than for the firm's incremental innovative performance (H3). Further, the main analysis reveals that there is no significant difference between the innovative performance of firms that simultaneously engage in both external search depth and organizational innovation, and the innovative performance of firms that do not (H2). In sum, the main analysis reveals that H1 is partly supported, while H2 and H3 are fully supported.

To test whether the above results are driven by a number of alternative explanations, I ran a number of robustness tests. First, acknowledging the importance of internal R&D for the success of external search and organizational innovation, I tested the model on a sub-sample of firms that perform internal R&D activities, excluding those firms that do not. This analysis shows that external search breadth and organizational innovation have no complementary effect on both firm's radical and incremental innovative performance. Therefore, H1 is rejected. In the same vein, the results demonstrate that H3 is rejected, since there is no significant difference between the radical and incremental innovative performance of firms that engage in both

[1] Explicit assumptions on how the joint occurrence of external search breadth and organizational innovation might affect the firm's radical and incremental innovative performance, respectively, have been further developed in H3.

external search breadth and organizational innovation simultaneously. On the contrary, the analysis provides evidence in support of H2.

A possible explanation for the above results is that the success of external search as well as the successful introduction of organizational innovation are primarily contingent upon the intensity of the internal R&D activities of the firm, rather than simply the presence of internal R&D activities (Chauvin and Hirschey, 1993; David, et., al 2001). In order to investigate this possibility, I tested the model on a sub-sample of firms that exhibit the higher R&D intensity. This analysis reveals that both H1 and H3 are fully supported. Nevertheless, it also shows that H2 is partly supported, since external search depth and organizational innovation seem to be complementary activities for the firm's radical, but not for the firm's incremental innovative performance (recall that H2 states that external search depth and organizational innovation have no complementary effect on both radical and incremental innovative performance).

Further, in order to mitigate possible concerns with respect to the presence of reverse causality between external search and organizational innovation, I replicated the above analysis by controlling for past performance. Adding past performance as control variable, enabled me to purify the error terms from possible correlations with the innovation strategies (Cassiman and Valentini, 2015). This analysis provides evidence in support of all three hypotheses (H1; H2; H3).

Last, in order to gain a deeper understanding of the hypothesized relationships, I investigated the complementary effect of external search and organizational innovation on the firm's radical and incremental innovative performance across all levels of external search breadth and depth (low; medium; high). This analysis reveals that H3

is fully supported, while H1 and H2 are partly supported. More specifically, the complementary effect of external search breadth and organizational innovation on the firm's radical innovative performance was supported across all levels of external search. However, the same complementary effect on the firm's incremental performance was proven to exist only for firms that exhibit high levels of external breadth. In the same fashion, the analysis revealed that the complementary effect of external search depth and organizational innovation on the firm's radical innovative performance is likely to exist only for those firms that demonstrate high levels of external depth. Further, the same complementary effect on the firm's incremental innovative performance was proved to be absent across all levels of external depth. Therefore, H1 and H2 were partly supported. Last, the effect of external search breadth and organizational innovation was proven to be stronger for the firm's radical than for the firm's incremental innovative performance. Thus, H3 was fully supported.

From the foregoing discussion of Table 5.11 it can be concluded that the decision to run additional robustness tests was wise, since they provide further insights into the examined relationships. More importantly, the model which controls for endogeneity (last column in table 5.11) provides solid evidence in support of all three hypotheses. Note, that these analyses are based on cross-sectional data, and hence the model which controls for endogeneity seems to be the most robust as it purifies the error terms from possible correlations with the innovation strategies (Cassiman and Valentini, 2015).

All the above results are further discussed in the following chapter. Specifically, I provide explanations that draw upon the literature, while highlighting the contribution of these findings to different lines of research. Finally, the managerial implications and limitations of this work are also outlined.

Chapter 6: Discussion and Conclusion

6.1. Chapter Overview

This chapter aims to critically discuss the findings of the thesis and suggest both theoretical and practical contributions. Accordingly, the present chapter is organized as follows. First, the main findings are discussed and the results of the robustness tests are interpreted in reference to the theory. Next, the theoretical and managerial implications of the study are outlined. Last, the limitations of the study and suggestions for future research are presented.

6.2. Discussion of the Results

Innovation is widely recognised as the driving force of corporate survival and growth (e.g., Danneels, 2002; Dutta et al., 2005). In their effort to innovate, firms have several strategy options available to them. Among others, search for external knowledge, and introduction of new managerial and working routines and practises, broadly known as organizational innovation (Damanpour, 1987), can significantly impact on the firms' ability to innovate. Through search for external knowledge, firms can gain access to novel ideas (Levinthan and March, 1993) and technologies broadly distributed in their network (Laursen and Salter, 2006). It has been argued that incorporating diverse pieces of information into existing knowledge stocks provides an opportunity for firms to solve complicated problems (March, 1996), to come up with new combinations of diverse information (Katila and Ahuja, 2002), and to recombine effectively internal knowledge (Fleming and Sorenson, 2001). Further, repeated use of external knowledge

sources facilitates the development of a good understanding of the concepts involved in the innovation processes (Katila and Ahuja, 2002) and offers access to complementary pieces of knowledge, such as users' technical know-how, and insights into pricing issues and users' behaviours (Tether, 2002). At the same time, the use of new managerial and working routines and practises has been found to enable operational flexibility, significant decreases of operational costs (e.g., Han et al., 1998), better dissemination of knowledge, and more efficient coordination of organizational activities (Koufteros and Marcoulides, 2006).

While few empirical studies (e.g., Foss et al., 2011; Han et al., 1998; Mol and Birkinshaw, 2009; Zobel, 2016) have jointly examined the effect of external search and organizational innovation on the firm's innovative performance, their results are quite inconsistent. For instance, Foss et al. (2011), Han et al. (1998) and Mol and Birkinshaw (2009) have found evidence that organizational innovation moderates the relationship between search for external knowledge and innovative performance. Zobel (2016), on the other hand, provides evidence that organizational innovation mediates the relationship between search for external knowledge and innovative performance. In this study, I contend that these inconsistencies arise because in reality, search for external knowledge and organizational innovation can mutually reinforce each other for the purposes of innovation. For this reason, I made an effort to scrutinize the impact of their complementary effect on the firm's innovative performance.

