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**The influence of a firm's prior related knowledge on
the use of information sources**
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Table of contents

Table of contents.....	2
Summary	3
1. Introduction	4
2. Theory.....	5
2.1 Innovative output.....	5
2.2 Information search.....	5
2.3 Prior related knowledge.....	7
3. Hypotheses	7
3.1 Innovation and the use of information sources	7
3.2 Prior related knowledge and information search.....	8
3.2.1 External search	8
3.2.2 Mediating factors.....	10
3.2.2.1 Costs	10
3.2.2.2 Search benefits	10
3.2.2.3 Risks	10
3.2.2.4 Accessibility	10
3.2.2.5 Comprehensibility	11
4. Research design	11
4.1 Sample & Data collection.....	11
4.2 Measurement	11
4.2.1 Innovative output.....	11
4.2.2 Use of an external information source and mediating factors.....	12
4.2.3 Prior related knowledge.....	13
4.2.4 Control variable	14
4.3 Analysis	14
5. Results.....	15
5.1 Innovative output.....	16
5.2 Use of external information sources.....	17
5.3 Mediating factors.....	19
6. Conclusions	21
7. Discussion	22
7.1 Limitations.....	22
7.2 Theoretical implications	22
7.3 Managerial and policy implications	23
References	24
Appendix A	29
Appendix B.....	30
Appendix C	31
Appendix D	32
Appendix E.....	33
Appendix F.....	34
Appendix G	35

Summary

Many scholars acknowledge that innovation is very important for firms' competitive advantage. Several governments confirm this by supporting the development of innovations with the help of policy programmes that stimulate knowledge transfer, R&D and innovative environments. An important determinant for successful innovation is the search of information. Understanding the organizational search process is therefore essential to increase firms' innovative output. It supports firms' managers to develop successful strategies and offers insights for policy makers to set up efficient policy instruments to stimulate external knowledge transfer. The organizational literature encloses however, very little empirical evidence on the relations between firms prior related knowledge, information search and innovation. This study aims to bridge these gaps in the literature by providing an empirical exploration on 1) the relationship between the use of external information sources and firms' innovative output as well as 2) the relationship between a firm's prior related knowledge and the use of external information sources. The empirical results are based on the data gathered by an online questionnaire for a study of the Province South Holland. The sample contains 164 innovative firms. Two types of external information sources are distinguished: institutional sources and market sources. A positive relationship is expected between the use of both sources and firms' innovative output. Further, it is hypothesized that institutional sources are stronger related to product innovation and market sources have a stronger link with process innovation. The economics of information (EI) perspective and absorptive capacity (AC) theory are used to set up hypotheses on the relationship between prior related knowledge and the use of external information sources. Based on these theories, an inverted U-shape relationship is hypothesized between prior related knowledge and the use of institutional and market information sources. It is expected that the turning point of the curve of institutional sources has a higher value of prior related knowledge than the turning point of market sources, because institutional sources contain more information that is fundamental and market sources include more information that is practical. Further, based on these theories, five mediating factors are identified that are expected to mediate the relationship between prior related knowledge and the use of external sources: perceived costs and risks (both negatively); search benefits, accessibility and comprehensibility (positively). The analysis contains 1) ordinal regression and binary logit models to test the relationship between the use of external information sources and firms' innovative output, 2) linear regression models to study the relation between a firm's prior related knowledge and the use of external information sources and 3) linear regression models and a Pearson correlation matrix to test the relationship between the mediating factors and the use of external information sources. The results show that the use of institutional information sources is positively related to the development of product innovation; process innovation is dependent on the use of market information sources. However, this study shows also that for the creation of more and multiple innovations, the use of both institutional and market sources are important. Further, the results confirm the inverted U-shape relationship between prior related knowledge and the use of external information sources. The inverted U-shape is mediated out by the addition of the five mediating factors into the model. The influence of the mediating factors perceived benefits, accessibility, comprehensibility and risks are confirmed. This is in line with the theoretical predictions. The factor perceived costs shows however deviating results. The factor perceived costs has no significant relationship with the use of market sources and, even more remarkable, it has a positive relationship with the use of institutional sources. This is not in line with the predictions from the economics of information perspective. Therefore, it is debatable whether this theory can be used as explanatory mechanism for organizational search behavior. Based on the results, theoretical and managerial recommendations are proposed.

1. Introduction

Innovation is an important determinant for enhancing a firm's chances for survival, economic growth and competitive advantage (Tushman & Smith, 2002), because markets are changing rapidly and the competitiveness within business environments increases steadily (Flynn & Chatman, 2001). This is also emphasized by Amabile (1997, p. 40), who stated that "innovation is absolutely vital for long-term corporate success [...] no firm that continues to deliver the same products and services in the same way can long survive. By contrast, firms that prepare for the future by implementing new ideas oriented toward this changing world are likely to thrive". Several governments acknowledge the importance of innovation by introducing policy instruments that stimulate the development of new products and processes. The Dutch ministry of Economic Affairs, for instance, has set up the policy programmes *Innovatievouchers*, *IOP*, *Technopartner*, *TTI* and *WBSO* (Senternovem, 2008). The European Union has founded the European Institute of Innovation and Technology (EIT, 2008) and supports several member states' national innovation policy programmes on research and technology, knowledge transfer, human resources, supporting innovative enterprises and market and innovation culture (for an overview see Pro Inno Europe, 2009).

Before innovation takes place, firms search for information (Katila, 2002). In this study, search is defined as a problem solving activity (Nelson & Winter, 1982) which combines information elements to develop innovations. Many scholars have emphasized that organizational search, on both internal and external way, is needed for successful innovation (e.g. Dodgson, 1991; Dodgson, 1993). Understanding the organizational information search process thus facilitates organizational search for innovations. An important determinant for innovation and search is firms' prior related knowledge. Prior related knowledge refers to the knowledge that is available within an organization, adopted in earlier learning and search processes. In the field of innovation studies, it is acknowledged that search processes increase firms' prior related knowledge and have a positive impact on the innovative output of a firm (e.g. Crossan & Bapuji, 2004). The innovative output indicates firms' developed product and process innovations. However, scholars have done little research on how firms' search behavior is related to innovation. Katila (2002) and Katila & Ahuja (2002) have offered an initial impetus by providing empirical evidence on the importance of the use of internal information and external information sources for product development. Although these studies are based on the organizational aspect of search, they mainly focused on the effect of search on firm performance. This study extends the studies of Katila (2002) and Katila & Ahuja (2002) by making a distinction between the development of product and process innovation in relation to information search. Further, empirical research that explicitly focuses on the relationship between prior related knowledge and information search at external sources is missing. Therefore, this paper aims to bridge the gaps in the literature by providing empirical evidence on 1) the relation between the use of different external sources for information and firms' innovative output and 2) the relation between a firm's prior related knowledge and the use of different external sources for information.