I began this study by introducing external breadth and external depth as two distinct approaches to search that may induce different types of organizational learning. In distinguishing between these two types of external search and analysing how each affects organizational change, I posited and found that their coexistence with

organizational innovation might exert different effects on the firm's innovative performance. Specifically, I suggested that external search breadth and organizational innovation are complementary activities, in the sense that engaging in one activity incrementally increases the effect of the other. However, I also claimed that this complementary relationship might not be present in the case of external search depth and organizational innovation. Further, I noted that the complementary effect of external breadth and organizational innovation is likely to be stronger for the radical than for the incremental innovative performance of the firm.

Indeed, the findings suggest that the complementary relationship between external search and organizational innovation varies significantly across the two components of external search. While, the econometric analysis provides evidence that external search breadth and organizational innovation are complementary activities for the firm's innovative performance, it also reveals that the complementary relationship between external search depth and organizational innovation is not supported. The results also suggest that these conclusions are valid only for firms that have high R&D investments. The effects of R&D intensity explain innovative performance variations when firms engage simultaneously in different external search strategies and organizational innovation. This perspective builds on previous work suggesting that the ability of the firm to generate genuinely new knowledge, and to assimilate and exploit existing knowledge is conditioned upon its R&D intensity (e.g., Laursen and Salter, 2006). The absorptive capacity of the firm has been traditionally perceived to be a byproduct of the firm's R&D activities (e.g., Cohen and Levinthal, 1990). As the firm intensifies its R&D activities, it becomes better able to use external knowledge (e.g., Allen, 1977; Mowery, 1983). These findings are also consistent with prior arguments relating to the positive contribution of R&D in generating new knowledge,

which may manifest itself in new products or even new improved organizational routines and practises (e.g., Criliches, 1979).[2] Further, these conclusions can be generalizable across different countries. In this study, I used a cross-national European sample, including country effects as instruments (e.g., control variables). Following previous studies (e.g., Cheng et al., 2014; Tuschke et al., 2014), it is assumed that each of these country variables pick up the unobserved country-specific attributes, enabling the respective models to provide generalizable results.

As discussed earlier, the findings suggest that the joint occurrence of external sourcing and organizational innovation might be beneficial for firms that engage in external search breadth, but not for firms that draw deeply from external sources or search channels, at least not unconditionally. These findings are consistent with my theoretical arguments that the complementary effect of the organizational innovation and external search on the firm's innovative performance is contingent upon different objectives and learning effects that the various external search strategies may involve. In particular, the findings provide evidence that external search breadth is associated with the exploratory activities of the firm, and therefore, it entails organic structures that strive to increase the amount of experimentation on external knowledge acquisition and utilization. As He and Wong (2004) argue intense experimentation leads to the introduction of radical organizational and operational improvements. Also, consistent with my arguments, the findings suggest that external search depth relates to the exploitation activities of the firm. As such, it is facilitated by mechanic structures that strive to maintain stability and to increase the efficiency of the firm's current operating and knowledge exchange activities (He and Wong, 2004; March, 1991).

The results reveal that one major challenge that companies deeply embedded within collaborative arrangements may face, is strong internal resistance against organizational changes (Nelson and Winter, 1982). External search depth by definition is a strategy employed by firms that seek to achieve and maintain stability in external sourcing linkages (Laursen and Salter, 2006). Therefore, regardless of whether new organizational routines have been introduced internally, their implementation can be prohibited by strong internal inertia pressures (Hannan and Freeman, 1984, 1989). These insights advance empirical research, as they provide clear indications that in the context of open innovation, successful introduction of organizational innovation does not unconditionally lead to successful implementation.

In order to unravel the phenomenon even further, and delve deeper into the above findings, I investigated the complementary relationship of external sourcing and organizational innovation across different levels of search. This analysis revealed that the complementary effect of external search breadth and organizational innovation on the firm's incremental innovative performance is supported only for high levels of breadth. The results are not surprising, because the effects of an organizational innovation are likely to be even more pronounced for firms that search very broadly as compared to firms that engage in low levels of breadth external sourcing. In fact, as the diversity of the external channels of knowledge with which a firm interacts increases, the likelihood of the prevailing organizational practises to become obsolete increases too. Hence, for firms that search very broadly is even more imperative to change organizational routines that no longer yield value, as compared to firms that follow a more preservative, in terms of magnitude, external search breadth strategy (Teece, 2007).

While searching broadly, on the one hand, increases the need for organizational innovation, it also fosters, on the other hand, the ability of the firm to implement an organizational innovation. In fact, relative to those firms who are less active in external search breadth, firms that search broadly are more likely to gain access to creative insights into organizational practices and routines successfully used in other settings (Mol and Julian Birkinshaw, 2009). These creative insights can help firms to come up with more useful and suitable for the purposes they strive to serve organizational innovations. The abundance of information available to these firms may not only inhibit internal stickiness, enabling the implementation of organizational practices that increase the efficiency of their contacts with external channels of knowledge and the efficiency of their internal communication systems (Cohen and Levinthal, 1990), but also it may offer access to new complementary knowledge that facilitates the development of both radical and incremental offerings (David et al., 2013).

The analysis also revealed that higher levels of external depth may unlock potential complementarities between organizational innovation and external search. The results confirmed that external depth and organizational innovation complement each other to incrementally increase the radical innovative performance of firms deeply reliant on external sources. Laursen and Salter (2006) claim that as the firm engages in more external search depth, it needs to devote more organizational resources. This, in turn, increases significantly the managerial costs, constraining performance benefits that can be gained through external knowledge sourcing. In this context, organizational innovation can act as a remedy, because it enables decreases in managerial costs and better allocation of attention to both external and internal sources of information (Han et al., 1998; Koufteros and Marcoulides, 2006). Further, relative to those firms who are less active in external search depth, firms who draw intensively from external

sources can gain multiple deep insights into organizational practices and routines successfully used in other settings (Mol and Birkinshaw, 2009). This, in turn, can positively impact on their ability to implement new organizational routines and practices (Hargadon, 2002) that enable better management of different organizational activities including external search.

Taken all the arguments together, it is obvious that not only organizational innovation can treat problems facing firms that over-search or rely deeply on the external sources of information, but also over-search and intense reliance on external sources can increase the likelihood of an organizational innovation being accepted and successfully implemented inside the firm. Therefore, the findings of the study provide evidence that the complementary relationship between external search and organizational innovation is even stronger for high and intensive levels of search.

Interestingly, the complementary effect of external search and organizational innovation on the incremental innovative performance is not supported for firms that rely deeply on external sources of information. In contrast to the conventional wisdom, these findings indicate that the boundaries between external search breadth and external search depth are not always very clearly. Firms who are deeply reliant on many sources of information may face one major challenge: Beyond some point of external depth, the number of external channels with which a firm interacts, can become so large that the firm may struggle to understand the different norms, habits, and routines embedded in these channels. This imposes constraints that may extend significantly the period that the firm should spend on trial and errors in order to learn how to gain knowledge from external sources and how to utilize this knowledge internally. Therefore, it makes the process of learning, subject to considerable uncertainty (Laursen and Salter, 2006). For this reason, especially at early stages of

search, deep reliance on external sources of knowledge may be facilitated by organic structures that traditionally aim to increase the amount of experimentation and lead to the introduction of more radical rather than more incremental innovations (He and Wong, 2004).

The findings further support the above argument by revealing that the complementary effect of external search breadth and organizational innovation is stronger for the firm's radical than for the firm's incremental innovative performance. External search breadth entails exploratory learning (Jansen et al. 2006), which in turn, increases the amount of experimentation (March, 1991). As such, it facilitates both the introduction of radical innovations and the implementation of new organizational routines and practices (He and Wong, 2004). In turn, these new routines and practices could coordinate the innovative efforts of individuals inside the firm, enabling them to sufficiently synthesize and capitalize on novel ideas (Nord and Tucker, 1987).

6.3. Theoretical Contribution of the Thesis

This thesis makes several contributions to different lines of research. First, it represents one of the first attempts to study the complementary effect of external search and organizational innovation on the firm's innovative performance. Therefore, the study builds on a growing line of work that seeks to identify the relationship between external sourcing and organizational innovation (e.g., Foss et al., 2011; Han et al., 1998; Mol and Birkinshaw, 2009; Zobel, 2016). The results explain several inconsistencies in the findings of past empirical research by revealing that external search and organizational innovation can mutually reinforce each other for the purposes of innovation. It also

reveals the conditions under which this relationship might be counterproductive. In particular, the study clarifies some of the ideas developed in the organizational learning literature (e.g., Gupta et al., 2006; He and Wong, 2004) and tries to integrate these insights into the discussion on how external sourcing and organizational innovation relate to each other. Thereby, a deeper understanding on the link between these activities is gained. Given the lack of previous empirical studies on the topic, the findings can serve as a guide for future theoretical and empirical work. Future empirical work to test and modify these hypotheses will benefit from incorporating a longitudinal perspective and assessing how radical and incremental changes in organizational routines complement external search and what are the respective innovative outcomes of these complementarities.

The findings also contribute to the open innovation literature to the extent that they add organizational components to external search. The study proposed that external search strategies could be understood through the lens of organizational learning theory. In this way, it supports a more comprehensive understanding of the different external search strategies found in the literature. The study also contributes to the line of work that examines the relationship between different external search strategies and different innovation outcomes (e.g., Foss et al., 2011; Laursen and Salter, 2006). By illustrating differences between learning in external breadth and external depth, and by indicating conditions under which external depth is facilitated by different types of learning, the study explains how external search strategies drive different innovation outcomes and how external search strategies can undermine the effect of their joint occurrence with organizational innovation.

Further, this thesis calls researchers to investigate more what are the different mechanisms behind the organizational routines that support external search breadth

and external search depth, respectively. However, future research should go beyond that by offering a more nuanced understanding on how these often conflicting organizational routines can coexist in harmony without causing severe tensions within the organization (Dougherty and Hardy, 1996). Extant literature typically considers the drivers of external search, however it has remained relatively silent on explaining how the explorative or exploitative orientation of a firm may favour one type of external search over another. Research on how these activities can be balanced at the individual level, and how these activities can be strategically controlled is needed.

This study also has implications for the organizational innovation literature to the extent that it emphasizes the importance of external search for the successful introduction of new organizational routines and practices. Further, this thesis indicates that different outcomes related to potential complementarities, reside in the different knowledge management processes that external search breadth and external search depth may entail. This finding opens up interesting avenues for future research on organizational innovation. There is much to be gained by using organizational learning theories to explain how organizational change occurs inside firms who engage in external search. To reap the benefits of their external networks, firms need to change organizational routines that no longer yield value (Teece, 2007). External search can facilitate the introduction of new routines by offering insights into organizational routines successfully used in other settings (Mol and Birkinshaw, 2009). However, the findings of the study indicate that successful introduction of new organizational practises does not unconditionally lead to successful implementation. Future research should investigate conditions under which organizational innovation can be successfully implemented when firms engage in exploitation of external knowledge.

Further, this study contributes to the burgeoning literature on external sourcing by highlighting additional challenges that firms are likely to face when they search for external knowledge. The results suggest that further research is needed to examine a) the lack of new organizational routines, b) the conflicting nature of organizational routines that support different external search strategies, and c) the difficulty to find the optimum approach to balance them (Atuahene-Gima, 2005), as potential antecedents of the strong diminishing effects of the external search strategies on the firm's innovative performance (e.g., Laursen and Salter, 2006). The findings indicate that firms should introduce and implement the right complementary organizational routines in order to facilitate the exploration and exploitation of external knowledge. Far beyond this, firms should be able to deal with the conflicting nature of organizational routines that support different external search strategies.

This study also questions the assumption that external search breadth and external search depth are two distinct theoretical approaches to search. Deep reliance on external channels of knowledge may trigger the same challenges as over-search. As Gupta et al. (2006) argue the same search activity could be interpreted as both exploration and exploitation. The findings of the thesis demonstrate that in the case of external depth, exploration and exploitation are related in a complex way (Gupta et al., 2006; He and Wong, 2004; Knott, 2002) and occur interchangeably. In this sense, the findings add both to the discussion of external sourcing and to the discussion of exploration and exploitation.