To test these relationships, hypotheses are proposed. The empirical analysis is based on a survey among Dutch innovative firms. The outline of this paper is as follows. First, section 2 describes the theoretical framework. In section 3, explanatory mechanisms are introduced and hypotheses are formulated, section 4 discusses the methodology, section 5 portrays the results, section 6 discusses the conclusions, and finally, section 7 describes the discussion.

2. Theory

In this paper, the following conceptual model is used (figure 1). For each concept, literature is reviewed and definitions are delineated.

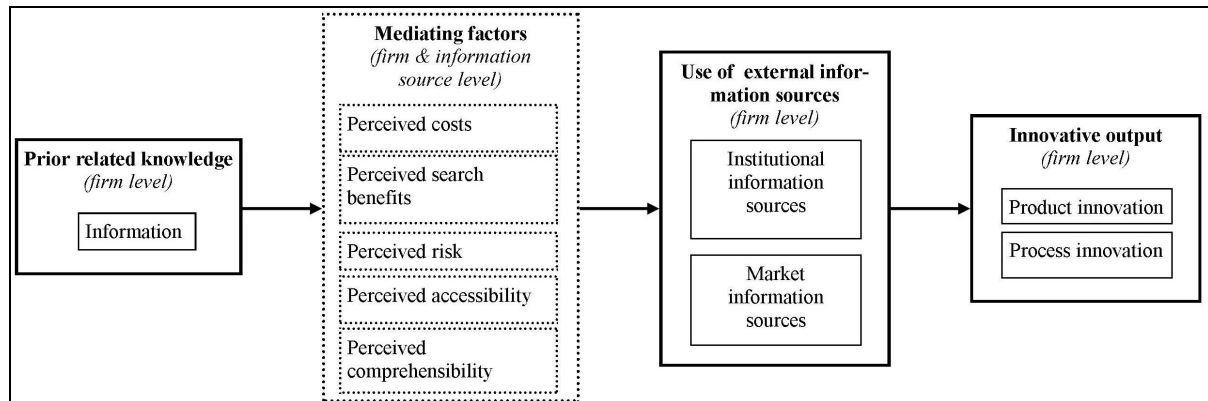


Figure 1: Conceptual model

2.1 Innovative output

The innovation literature distinguishes several types of innovation (Abernathy & Utterback, 1978; Clark, 1985; Henderson & Clark, 1990; Tushman & Smith, 2002; Utterback, 1994). An important distinction within the innovation research field is that between process and product innovation (Utterback, 1994). A product innovation is the development and market implementation of a new or improved product; a process innovation is a new or improved production process. Both product and process innovations may enhance the competitive performance of a firm. Product innovations normally have more impact on the value chain than process innovations, because customers of a product are often wide spread (P. Anderson & Tushman, 1991). For process innovations, this is not necessarily the case. Process innovations result in quality improvements and price reduction of products, without radical market changes (P. Anderson & Tushman, 1991). An example of a product innovation is the development of the automobile (Klepper, 1997; Utterback, 1994). An example of a process innovation is the introduction of robots in manufacturing processes of automobiles (Utterback, 1994).

2.2 Information search

The literature on organizational learning offers a wide variety of related concepts and dimensions (see Huber, 1991). Information search is one type of the organizational learning process (Huber, 1991). Although many researchers have discussed search, there is some inconsistency in the literature about the concept of organizational search (Huber, 1991). March (1991) for instance, relates organizational search to the concept of exploration. Huber (1991) refers to search in the process of information acquisition, while Tidd et al. (2001) and Choo (2001) mention the term scanning. All mentioned scholars have, however, in common that they refer to the search process as a mean, to gain information, for instance through R&D, training, recruitment, etc. (Dodgson, 1993).

Organizational search can take place in two ways: internal and external. Internal search is based on finding information inside the firm; external search is based on finding information outside the firm (Bierly & Chakrabarti, 1996; Crossan & Bapuji, 2004; Dodgson, 1993). Internal search is based on firms' prior related knowledge and cumulated past experiences

(Crossan & Bapuji, 2004; Huber, 1991), which consist of the organizational memory of collective experiences from organizational members. The concepts cumulated past experience and prior related knowledge are in the definition of this paper very close related to each other.

The search literature mentions several external information sources. The experiences of other firms (Crossan & Bapuji, 2004), for instance, are an important source of information. Also, users (e.g. Hippel, 1976), suppliers (Bessant, Kaplinsky, & Lamming, 2003), governmental institutions (Shaffer, 1995), knowledge institutes or scientists (Laursen & Salter, 2004) and intermediary institutions (Provan & Human, 1999) are a way to adopt external information. When firms search externally for solutions of innovation related problems, firms make a selection of information sources that possibly contain the information they need. This selection is based on the characteristics of the sources, which differ for each potential information source. Scholars argue that information sources could, based on the characteristics of the sources, be divided in two groups: institutional and market sources (Laursen & Salter, 2004). Laursen & Salter (2004) studied the types of firms that use universities as a source for innovation. One of their conclusions is that universities are for a modest part a direct source of information, because of the mismatch between the universities' characteristics as information source and the search strategy of a firm. Sources that are used more often are internal information sources and market information sources. Market sources are external information sources that supply information from market-related actors as suppliers, competitors, clients and customers (Laursen & Salter, 2004). Institutional sources on the other hand are external information sources that are not market-related. For instance, universities, higher educational institutes and public and private research organizations (Laursen & Salter, 2004). The distinction between market sources and institutional sources is also acknowledged by Felder et al. (1996) and Klomp & Van Leeuwen (2001). These scholars distinguish the information sources 'science' and 'other sources (customers, suppliers and competitors)' in their empirical analyses.

In the organizational search literature, several types of search are distinguished. Huber (1991) reviewed the literature and divided organizational search in three different types: scanning, performance monitoring and focused search. Scanning refers to the ongoing search process for information about possible market changes and has a broad search character (Huber, 1991; Tidd et al., 2001). Firms have to react on changes in their environment to stay competitive. Therefore, they search for improved organizational designs (Bruderer & Singh, 1996), methods to optimize manufacturing (Jaikumar & Bohn, 1992) and ideas for new product innovation (Katila & Ahuja, 2002). Thus, the ongoing search process is needed to stay competitive. A failing ongoing search process could result in expensive transformation processes to change the suboptimal strategy (Miller & Friesen, 1980; Tushman & Romanelli, 1985). The relationship between organizational scanning and firm performance is tested in several empirical studies (see for instance Daft, Sormunen, & Parks, 1988; Dollinger, 1984; Subramanian, Kamalesh, & Yauger, 1994; Tushman & Katz, 1980). Performance monitoring is used by firms to test whether organizational objectives are achieved (Huber, 1991). Performance monitoring is therefore a goal directed search strategy to assess whether the organization is fitting environmental changes to attain a competitive position in the market. Scanning and performance monitoring are based on detecting a wide range of signals from the environment (Tidd et al., 2001).