Further, the study contributes to the dynamic capabilities literature by addressing repeated calls for understanding the micro-foundations of organizational capabilities and performance (Barney et al., 2011; Eisenhardt et al., 2010). The findings reveal the contribution of external search to the development of new organizational routines that

facilitate the innovative activities of individuals inside the firm. Teece (2007) argue that firms who base their sensing, creative, and learning functions on the cognitive traits of few individuals are very likely to become vulnerable. In order to overcome this constraint, firm must introduce and implement new managerial and working routines and practices that enable individuals to garner new technological information, tap developments in exogenous science, monitor customer needs and competitor activity, and shape new product and process opportunities (Teece, 2007). Also, the study contributes to this stream of literature by showing that in the context of open innovation, one of the greatest challenges that firms face, is how to successfully implement new managerial and working routines and practices.

These findings, collectively, open up entirely new avenues for investigating organizational strategies that deal with asymmetries on the underlying knowledge processes that occur in different search activities or in the same search activity and render bundles of organizational choices ineffective. I suggest that, among others, the literature on ambidexterity can be very useful in unravelling the phenomenon and providing some answers on how firms can balance these asymmetries. For instance, the proponents of contextual ambidexterity have proposed a tool for dealing with the contradictory knowledge processes of exploitation and exploration (e.g., Lubatkin et al., 2006). Specifically, Ghoshal and Bartlett (1997) suggest that individual and collective behaviours towards the integration of these knowledge processes can be shaped by invisible sets of stimuli and pressures. Further, these behaviours should be contextualized by social processes (e.g., socialization and recognition practices), and organizational culture that promotes integration (Birkinshaw and Gibson, 2004).

6.4. Managerial Implications

The findings also suggest some important managerial implications. The study provides evidence on the complementary effects of the innovation strategies. It shows that innovative performance may be the outcome of interrelated strategic choices on external search strategies and organizational innovation that interact and mutually reinforce each other. More precisely, the study explains that on the one hand, firms should innovate internally by implementing new organizational routines that support the identification, distribution, assimilation, and commercialization of external knowledge, while, on the other hand, they should devote significant effort to external search in order to gain useful insights into the implementation of novel organizational routines that fit with their particular external search strategies.

Further, the study explains why managers must realize and develop the ability to deal with potential tensions arising from different knowledge management processes that different external search strategies bring to the table. Firms must be able to excel at both exploration and exploitation of knowledge in order to survive (Atuahene-Gima, 2005). But since these activities entail conflicting supportive organizational routines, firms should be able to develop the appropriate organizational culture and social processes that facilitate their integration (Gibson and Birkinshaw, 2004). In addition, the study suggests that the development of organizational routines that facilitate both exploration and exploitation of knowledge, is more imperative for firms who deeply interact with many external actors than for firms who engage in superficial and shallow knowledge search. In order to reap the benefits of deep search, firms should be able to simultaneously introduce and balance organizational routines that facilitate experimentation and adaptation, and organizational routines that facilitate organizational stability and operational efficiency.

The study also shows that different external search strategies and different levels of external search breadth and depth may lead to the introduction of organizational and product innovations associated with different degrees of novelty. Further, it offers insights into how potential complementarities between different external search strategies and organizational innovations may affect the degree of novelty of the firm's offerings. Therefore, it provides managers with a fresh tool for identifying what are the most appropriate external search and organizational innovation activities for the development of radical and incremental innovations, and how these activities can mutually reinforce or impede the levels of novelty achieved. Overall, this study provides managerial insights into how and when firms can benefit from their external sourcing activities when combined with organizational innovation and vice versa.

6.5. Limitations of the Thesis and Future Research

The results of the thesis seem robust to a number of alternative specifications and checks. However, they should be carefully interpreted due to the inherited limitations of the data. Since CIS (2008) does not provide data fine grained enough, dummy variables have been used to measure the adoption of organizational innovation. Further, due to the econometric technique used for testing complementarity, I had to follow the same approach in measuring external search strategies. In order to deal with this limitation, I tested the complementary relationship between external search and organizational innovation across different levels of breadth and depth. Although, I believe that using dummies to measure organizational innovation is a fairly good

starting point, I also acknowledge the opportunity for future research to use more fine grained data. In any case, organizational innovation is not about how much, since its level of adoption depends on the needs of the firm (Mol and Birkinshaw, 2008). However, the use of more fine grained data can provide deeper insights into how the complementary relationship works for different levels of organizational innovation adoption.

Furthermore, due to inherited limitations of the data, this study focused on the more abstract level of organizational 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 interaction with specific external channels, such as customers, universities, competitors or public institutions, and specific types of organizational innovation, such as total quality management, customer orientation, lean management, vertical disintegration, decision delegation, communication channels, reward systems etc.

Another limitation of this study is that it focused merely on external search, ignoring the involvement of external agencies in the focal firm. In doing so, the study has overemphasized the distinction between the internal and external environment. It is possible that some of the external agencies with whom the focal firm interacts were associated with the focal firm at some point in the past. Therefore, especially in today's world of complex networks, the boundaries between the internal and external environment of the firm might not be always clear-cut (Mol and Birkinshaw, 2008). Future, research should take into consideration this boundary condition and examine how this involvement might affect the levels of resistance against externally-initiated organizational changes, rendering the joint occurrence of external search and

organizational innovation either productive or counterproductive. I also acknowledge that although country variables have been included in the analysis, the study does not directly address the influence of certain cultural biases. Perhaps the use of external knowledge differs between countries and organizations that operate in different industries due to differences in the institutional factors that drive inter-organizational trust (Mol and Birkinshaw, 2008). Future studies should examine how different institutional factors influence the development of inter-organizational trust and how such a trust might affect the integration of external knowledge and therefore, the complementary relationship between external search and organizational innovation.

In addition, although I clarified conditions under which the complementary relationship between organizational innovation and external search is either productive or counterproductive, I was unable to unravel and distinguish potential complementary effects between different external search strategies and more radical or incremental organizational changes. The data precluded a fine grained analysis of such a distinction. Insights into whether the degree of novelty associated with new organizational practises will be contingent upon the different external search strategies that firms follow and vice versa, can add important dimensions to the previous discussion. By definition, external search depth is a strategy that includes intensive and frequent interactions with external channels (Laursen and Salter, 2006). Therefore, it stimulates recurrent learning episodes that drive the repetition and as such, the automaticity in the execution of related tasks (Zollo and Winter, 2002). In the best case, automaticity might lead to sporadic acts of creativity which manifest themselves in incremental organizational changes (Schreyögg and Kliesch-Eberl, 2007), evolving so gradually and so close to the neighbourhood of the current routines and practises (Johnson and Johnson, 2002) than can be hardly understood or either recognized (Zollo

and Winter, 2002). The most direct implication of this phenomenon is that it can reduce significantly the collective understanding of the action-performance linkages, preventing firms from understanding which routines can and which routines cannot yield value (Zollo and Winter, 2002) to the firm's external search activities or more broadly, to the firm's innovation activities. On the contrary, external search breadth entails infrequent and shallow interactions with external channels of knowledge (Laursen and Salter, 2006). Such a type of interaction requires more deliberate organizational learning processes (Zollo and Winter, 2002). Firms must experiment in mastering external knowledge (Laursen and Salter, 2006). This experimentation might result in the introduction of more radical organizational innovations (He and Wong, 2004), while it might also lead to a better understanding of the action-performance linkages (Zollo and Winter, 2002). This perspective expands arguments presented in this thesis, by providing additional explanations on why the complementary effect of external search and organizational innovation has been validated for firms that engage in external search breadth rather than for firm that engage in external search depth. Therefore, it calls researchers to further investigate this possibility by taking into consideration the degree of novelty associated with organizational routines and practices introduced inside the firm.

Another limitation of the study is that I focused only on incremental and radical innovation. Future research should take into consideration other types of innovation outcomes, such as modular and architectural innovations. Further, this study uses Laursen and Salter's (2006) indices for measuring both external search breadth and depth. These indices might have some limitations. The major limitation is that the index of external search depth might not be able to capture accurately the extent to which firms draw deeply from the different external sources or search channels

(Laursen and Salter, 2006). In reality, this index captures the number of external sources on which firms rely intensively during their innovative activities. Because of this limitation, previous studies suggest that the measurements of external search breadth and depth might be highly correlated (e.g., Kohler et al., 2012). One possible way to deal with this limitation is to divide the variable of depth by the number of sources used, so that the resulting variable takes a minimum value of 0 and a maximum of 1 (Kohler et al., 2012). In this study, the correlation matrix (see appendix B, table 6.3) provides clear evidence that external search breadth and external search depth (correlation coefficient r = 0.3889) are not highly correlated, eliminating the respective risk. However, future research should further eliminate such a risk by using alternative measurements for external search depth, including the measurement proposed in this section.

Finally, since the findings are based on cross-sectional evidence, my 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.

6.6. Chapter Summary

This chapter interpreted the results of the hypotheses testing in reference to the theory. The results of the study provide evidence that external search and organizational innovation are complementary activities. However, the joint occurrence of different external search strategies with organizational innovation was found to exert asymmetric effects on the firm's innovative performance, as well as on the degree of novelty achieved. These results were also found to vary across different levels of

external search. In this chapter, the theoretical and managerial implications of these findings, as well as the limitations and the directions for future research were presented.

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Appendix A: The Community Innovation Survey 2008

The Community Innovation Survey 2008

(CIS 2008)

THE HARMONISED SURVEY QUESTIONNAIRE

The Community Innovation Survey 2008

FINAL November 28, 2008

This survey collects information on your enterprise's innovations and innovation activities between 2006 and 2008 inclusive.

An innovation is the introduction of a new or significantly improved product, process, organisational method, or marketing method by your enterprise. The innovation must be new to your enterprise, although it could have been originally developed by other enterprises.

The questions on innovation activities only refer to product and process innovations.

Please complete all questions, unless otherwise instructed.

Person we should contact if there are any queries regarding the form:

Name: _____

Job title: _____

Organisation: _____

Phone: _____

Fax: _____

E-mail: _____

1. General information about the enterprise

Name of enterprise ___*ID*

Address[3] _____*NUTS*

Postal code ___ Main activity[4] _*NACE*

1.1 In 2008, was your enterprise part of an enterprise group? (A group consists of two or more legally defined enterprises under common ownership. Each enterprise in the group can serve different markets, as with national or regional subsidiaries, or serve different product markets. The head office is also part of an enterprise group.)

Yes ☐

No ☐

In which country is the head office of your group located? [5]_____ *HO*

If your enterprise is part of an enterprise group: Please answer all further questions only for the enterprise for which you are responsible in [your country]. Exclude all subsidiaries or parent enterprises.

1.2 In which geographic markets did your enterprise sell goods and/or services during the three years 2006 to 2008?

	Yes	No
A. Local / regional within [your country]	☐	☐
B. National (other regions of [your country])	☐	☐
C. Other European Union (EU), EFTA, or EU candidate countries*	☐	☐

[3] NUTS 2 code

[4] NACE Rev.2 (4 digit code)

[5] Country code according to ISO standard

D. All other countries ☐ ☐

Which of these geographic areas was your largest market in terms of turnover between 2006 and 2008? (Give corresponding letter) _____

*: Include the following countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Slovakia, Switzerland, Turkey, Spain, Sweden and the United Kingdom.

2. Product (good or service) innovation

A product innovation is the market introduction of a new or significantly improved good or service with respect to its capabilities, user friendliness, components or sub-systems. Product innovations (new or improved) must be new to your enterprise, but they do not need to be new to your market. Product innovations could have been originally developed by your enterprise or by other enterprises.