This paper is focusing on the focused search dimension of organizational learning, because focused search is, as opposed to scanning and performance monitoring, a goal directed search process which is based on detecting solutions in reaction to actual or suspected (technical)

problems or opportunity (Huber, 1991). Focused search refers to “organizational members or units that actively search in a narrow segment of the organization’s internal or external environment, often in response to actual or suspected problems or opportunities” (Huber, 1991, p. 97). Focused search is related to policy programmes that stimulate the search of solutions for (technical) innovation problems to increase firms’ innovative activity, because a high degree of innovative activity of firms stimulates regional and/or national economic development (Oughton, Landabaso, & Morgan, 2002).

2.3 Prior related knowledge

The knowledge that is available within a firm is called in the literature a firm’s accumulated prior knowledge and experience (W. M. Cohen & Levinthal, 1990). This knowledge “includes basic skills, [...] a shared language but [...] also knowledge of the most recent scientific or technological developments in a given field” (W. M. Cohen & Levinthal, 1990, p. 128). Several scholars in the organizational learning literature also mention the term knowledge base to define the knowledge of a firm (see for instance Kogut & Zander, 1992; Zahra & George, 2002). Prior related knowledge is a collection of earlier adapted knowledge that can be used to understand new information. Prior related knowledge is a subset of a firm’s knowledge base. The term knowledge base also includes firms’ capabilities to know “how to create and transfer knowledge efficiently within an organizational context” (Kogut & Zander, 1992, p. 384). Further, the literature distinguishes several different types of knowledge: information and know-how (Kogut & Zander, 1992). Scholars argue that *information* is less complex contrary to *know-how* and easier to codify. Information is seen as knowing what, characterized by facts, propositions and symbols. Know-how refers to skills, expertise and routines (Hippel, 1988; Kogut & Zander, 1992). In this study, prior related knowledge is delineated to information and is built on a cumulative trajectory of information search and adoption.

3. Hypotheses

In this section, hypotheses are formulated on the relationship between information search and firms’ innovative output as well as the relationship between prior related knowledge and information search. For the latter, two mechanisms will be introduced that explain the relationship. Those mechanisms are the economics of information perspective (Stigler, 1961) and the absorptive capacity theory (W. M. Cohen & Levinthal, 1990). Based on these mechanisms, five factors are defined that are expected to mediate information search at organizations.

3.1 Innovation and the use of information sources

It is now well accepted that the use of external information together with the use of internal information is positive related to competitive advantage and innovation (Cassiman & Veugelers, 2006; Kogut & Zander, 1992; Teece, Pisano, & Shuen, 1997). It is thus plausible that there is a positive relationship between the use of external sources for information acquisition and firms’ innovative output.

Further, it is also likely that the use of external information sources is related to the type of innovative activity. Because fundamental information is primarily available at institutional information sources (Sorenson & Fleming, 2004) and more applied information can be found usually at market information sources (Klomp & Van Leeuwen, 2001), it is expected that

firms that search mainly at institutional information sources have a stronger link with product innovation. In addition, firms that use more often market sources to search for information have a stronger relationship with process innovation. Those relations are depicted in the following hypotheses.

Hypothesis 1a: There is a positive relationship between the use of external information sources and firms' innovative output.

Hypothesis 1b: The positive relationship between the use of external information sources and product innovation is stronger for institutional sources than for market sources.

Hypothesis 1c: The positive relationship between the use of external information sources and process innovation is stronger for market sources than for institutional sources.

3.2 Prior related knowledge and information search

3.2.1 External search

This paper uses two explanatory mechanisms to describe information search: the economics of information perspective and the absorptive capacity theory. The economics of information (EI) perspective, first described by Stigler (1961), is a prominent mechanism to describe search in economics (Stiglitz, 2000). The EI perspective states that actors search as long as the benefits of information outweigh the costs of searching (Stigler, 1961). The EI perspective is not much used as explanatory mechanism for organizational search. Some scholars in the field of organizational search mention the EI perspective, but do not use it as main explanatory mechanism (see for instance Knudsen & Levinthal, 2007; Shane, 2000). In the consumer behavior literature, however, the EI perspective is used in many studies (see for instance Beatty & Smith, 1987). The consumer literature describes two important factors that determine consumer search: invested resources and search benefits (Blackwell, Miniard, & Engel, 2001; Goldman & Johansson, 1978). In line with consumer search, invested resources and search benefits are also important determinants for organizational search (Stiglitz, 2000). Organizational resources are "firm-specific assets that are difficult if not impossible to imitate" (Teece et al., 1997, p. 515), for instance, land and equipment, labor (including employees capabilities and knowledge) and capital (tangible e.g. money and intangible e.g. time) (Mahoney & Pandian, 1992). The amount of invested organizational resources determines the organizational search costs. Also, the search costs are influenced by the risks of losing resources during the search process and the accessibility of the source. The EI perspective states that organizations always try to minimize their search costs. Organizations stop their external search process when they have enough information adopted to solve the technical problem or when the costs of continuing the search become too high. Thus, from a certain point in the search process, the EI perspective implies a negative relation between firms' prior related knowledge and the use of external information sources.

On the other hand, the absorptive capacity theory implies a positive relation between firms' prior related knowledge and the use of external information sources. Cohen & Levinthal (1990) claim that the ability to screen external information is a function of the absorptive capacity of a firm. An important source for firms' absorptive capacity is internal basic research (Dyer & Singh, 1998; Lane & Lubatkin, 1998; Rosenberg, 1990). A high degree of absorptive capacity allows organizations to comprehend new information easier. Also, the importance of a firm's routines (Zahra & George, 2002) and skills of employees (Vinding,

2006) are distinguished as important determinants of information comprehensibility. Following the absorptive capacity theory, the resources that are invested in the search process facilitate future information search investment.

The relationship between firms' prior related knowledge and the use of external information sources is thus influenced by the EI perspective (negatively) and absorptive capacity theory (positively). Combining the arguments of both theories suggest that prior related knowledge has firstly a positive relation with the use of information sources, but at a certain point, the relationship becomes negative. This presumes an inverted U-shape relationship between firms' prior related knowledge and the use of external information sources (figure 2). This U-shape relationship is confirmed by studies on consumer search behavior (E. J. Johnson & Russo, 1984; Moorthy, Ratchford, & Talukdar, 1997).