During the three years 2006 to 2008, did your enterprise introduce:

	Yes	No
New or significantly improved goods. (Exclude the simple resale of new goods purchased from other enterprises and changes of a solely aesthetic nature.)	☐	☐
New or significantly improved services.	☐	☐

If no to both options, go to section 3, otherwise:

2.2 Who developed these product innovations?

<u>Select the most appropriate option only</u>

Mainly your enterprise or enterprise group ☐

Mainly your enterprise together with other enterprises or institutions ☐

Mainly other enterprises or institutions ☐

2.3 Were any of your product innovations during the three years 2006 to 2008:

		Yes	No
New to your market?	Your enterprise introduced a new or significantly improved good or service onto your market before your competitors (it may have already been available in other markets)	☐	☐
Only new to your firm?	Your enterprise introduced a new or significantly improved good or service that was already available from your competitors in your market	☐	☐

Using the definitions above, please give the percentage of your total turnover[6] in 2008 from:

New or significantly improved goods and services introduced during 2006 to 2008 that were new to your market	☐☐☐ %
New or significantly improved goods and services introduced during 2006 to 2008 that were only new to your firm	☐☐☐ %
Goods and services that were unchanged or only marginally modified during 2006 to 2008 (include the resale of new goods or services purchased from other enterprises)	☐☐☐ %
Total turnover in 2008	1 0 0 %

3. Process innovation

A process innovation is the implementation of a new or significantly improved production process, distribution method, or support activity for your goods or services. Process innovations must be new to your enterprise, but they do not need to be new to your market. The innovation could have been originally developed by your enterprise or by other enterprises.

[6] For Credit institutions: Interests receivable and similar income, for insurance services: Gross premiums written

Exclude purely organisational innovations – these are covered in section 8.

3.1 During the three years 2006 to 2008, did your enterprise introduce:

	Yes	No
New or significantly improved methods of manufacturing or producing goods or services	☐	☐
New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services	☐	☐
New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing	☐	☐

If no to all options, go to section 4, otherwise:

3.2 Who developed these process innovations?

Select the most appropriate option only:

Mainly your enterprise or enterprise group	☐
Mainly your enterprise together with other enterprises or institutions	☐
Mainly other enterprises or institutions	☐

1. Ongoing or abandoned innovation activities for process and product innovations

Innovation activities include the acquisition of machinery, equipment, software, and licenses; engineering and development work, industrial design, training, marketing and R&D when they are *specifically* undertaken to develop and/or implement a product or process innovation. Also include basic R&D as an innovation activity even when not related to a product and/or process innovation.

4.1 During 2006 to 2008, did your enterprise have any innovation activities that did not result in a product or process innovation because the activities were:

	Yes	No
Abandoned or suspended before completion	☐	☐
Still ongoing at the end of the 2008	☐	☐

If your enterprise had no product or process innovations or innovation activity during 2006 to 2008 (no to all options in questions 2.1, 3.1, and 4.1), go to section 8.

Otherwise, go to section 5

5. Innovation activities and expenditures for process and product innovations

5.1 During the three years 2006 to 2008, did your enterprise engage in the following innovation activities:

		Yes	No
In-house R&D	Creative work undertaken within your enterprise to increase the stock of knowledge for developing new and improved products and processes (include software development in-house that meets this requirement)	☐	☐
External R&D	If yes, did your enterprise perform R&D during 2006 to 2008: Continuously (your enterprise has permanent R&D staff in-house)		
	Same activities as above, but performed by other enterprises (including other enterprises or subsidiaries within your group) by public or private research organisations and purchased by your enterprise	☐	☐
Acquisition of machinery, equipment and software	Acquisition of advanced machinery, equipment and computer hardware or software to produce new or significantly improved products and processes	☐	☐

Acquisition of external knowledge	Purchase or licensing of patents and non-patented inventions, know-how, and other types of knowledge from other enterprises or organisations for the development of new or significantly improved products and processes	☐	☐
Training for innovative activities	Internal or external training for your personnel specifically for the development and/or introduction of new or significantly improved products and processes	☐	☐
Market introduction of innovations	Activities for the market introduction of your new or significantly improved goods and services, including market research and launch advertising	☐	☐
Other	Other activities to implement new or significantly improved products and processes such as feasibility studies, testing, routine software development, tooling up, industrial engineering, etc.	☐	☐

5.2 Please estimate the amount of expenditure for each of the following four innovation activities in <u>2008</u> only. (Include personnel and related costs)[7]

If your enterprise had no expenditures in 2008, please fill in '0'

In-house R&D (Include capital expenditures on buildings and equipment specifically for R&D)	
Purchase of external R&D	
Acquisition of machinery, equipment and software (Exclude expenditures on equipment for R&D)	
Acquisition of external knowledge	

[7] Give expenditure data in 000's of national currency units to eight digits.

Total of these four innovation expenditure categories ☐

5.3 During the three years 2006 to 2008, did your enterprise receive any public financial support for innovation activities from the following levels of government? Include financial support via tax credits or deductions, grants, subsidised loans, and loan guarantees. Exclude research and other innovation activities conducted entirely for the public sector under contract.

	Yes	No
Local or regional authorities	☐	☐
Central government (including central government agencies or ministries)	☐	☐
The European Union (EU)	☐	☐
If yes, did your enterprise participate in the EU 6th or 7th Framework Programme for Research and Technical Development?	☐	☐

6. Sources of information and co-operation for innovation activities

6.1 During the three years 2006 to 2008, how important to your enterprise's innovation activities were each of the following information sources? Please identify information sources that provided information for new innovation projects or contributed to the completion of existing innovation projects.

Tick 'not used' if no information was obtained from a source.

		Degree of importance			
	Information source	High	Medim	Low	Not used
Internal	Within your enterprise or enterprise group	☐	☐	☐	☐

Market sources	Suppliers of equipment, materials, components, or software	☐	☐	☐	☐
	Clients or customers	☐	☐	☐	☐
	Competitors or other enterprises in your sector	☐	☐	☐	☐
	Consultants, commercial labs, or private R&D institutes	☐	☐	☐	☐
Institutional sources	Universities or other higher education institutions	☐	☐	☐	☐
	Government or public research institutes	☐	☐	☐	☐
Other sources	Conferences, trade fairs, exhibitions	☐	☐	☐	☐
	Scientific journals and trade/technical publications	☐	☐	☐	☐
	Professional and industry associations	☐	☐	☐	☐

6.2 During the three years 2006 to 2008, did your enterprise co-operate on any of your innovation activities with other enterprises or institutions? Innovation co-operation is active participation with other enterprises or non-commercial institutions on innovation activities. Both partners do not need to commercially benefit. Exclude pure contracting out of work with no active co-operation.