Hypothesis 2: The relationship between the size of a firm's prior related knowledge and the use of external information sources has the form of an inverted U-shape.

Insights in the organizational search literature suggest that the inverted U-shape differs for institutional and market information sources. Laursen & Salter (2004) found that just a small number of firms use universities as a source of information. These firms are often located in knowledge-intensive industrial sectors and have therefore more experience with R&D, which implies a higher amount of prior related knowledge. In addition, Cohen & Levinthal (1989) found that a higher amount of firms' prior related knowledge is needed to use (public) research institutes as information source. Because of the fundamental character of information at institutional sources (Sorenson & Fleming, 2004), more prior related knowledge is needed to comprehend the information (Laursen & Salter, 2004). This implies that the use of institutional information sources requires a higher level of prior related knowledge in contrary to the use of market information sources. This results into the following hypothesis:

Hypothesis 3: Firms that use institutional information sources adopt more information before the search costs exceed the benefits than firms that use market information sources. This means that the turning point of the inverted U-shape of institutional information sources has a higher level of prior related knowledge than the turning point of the inverted U-shape of market information sources (see figure 2).

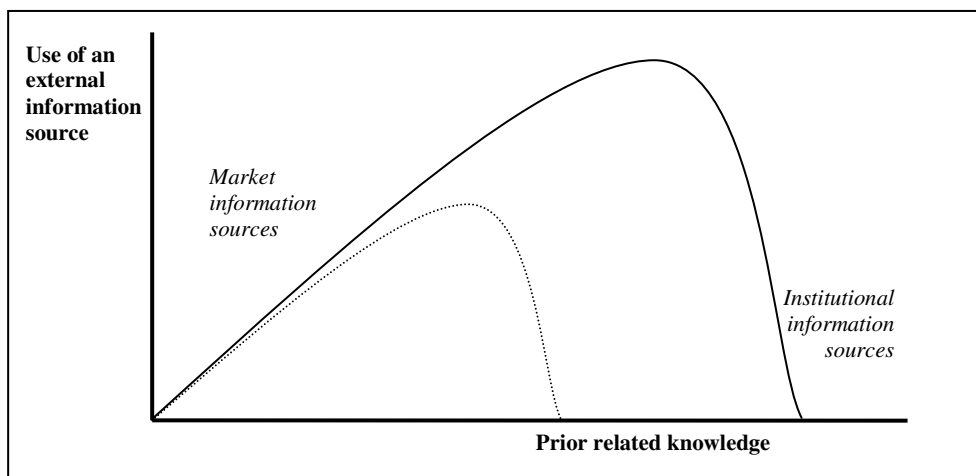


Figure 2: The relationship between the amount of a firms' prior related knowledge and the use of external information sources

3.2.2 *Mediating factors*

Based on the EI perspective and the absorptive capacity theory, five factors can be identified that are expected to explain the inverted U-shaped relationship between prior related knowledge and the use of information sources. Especially the EI perspective is expected to have a prominent role in the clarification, because the factors perceived costs, search benefits, risks and accessibility are related to this explanatory mechanism. The factor perceived comprehensibility is based on the absorptive capacity theory. For each concept, it is explained how it influences information search. This has resulted in hypothesis 4.

3.2.2.1 *Costs*

The factor *perceived costs* refers to the amount of resources that is needed to acquire information at an information source. Those resources, often mentioned as organizational capital (O'Reilly & Anderson, 1979), consist of financial costs and costs in terms of labor time (Mahoney & Pandian, 1992). Firms, especially SMEs, do not have inexhaustible budgets and are thus limited in their search effort. A reduction of the perceived search costs leads to a higher chance that the gains of information exceed the search costs, which implies an increased use of an external information source.

3.2.2.2 *Search benefits*

Information sources differ in its costs and benefits. According to the EI perspective (Stigler, 1961) and the insights from the consumer behavior literature (e.g. Goldman & Johansson, 1978), it is assumed that firms prefer information sources that contain information with high search benefits against the lowest costs. An information source with high benefits has a higher chance to exceed the costs of searching. Therefore, it becomes more attractive for firms to use. The *perceived search benefits* are therefore added as a mediating factor in the relationship between prior related knowledge and the use of external information sources.

3.2.2.3 *Risks*

The *perceived risks* of an information source refer to the chance that invested resources during search do not result in expected gains (Bolton, 1993; Bromiley, 1991; Greve, 2003). Organizational decision makers normally avoid high risks (Greve, 2003), because of the uncertainty of losing resources during the search process. Therefore, the search costs of information sources with high risks are higher compared to sources with low risks. This results in a lower chance to exceed the gains of information. Therefore, sources with high risks are less likely to be used by firms.

3.2.2.4 *Accessibility*

Some scholars claim that search behavior is highly influenced by the *perceived accessibility* of the source (Culnan, 1983; O'Reilly, 1982). Accessibility is the ease of using an information source (O'Reilly, 1982). The use frequency of an information source is lower when an information source is difficult to access. Namely, a low degree of accessibility requires the investment of more resources to adopt information. Thus, a high-perceived accessibility of an information source leads to a higher use frequency of the source. Examples of accessibility factors are the degree of geographical proximity (Acs, Anselin, & Varga, 2002; Jaffe, Trajtenberg, & Henderson, 1993; Kleinknecht & Poot, 1992) and a firm's position in its

networks (Lin & Chen, 2006; Morren, 2007; Zaheer & Bell, 2005). The network literature, for instance, emphasizes the important role of network contacts to increase the accessibility of an information source (Jensen et al., 2007; B. Johnson, Lorenz, & Lundvall, 2002; Lundvall & Johnson, 1994).

3.2.2.5 Comprehensibility

Interpretation of information is important for the adoption of information (Huber, 1991). The *perceived comprehensibility* of an information source refers to the level of organizational understanding of the external information. According to the absorptive capacity theory (W. M. Cohen & Levinthal, 1990), information comprehensibility occurs when new information fits a firm's prior related knowledge. A large amount of prior related knowledge results in a high degree of perceived understanding of external information, which leads to a more efficient search process. The information source becomes therefore attractive for firms to use.

Hypothesis 4: The relationship between prior related knowledge and information search is mediated by the factors perceived costs, search benefits, accessibility, risks and comprehensibility.

4. Research design

4.1 Sample & Data collection

In June and July 2009, about 3000 companies in the Dutch province South Holland received an invitation to participate an online questionnaire for a study of the Province South Holland. The questionnaire was part of the regional innovation monitor. The outcomes of this study help to develop policy strategies to increase the innovative activity of South Holland in the upcoming 5 years (2010-2015). The data collection is based on two sources. First, an email database from the intermediary organization Kennisalliantie is used. This organization is supported and financed by governmental institutions and a few large Dutch companies to support innovation within the South Holland region. The email database contained about 1700 innovative entrepreneurs. Because the entrepreneurs within this sample have experience with the development of new product and processes, it is a representative sample for this study. The second source for data collection is the Dutch Chamber of Commerce. 1300 companies with more than 50 employees and located in South Holland received a letter with an invitation for the online questionnaire. To ensure a representative sample of innovative firms, invitation letters for the survey are only sent to firms that are established in innovative sectors, such as horticulture, life & health sciences and transport & logistics. It is important for this study that the sample contains innovative firms, because organizational search for technical information takes especially place at this type of firms. The survey resulted in 209 respondents from which 164 completed the questionnaire. Appendix A displays the operationalization scheme. The following sections use this scheme to discuss the measurement.

4.2 Measurement

4.2.1 Innovative output

In the questionnaire, participants indicated the innovative output of their firms based on the number of developed product and process innovation the last three years. For both types of innovation, the respondents answered the question how many innovations they have

developed. The answer is based on a five-point scale from “0 product/process innovations during the last three years” (=1), “1 innovation” (=2), “2 innovations” (=3), “3 innovations” (=4) or “more than 3 innovations” (=5). Appendix B presents the descriptive statistics of these variables.

4.2.2 *Use of an external information source and mediating factors*

In the survey, the respondents also answered questions with regard to organizational search for information. People were asked to answer questions about their use, the perceived costs, accessibility, risks, search benefits and comprehensibility of the following information sources: 1) universities and other high educational institutes, 2) other public research organizations (e.g. TNO), 3) other public institutions 4) private research organizations, 5) consumers, 6) other clients or users, 7) suppliers, 8) competitive firms and 9) (non-competitive) networks of entrepreneurs. For the use and the perceived accessibility of information sources, the participants gave their opinion on a proposition on a five-point scale that varied from “fully disagree” to “fully agree”. The questions about the perceived costs and risks contained a five-point scale from “very low costs/risks” to “very high costs/risks”, the question about the perceived comprehensibility were answerable with a five-point scale from “very low level of comprehensibility” to “very high level of comprehensibility” and finally, the question about the degree of valuable information contained a five-point scale from “not very valuable” to “very valuable”. An exploratory principal component factor analysis for the dependent variable *use of an information source* revealed that a two-factor solution best fits the data. The two factors are institutional and market information sources, which confirm the findings by Laursen & Salter (2004). The solution is modeled in a confirmatory factor analysis. The mediating factors are also modeled in this two-factor solution. Table 1 presents the measurement model for the dependent variable and mediating factors. Appendix C displays the descriptive statistics.

Table 1: The measurement model for the dependent variable use of information sources and mediating factors

Indicator	Explained variance						Latent variable
	Use	Costs	Search benefits	Risks	Access-ibility	Comprehen-sibility	
Universities and other high educational institutes	0.64	0.61	0.65	0.53	0.63	0.71	Institutional information sources
Other public research organizations (e.g. TNO)	0.65	0.77	0.60	0.65	0.65	0.73	
Other public institutes	0.65	0.57	0.67	0.58	0.49	0.49	
Private research organizations	0.43	0.66	0.40	0.62	0.51	0.60	Market information sources
Consumers	0.40	0.62	0.43	0.46	0.46	0.53	
Other clients or users	0.59	0.78	0.58	0.63	0.67	0.78	
Competitive firms	0.49	0.61	0.44	0.54	0.49	0.70	
Suppliers (Non-competitive) networks of entrepreneurs	0.56 0.51	0.53 0.57	0.49 0.55	0.59 0.53	0.53 0.43	0.67 0.63	

4.2.3 Prior related knowledge

Prior related knowledge was measured by four indicators: the number of high-educated employees, the number of registered patents (the last three years), the time used for documentation of knowledge and the amount of R&D expenditures. The number of high-educated employees is a result of multiplying the indicators firm's total number of employees with the percentage of employees that are high educated. The number of registered patents was measured on a five-point scale from "0 patents" to "more than 3 patents". The indicator firm's time that is used for documentation of knowledge is based on a question with a five-point answer scale from "fully disagree" to "fully agree". The R&D expenditures are measured in Euros. However, the distribution of the R&D expenditures is skewed. To create a more gradual scale, the natural logarithm of R&D expenditures plus one $(\ln+1)$ ¹ was used. This is unlikely to causing measurement difficulties, because the marginal innovative output is measured until three innovations². Exploratory principal component factor analysis was used to reveal which indicators best fitted the data. Table 2 presents the measurement model for the confirmatory factor analysis. The descriptive statistics of the indicators related to prior related knowledge are presented in appendix D.

¹ To prevent a method error for firms that spent 0 Euro on R&D. One euro on this distribution is assumed to be imperceptible.

² The highest score for the innovative outcome indicators is "more than 3 innovations".

Table 2: The measurement model for the independent variable		
Indicator	Explained variance	Latent variable
Number of high-educated employees	0.61	Prior related knowledge of a firm
Number of registered patents (the last three years)	0.60	
Time used for documentation of knowledge	0.39	
R&D expenditures (natural logarithm)	0.38	

4.2.4 Control variable

The respondents have indicated their SBI-code in the questionnaire. The SBI-code is a classification of economic activities and is used by the Dutch central statistics agency (CBS) and the Chamber of Commerce. The SBI-code is based on the classification of the European Union (Nomenclature statistique des activités économiques dans la Communauté Européenne: NACE) and the United States (International Standard Industrial Classification of All Economic Activities: ISIC). The firms that responded to the survey have their roots in several different sectors. The type of innovation can be dependent on the sector in which a firm is located (Pavitt, 1984). Also, the sector can influence the type of information source that a firm uses to obtain information (Pavitt, 1984). Therefore, based on the SBI classification, firms are divided into one of the five categories of the Pavitt taxonomy: supplier-dominated (1), scale-intensive (2), specialized supplier (3), science-based (4) and information-intensive (5) (Pavitt, 1984; Tidd et al., 2001). Appendix E presents the frequency table and bar chart. To eliminate the influence of a firm's sector, they are added as dummy variables to the analyses.

4.3 Analysis

The analysis is divided in three parts. First, the relationship between the use of information sources and firms' innovative output is modeled. Secondly, a model is performed that tests the relationship between prior related knowledge and the use of information sources. Thirdly, the influence of the mediating factors on the relationship between prior related knowledge and the use of external sources is tested. The control variable sector is added to all models. Table 3 gives an overview.