Yes ☐

No ☐ (Please go to question

6.3 Please indicate the type of innovation co-operation partner by location

(Tick all that apply)

Type of co-operation partner	[Your country]	Other Europe*	United States	China or India	All other countries
A. Other enterprises within your enterprise group	☐ *Co11*	☐ *Co12*	☐*Co13*	☐ *Co14*	☐ *Co15*

B. Suppliers of equipment, materials, components, or software	☐ *Co21*	☐ *Co22*	☐*Co23*	☐ *Co24*	☐ *Co25*
C. Clients or customers	☐ *Co31*	☐ *Co32*	☐*Co33*	☐ *Co34*	☐ *Co35*
D. Competitors or other enterprises in your sector	☐ *Co41*	☐ *Co42*	☐*Co43*	☐ *Co44*	☐ *Co45*
E. Consultants, commercial labs, or private R&D institutes	☐ *Co51*	☐ *Co52*	☐*Co53*	☐ *Co54*	☐ *Co55*
F. Universities or other higher education institutions	☐ *Co61*	☐ *Co62*	☐*Co63*	☐ *Co64*	☐ *Co65*
G. Government or public research institutes	☐ *Co71*	☐ *Co72*	☐*Co73*	☐ *Co74*	☐ *Co75*

*: Include the following European Union (EU) countries, EFTA, or EU candidate countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Slovakia, Switzerland, Turkey, Spain, Sweden and the United Kingdom.

6.4 Which type of co-operation partner did you find the most valuable for your enterprise's innovation activities? (Give corresponding letter) _____

PMOS

7. Innovation objectives during 2006-2008

7.1 How important were each of the following objectives for your activities to develop product (good or service) or process innovations between 2006 and 2008?

If your enterprise had several projects for product and process innovations, make an overall evaluation

	High	Medium	Low	Not relevant	
Increase range of goods or services	☐	☐	☐	☐	*ORANGE*
Replace outdated products or processes	☐	☐	☐	☐	*OREPL*
Enter new markets	☐	☐	☐	☐	*OENMK*
Increase market share	☐	☐	☐	☐	*OIMKS*

Improve quality of goods or services	☐	☐	☐	☐	*OQUA*
Improve *flexibility* for producing goods or services	☐	☐	☐	☐	*OFLEX*
Increase *capacity* for producing goods or services	☐	☐	☐	☐	*OCAP*
Improve health and safety	☐	☐	☐	☐	*OHES*
Reduce labour costs per unit output	☐	☐	☐	☐	*OLBR*

8. Organisational innovation

An organisational innovation is a new organisational method in your enterprise's business practices (including knowledge management), workplace organisation or external relations that has not been previously used by your enterprise. It must be the result of strategic decisions taken by management.

Exclude mergers or acquisitions, even if for the first time.

8.1 During the three years 2006 to 2008, did your enterprise introduce:

	Yes	No
New business practices for organising procedures (i.e. supply chain management, business re-engineering, knowledge management, lean production, quality management, etc)	☐	☐
New methods of organising work responsibilities and decision making (i.e. first use of a new system of employee responsibilities, team work, decentralisation, integration or de-integration of departments, education/training systems, etc)	☐	☐
New methods of organising external relations with other firms or public institutions (i.e. first use of alliances, partnerships, outsourcing or sub-contracting, etc)	☐	☐

If no to all options, go to section 9.

Otherwise, go to question 8.2

8.2 How important were each of the following objectives for your enterprise's organisational innovations introduced between 2006 and 2008 inclusive?

If your enterprise introduced several organisational innovations, make an overall evaluation

	High	Medium	Low	Not relevant
Reduce time to respond to customer or supplier needs	☐	☐	☐	☐
Improve ability to develop new products or processes	☐	☐	☐	☐
Improve quality of your goods or services	☐	☐	☐	☐
Reduce costs per unit output	☐	☐	☐	☐
Improve communication or information sharing within your enterprise or with other enterprises or institutions	☐	☐	☐	☐

9. Marketing innovation

A marketing innovation is the implementation of a new marketing concept or strategy that differs significantly from your enterprise's existing marketing methods and which has not been used before.

It requires significant changes in product design or packaging, product placement, product promotion or pricing.

Exclude seasonal, regular and other routine changes in marketing methods.

9.1 During the three years 2006 to 2008, did your enterprise introduce:

Yes	No

Significant changes to the aesthetic design or packaging of a good or service (*exclude changes that alter the product's functional or user characteristics – these are product innovations*)	☐	☐
New media or techniques for product promotion *(i.e. the first time use of a new advertising media, a new brand image, introduction of loyalty cards, etc*)	☐	☐
New methods for product placement or sales channels *(i.e. first time use of franchising or distribution licenses, direct selling, exclusive retailing, new concepts for product presentation, etc)*	☐	☐
New methods of pricing goods or services *(i.e. first time use of variable pricing by demand, discount systems, etc)*	☐	☐

If no to all options, go to section 10.

Otherwise, go to question 9.2

9.2 How important were each of the following objectives for your enterprise's marketing innovations introduced between 2006 and 2008 inclusive?

If your enterprise introduced several marketing innovations, make an overall evaluation

	High	Medium	Low	Not relevant
Increase or maintain market share	☐	☐	☐	☐
Introduce products to new customer groups	☐	☐	☐	☐
Introduce products to new geographic markets	☐	☐	☐	☐

10. Innovations with environmental benefits

An environmental innovation is a new or significantly improved product (good or service), process, organizational method or marketing method that creates environmental benefits compared to alternatives.

The environmental benefits can be the primary objective of the innovation or the result of other innovation objectives. The environmental benefits of an innovation can occur during the production of a good or service, or during the after sales use of a good or service by the end user.

10.1 During the three years 2006 to 2008, did your enterprise introduce a product (good or service), process, organisational or marketing innovation with any of the following environmental benefits?