Table 3: Overview of the dependent variables, independent variables and hypotheses						
Independent variables	Dependent variables					
	Innovative output		Use of external information sources		Use of external information sources	
	Product and process innovation (yes/no)	Number of product and process innovations	Use of institutional information sources ^a	Use of market information sources ^a	Use of institutional information sources ^a	Use of market information sources ^a
Use of institutional information sources ^a Use of market information sources ^a	H1, H1a, H1b					
Prior related knowledge Prior related knowledge (squared) Mediating factors			H2, H3		H4	

a: These variables are both used as an independent and dependent variable (different analyses).

First, two binary logit models are estimated. The dependent variable is a dummy that signifies whether a firm has introduced one type of innovation or not (based on the innovative output indicators); the independent variables are the use of institutional sources and the use of market sources. Binary logit models are used to test if there is a positive relation between the use of external information sources and innovative output. Next, to test if the use of external information sources is differently related to the amount of innovative output (the number of product or process innovations), two ordinal regression analyses are fitted. Ordinal regression analyses are used, because the dependent variables number of product innovations and number of process innovations are categorically arranged. Ordinal regression analysis offers the possibility, contrary to linear regression and the binary logit models, to add variables that are categorically arranged. The first ordinal regression model tests the relationship between the use of external information sources (institutional and market sources) and the number of product innovations. In addition, the relationship between the use of external information sources and the number of process innovations is examined. The ordinal regression models used the same variables as the binary logit models.

Next, linear regression analyses are fitted to test hypotheses H2, H3 and H4. This model contains two dependent variables: use of institutional information sources and use of market information sources. The independent variables are prior related knowledge and to test the inverted U-shape relationship, the squared term of prior related knowledge. To test hypothesis 3, mediating factors are added into the linear regression model. Also, a Pearson correlation matrix is used to study the influence of the mediating factors (see appendix F). The regression analyses in this model are performed in three blocks. The first block contains the independent variables. The second block contains the mediating factors. The third block contains the dummy variables sector.

5. Results

Following the conceptual model, the results are divided in three sections. Firstly, the outcomes of the binary logit models and the ordinal regression analyses will be discussed, secondly, the results of the linear regression models will be presented and thirdly, the role of the mediating factors will be discussed.

5.1 Innovative output

The results (table 4) of the binary logit models show that product innovation is only positively predicted by institutional sources (Wald's effect size 7.880) and process innovation is only positive predicted by market information sources (Wald's effect size 8.371). These results confirm the findings by Sorenson & Fleming (2004) and Klomp & Van Leeuwen (2001). These scholars imply that firms that search mainly at institutional sources have a stronger link with product innovation; firms that primarily use market sources have a stronger relationship with process innovation. However, the results from the ordinal regression models show that the use of institutional and market information sources have both significant positive relationships with the number of product and process innovations (see table 4). The effect of the use of information sources on the number of innovations differs in sizes. The use of institutional information sources has a larger estimator value than the use of market information sources. A larger value implies a higher probability that a higher category is scored for the dependent variable (number of product and process innovations). This result is emphasized by the values of the Wald statistics of the ordinal regression analyses. This statistic method demonstrates that the relationship between the use of information sources and the number of product innovations is stronger for the use of institutional information sources (effect size 8.528) compared to market information sources (effect size 5.475). The relationship between the use of institutional information sources and the number of process innovations (effect size 9.619) is also stronger than the relationship between market information sources and the number of process innovations (effect size 4.699). These results are in line with the theoretical predictions (hypothesis 1, 1a and 1b). Further, the analyses show that the control variable sector has little effect on innovative output. Only firms that are characterized as specialized supplier positively influence the relationship between the use of information sources and the number of product innovations (Wald's statistics effect size 5.944).

Table 4: Output table for innovative output					
		Innovative output			
		Product innovation (yes/no)	Process innovation (yes/no)	Number of product innovations (ordinal)	Number of process innovations (ordinal)
Model performance	Intercept	1.840 ***	1.372 **		
	Use of institutional information sources	0.686 **	0.196	0.498 **	0.533 **
	Use of market information sources	0.266	0.594 **	0.395 *	0.373 *
	Control variable sector (Pavitt sector)			0.468	0.714
	Supplier dominated			0.319	0.487
	Scale intensive	-0.043	-0.139	1.126 *	-0.633
	Specialized supplier Science based			0.848	0.781
Information intensive			0 ^a	0 ^a	
Nagelkerke's R ²	0.166	0.144	0.194	0.198	
Sig.	0.001 **	0.001 **	0.000 ***	0.000 ***	

* p < 0.05

** p < 0.01

*** p < 0.001

a This parameter is set to zero because it is redundant

5.2 Use of external information sources

Both linear regression models that test the relationship between prior related knowledge and the use of external information sources are significant ($p < 0.05$). The dummy variables sector do not significantly influence the model. The addition of the dummy variables has therefore no effect on the relationship between prior related knowledge and the use of external information sources. Further, the explained variance for the relationship between prior related knowledge and the use of market information sources has a R^2 of 0.066, which indicates that a high degree of variance is left on explained. The relationship between prior related knowledge and the use of institutional information sources has a high explained variance ($R^2 = 0.274$). Table 5 presents the outcomes of the regression analyses; the results are given as unstandardized effect sizes.

Table 5: Output table for the use of external information sources			
		Use of external information sources	
		Use of institutional information sources	Use of market information sources
Control variable sector	Intercept	0.122	0.251
	Prior related knowledge	0.745 ***	0.452 ***
	Squared term prior related knowledge	-0.145 ***	-0.112 **
	Scale intensive	-0.023	0.058
	Specialized supplier	0.281	-0.277
	Science based	-0.190	-0.344
	Information intensive	0.003	0.105
Model performance	Adjusted R ²	0.274	0.066
	Sig.	0.000 ***	0.010 *

* p < 0.05
 ** p < 0.01
 *** p < 0.001

The relationship between prior related knowledge and the use of external information sources has the form of an inverted U-shape, which confirms hypothesis 2 and figure 2. It is hypothesized in this paper that the turning points of the inverted U-shapes are reached when the costs of using the external information source becomes too high compared to the search benefits. The x-coordinates of the turning points of the inverted U-shaped relationships are, according to the formula $x_{max} = -b / 2a$, 2.57 for the use of institutional information sources and 1.85 for the use of market information sources. The values of the turning points are, because of the factor analysis, based on standardized variables. The variable prior related knowledge is therefore characterized by the standard normal probability distribution from which the values are distributed around a mean $\mu = 0$ with a standard deviation $\sigma = 1$. As a result, the x-values of the turning points can be translated to the number of standard deviations from the mean, the Z value. For the use of institutional information sources, the value of Z is 2.57. The Z value for the turning point of market information sources is 1.85. Statistics offer the possibility to calculate the probability that an actor from the population is beyond a given Z value. For the turning point of institutional information sources, the probability is 0.5% (Wonnacott & Wonnacott, 1990). This implies that 0.5% from 164 firms, 0.82 firms, are beyond the turning point. For market information sources, the probability value is 3.2%, which implies that 3.2% from 164 firms, 5.25 firms, are beyond the turning point. It is therefore, questionable if the relationship between prior related knowledge and the use of institutional sources really has the form of an inverted U-shape. The dataset contains namely very little empirical cases that lie behind the turning point of institutional sources (0.82 firms). In this study, it is hypothesized that the relationship becomes negative after the turning point, but it is also possible that the relationship becomes constant. The lack of empirical data could also be a sign that the turning point of institutional sources lays even further from the mean than is calculated above. The curve of market sources is more predictable. The cases (5.25 firms) that lie behind the turning point of market sources gives reasonable indication that the relationship between prior related knowledge and use of market sources is characterized by an inverted U-shape.