	Yes	No
Environmental benefits from the production of goods or services within your enterprise		
Reduced material use per unit of output	☐	☐
Reduced energy use per unit of output	☐	☐
Reduced CO_2 'footprint' (total CO_2 production) by your enterprise	☐	☐
Replaced materials with less polluting or hazardous substitutes	☐	☐
Reduced soil, water, noise, or air pollution	☐	☐
Recycled waste, water, or materials	☐	☐
Environmental benefits from the after sales use of a good or service by the end user		
Reduced energy use	☐	☐
Reduced air, water, soil or noise pollution	☐	☐
Improved recycling of product after use	☐	☐

10.2 During 2006 to 2008, did your enterprise introduce an environmental innovation in response to:

	Yes	No
Existing environmental regulations or taxes on pollution	☐	☐

Environmental regulations or taxes that you expected to be introduced in the future	☐	☐
Availability of government grants, subsidies or other financial incentives for environmental innovation	☐	☐
Current or expected market demand from your customers for environmental innovations	☐	☐
Voluntary codes or agreements for environmental good practice within your sector	☐	☐

10.3 Does your enterprise have procedures in place to regularly identify and reduce your enterprise's environmental impacts? (For example preparing environmental audits, setting environmental performance goals, ISO 14001 certification, etc).

☐ Yes: implemented before January 2006

☐ Yes: Implemented or significantly improved after January 2006

☐ No

11. Basic economic information on your enterprise

11.1 What was your enterprise's total turnover for 2006 and 2008?[8] *Turnover is defined as the market sales of goods and services (Include all taxes except VAT*[9]*).*

2006	2008
☐☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐☐
TURN06	*TURN08*

[8] Give turnover in '000 of national currency units to nine digits.

[9] For Credit institutions: Interests receivable and similar income; for Insurance services: Gross premiums written

11.2 What was your enterprise's total number of employees in 2006 and 2008?[10]

2006	2008
EMP06	*EMP08*

[10] Annual average. If not available, give the number of employees at the end of each year. Give figures to six digits.

Appendix B: Correlations among Study Variables

Table 6.1. Correlations among study variables and dummies created for the productivity tests (Breadth & Organizational Innovation)

	INNWORLD	INNFIRM	EMP	RDNIT	GEOMARKET	SUPPORT	USER	COLLAB	ONLY BR	ONLY OI	BR & OI	TURNOVER 2006
INNWORLD	1.0000											
INNFIRM	0.1374	1.0000										
EMP	0.0645	0.0203	1.0000									
RDINT	0.0039	-0.0098	-0.0141	1.0000								
GEOMARKET	0.0814	0.0847	0.0887	-0.0052	1.0000							
SUPPORT	0.1371	0.0467	0.0548	0.0439	-0.0610	1.0000						
USER	0.1284	0.1344	0.0735	0.0067	0.0780	0.0578	1.0000					
COLLAB	0.1797	0.1178	0.1697	0.0152	0.0481	0.2628	0.1352	1.0000				
ONLY BR	-0.0898	-0.0161	-0.1160	-0.0002	-0.0159	-0.0287	-0.0391	-0.0909	1.0000			
ONLY OI	-0.0836	-0.0957	-0.0057	-0.0051	-0.0163	-0.0681	-0.1012	-0.0893	-0.1282	1.0000		
BR & OI	0.1851	0.1342	0.1383	0.0058	0.0343	0.1052	0.1528	0.1990	-0.8197	-0.1837	1.0000	
TURNOVER 2006	0.0227	0.0109	0.1566	-0.0028	0.0020	0.0400	0.0213	0.0667	-0.0395	0.0005	0.0441	1.0000

Table 6.2. Correlations among study variables and dummies created for the productivity test (Breadth & Organizational Innovation)

	INNWORLD	INNFIRM	EMP	RDINT	GEOMARKET	SUPPORT	USER	COLLAB	ONLY DE	ONLY OI	DE & OI	TURNOVER 2006
INNWORLD	1.0000											
INNFIRM	0.1374	1.0000										
EMP	0.0645	0.0203	1.0000									
RDINT	0.0039	-0.0098	-0.0141	1.0000								
GEOMARKET	0.0814	0.0847	0.0887	-0.0052	1.0000							
SUPPORT	0.1371	0.0467	0.0548	0.0439	-0.0610	1.0000						
USER	0.1284	0.1344	0.0735	0.0067	0.0780	0.0578	1.0000					
COLLAB	0.1797	0.1178	0.1697	0.0152	0.0481	0.2628	0.1352	1.0000				
ONLY DE	-0.0411	-0.0057	-0.0586	0.0027	-0.0086	0.0283	0.2315	0.0067	1.0000			
ONLY OI	0.0141	-0.0139	0.0311	-0.0088	0.0055	-0.0473	-0.3348	-0.0443	-0.2649	1.0000		
DE & OI	0.1542	0.1214	0.1165	0.0123	0.0257	0.1307	0.4304	0.2200	-0.3310	-0.3925	1.0000	
TURNOVER 2006	0.0227	0.0109	0.1566	-0.0028	0.0020	0.0400	0.0213	0.0667	-0.0223	-0.0032	0.0498	1.0000

Table 6.3 Correlations among all study variables

	INNWORLD	INNFIRM	BREADTH	DEPTH	EMP	RDINT	GEOMARK	SUPPORT	USER	COOLAB
INNWORLD	1.0000									
INNFIRM	0.0061	1.0000								
BREADTH	0.1325	0.0796	1.0000							
DEPTH	0.0903	0.0412	0.3889	1.0000						
… EMP	0.0251	0.0487	0.1628	0.0457	1.0000					
RDINT	0.0142	0.0009	0.0237	0.0360	0.0141	1.0000				
GEOMARK	0.0447	0.0486	0.0318	0.0036	0.0885	0.0052	1.0000			
SUPPORT	0.1073	0.0212	0.2305	0.1503	0.0555	0.0440	0.0605	1.0000		
USER	0.0729	0.0556	0.2911	0.5723	0.0742	0.0066	0.0787	0.0588	1.0000	
COOLAB	0.0988	0.0426	0.3057	0.2122	0.1708	0.0154	0.0479	0.2633	0.137	1.0000