If we, in spite of the limitations, assume that prior related knowledge and the use of institutional sources are inverted U-shaped related to each other, the turning point of

institutional sources has a higher level of prior related knowledge than the turning point of market sources. This confirms hypothesis 3. Firms that use institutional sources, longer experience the need to continue searching to increase their prior related knowledge than they do at market sources. Namely, for market sources, the costs of searching earlier surpass the benefits. Firms with a relatively high degree of prior related knowledge could therefore decide to stop searching at market sources and start searching at institutional sources.

5.3 Mediating factors

The outcomes of the linear regression model with the addition of the mediating factors are presented in table 6.

		Use of external information sources	
		Use of institutional information sources	Use of market information sources
	Prior related knowledge	0.179 *	0.035
	Squared term prior related knowledge	-0.036	-0.010
	Perceived costs	-0.026	0.031
	Perceived benefits	0.719 ***	0.672 ***
Mediating factors	Perceived accessibility	0.022	0.060
	Perceived risks	0.011	-0.092
	Perceived comprehensibility	0.073	0.029
	Scale intensive	-0.118	0.084
	Specialized supplier	0.233	0.010
	Science Based	0.018	-0.036
	Information Intensive	-0.057	-0.123
Control variable sector			
Model performance	Adjusted R ²	0.692	0.579
	Sig.	0.000 ***	0.000 ***

* p < 0.05
 ** p < 0.01
 *** p < 0.001

The addition of the mediating factors results in a higher value of the explained variance. Especially the explained variance of market sources is increasingly higher ($R^2 = 0.608$) compared to the explained variance of the regression model without the mediating factors. According to the results of the regression model, this difference is completely based on the influence of the perceived benefits of an information source, because the other mediating factors are masked by the perceived benefits of an information source. The regression models

also show that the influence of prior related knowledge is distinguished. As a result, the inverted U-shaped relationships between prior related knowledge and the use of institutional and market information sources are mediated out by the perceived benefits of an information source. These findings are not fully in line with the theoretical predictions, because it was expected that the mediating factors explain the inverted U-shape relationship. However, the relationship between prior related knowledge and information search is mediated by the perceived benefits, which partly confirms hypothesis 4.

The results of the previous regression model show the importance of the mediating factor perceived benefits of an information source. The other mediating factors seem to be masked out by the perceived benefits³. Therefore, to study the relations between the other mediating factors and the use of market and institutional sources, a Pearson correlation matrix is composed. The matrix shows that the mediating factors perceived benefits, perceived accessibility and perceived comprehensibility have a significant positive relationship with the use of institutional and market sources. The factor perceived comprehensibility, based on the AC theory, and the factors perceived benefits and accessibility, which represent the EI perspective, were also expected to have a positive relationship with the use of external information sources. The results are thus in line with the theoretical predictions. The decrease of the use of an information source, which is predicted by the EI perspective at a certain point in the search process, should be based on the increase of the perceived risks and the perceived costs. The factor perceived risks is indeed negatively related to the use of both external information sources, which is in line with the presumptions from the EI perspective. However, the results of the factor perceived costs differs from the EI assumptions. The perceived costs do not have a significant relationship with the use of market sources and are positively related to the use of institutional sources. This implies that an increase of the search costs results in an increase of the use of institutional sources. It is therefore debatable whether the EI perspective is a good theoretical predictor of organizational search behavior. It seems that the factor search costs is, in contrary to consumer search, not a very important determinant for the search behavior of firms. However, there are no empirical papers that could confirm or decline that, which emphasizes the underdevelopment of explanatory mechanisms for organizational search (Knudsen & Levinthal, 2007). A possible argument for the remarkable results is that the perceived search benefits are more important for organizations than the perceived search costs⁴. Based on this argument, it can statistically be explained that the perceived costs are not related to the use of market sources. Because the data of this study showed a clear inverted U-shape for the use of market information sources, it is difficult to make a linear prediction between the perceived costs and the use of market sources. This explains also why the perceived costs have a positive relationship with the use of institutional sources. Because of the little empirical data behind the turning point of the curve of the use of institutional sources, there is not a clear inverted U-shape. It is therefore likely that a positive relationship between the perceived costs and the use of institutional sources is predicted.

³ Another exploratory linear regression analysis is performed to study which factors influence the perceived benefits of an information source (see appendix G for the results). Unfortunately, this model offers insufficient insights on the influence of the other factors on the perceived benefits.

⁴ This is confirmed by higher predictors in the correlation matrix of perceived benefits, in contrary to the perceived costs.

6. Conclusions

The aims of this study were twofold. This study provided empirical results on the relationship between information search and innovation and it offers empirical evidence on the relationship between firms' level of prior adapted knowledge and external information search.

The results demonstrated a positive relationship between the use of external information sources and firms' innovative output. It is revealed that product innovation is positively predicted by institutional sources, whereas process innovation is positively related to market sources. It is therefore in line with theoretical predictions of Sorenson & Flemings (2004) and Klomp & Van Leeuwen (2001), who state that product innovation is mainly dependent on the fundamental knowledge of institutional sources and process innovations is more related to practical information at market sources. However, this study showed further that the number of firms' product and process innovations are dependent on both sources. Firms' search strategies in shaping innovative activities are thus more complex than current organizational learning literature studies described. Other scholars namely focused on firms' search behavior at a single information source, as university-industry linkage (see for instance Laursen & Salter, 2004; Spencer, 2001) or other firms (Crossan & Bapuji, 2004). This study extended recent research on organizational search by showing that successful innovation requires search investment at both institutional and market sources. For firms, it is thus most important to use institutional sources for the development of product innovations, but it should also focus on market sources to increase their innovative output. The same holds for process innovation. Although market sources are the most important source of information, a higher number of process innovations is only achieved when firms use both institutional and market sources.

The results demonstrate further that the hypothesized inverted U-shaped relationship between firms' prior related knowledge and the use of external information sources is confirmed. Firms that use institutional information sources could adopt more information before the search costs exceed the benefits than firms that use market information sources. These findings are in line with the combined theoretical insights from the economics of information (Stigler, 1961) and absorptive capacity perspectives (W. M. Cohen & Levinthal, 1990). The results of the analyses of the mediating factors also confirmed the theoretical predictions. However, only the perceived costs demonstrated remarkable results. It has not a relationship with market sources and is positively related to institutional sources. These findings are not in line with the theoretical predictions and imply that the negative curve of the inverted U-shape is only caused by the perceived risks of a source. High risks of losing resources during the information search process are thus the only reason for a decline of the use of an external source. That explains why organizational decision makers often avoid high risks (Greve, 2003), but it mismatches with the claims of Stiglitz (2000), who states that firms always minimize their search costs. Therefore, it is debatable whether the EI perspective is suitable as an explanatory mechanism for organizational search behavior. The predictions of the AC theory are, on the other hand, confirmed in this study. A higher level of prior related knowledge causes more comprehensibility of external information, which increases the use of external sources. More use of information sources results in turn on more innovative output. Prior related knowledge is thus an important factor in a firm's innovation process (W. M. Cohen & Levinthal, 1990). This study demonstrated that prior related knowledge is important for the development of innovations by finding solutions on (technical) innovative problems, but it also play a significant role in the scanning phase of the innovation process by discovering innovative opportunities (Shane, 2000). It thus seems that the AC theory is performing well as explanatory mechanism for organizational search.

7. Discussion

7.1 Limitations

This study has limitations with regard to the sample. First, the response rate of the questionnaire was rather low. Many entrepreneurs were approached to fill in the survey, but they probably had low priority to fill in the survey, which resulted in the high rate of non-response. The sample of this study is therefore too small to form a true representation of the populations. Also, the survey contained only innovative firms. Future research has to confirm and extend this study's results by using a larger and more representative sample. Further, this paper has focused only on the concepts of prior related knowledge, search, use of information sources and innovative output. In the organizational and information search literature, many other related concepts are distinguished that are not discussed in this study, such as procedural knowledge (J. R. Anderson, 1982; M. D. Cohen, 1991), know-how (Grant, 1996; Jensen et al., 2007) and tacit knowledge (e.g. Cowan & Foray, 1997). Future research also needs to take these concepts into account.

7.2 Theoretical implications

Despite these limitations, this study contributes to the comprehensibility of organizational search behaviour. In spite of the recognition that innovation needs the search of external information, the empirical literature on the relationship between information search and innovation is scarce (e.g. Crossan & Bapuji, 2004). This paper puts a first step in the direction of the development of it. This study builds on earlier findings about organizational learning processes (Huber, 1991) and especially about organizational search behaviour (Katila & Ahuja, 2002; Katila, 2002). This study extends the findings of those authors by providing empirical evidence on search behaviour at external sources. The inverted U-shape relationships between prior related knowledge and the use of external sources are in line with findings from Meeus et al. (2004). This study has further made a first step in bridging the current underdevelopment of explanatory mechanisms in the organizational search literature (Knudsen & Levinthal, 2007). Thereby, it extends on a study by Shane (2000). This scholar already used the insights of the EI perspective and AC theory to emphasize the importance of prior related knowledge in the scanning search process for the recognition of entrepreneurial opportunities. Future empirical research will have to confirm and expand the findings of Shane (2000) and this study to create wide acceptance of explanatory mechanisms to understand organizational search behavior. The understanding of search behavior of firms is namely important, because the uncertainty of innovation always leads to the need and, therefore, the search of information. A larger research sample is needed to verify whether the proposed inverted U-shape of institutional sources is correct.

Future theoretical endeavors also have to reveal the role of the perceived costs in relation to the use of information sources to draw conclusions on the capability of the EI perspective as explanatory mechanism for organizational search behavior. The remarkable results on the role of the perceived costs of an information source are not in line with the theoretical predictions of Stigler (1961) and Stiglitz (2000). According to the resource-based view of the firm (Mahoney & Pandian, 1992), resources, which include search costs, are a very important determinant for achieving competitive advantage and have to be invested on an efficient way to attain economic rents. It is therefore unlikely that search costs have a positive (institutional sources) or have not a (market sources) relationship with the use of external information

sources. There thus needs to be an utilization argument for search. Although the remarkable results of the perceived costs, this study has, however, showed evidence for an economic explanation of organizational search. Future research has to verify that.

7.3 Managerial and policy implications

A better understanding of firms' search behaviour to develop innovations also has important implications for the European Institute of Innovation and Technology and national policy makers that intent to increase knowledge transfer. They have to focus their policy programmes on promoting search strategies that focuses on the use of both institutional and market sources. Policy markers have to promote institutional sources of information by decreasing the difficulties that firms experience by using institutional sources. The results showed that the maximum of the inverted U-shape of market sources is earlier reached than the maximum of the inverted U-shape of institutional sources. Institutional sources are apparently more difficult to use. Especially when firms reach the maximum of market sources, they also should use institutional sources. When managers are mastering the capability to combine the use of institutional and market sources, this will result in more innovative output. Research by Levinthal and March (Levinthal & March, 1993) already showed that many organizations have the propensity to specialize in one form of search behavior (e.g. internal or external focus). Managers have to be convinced to change their search strategy to one that focuses on both types of external sources. This emphasizes the importance for managers to master dynamic capabilities (Teece et al., 1997; Tripsas & Gavetti, 2000; Zollo & Winter, 2002) to reconfigure their firms' search behavior. "Dynamic" refers to the capacity of a firm to change their competences (Teece et al., 1997): firms' information search process must focus on information available within and outside the market. The term "capabilities" emphasizes the role of management to realize a change in firms' search competences. A better development of firms' dynamic capabilities for information search processes has important implications for managers. Focused search is needed to find new information to develop innovations. Mastering dynamic capabilities for search strategies such as the ability to both find and combine fundamental and applied information at diverse sources, can provide a more stable basis for a larger innovative output.

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Appendix A

The survey uses several indicators to measure the dependent and independent variable, and mediating factors. Table 8 schematically presents the operationalizationscheme.

Table 7: Operationalization scheme			
Variable	Dimension	Indicator	Measurement scale
<i>Innovative output</i>	Development of innovations	Development of product innovations	Binary scale: No = 0; Yes = 1
		Development of process innovations	
	Number of innovation	Number of implemented product innovations last three years	Likert scale 1-5: 1 = 0 product innovations; 5: 3 or more product innovations
		Number of implemented process innovations last three years	
<i>se of an external information source</i>	Institutional information sources	Use frequency of institutional information source 1. universities and other high educational institutes, 2. other public research organizations (e.g. TNO), 3. other public institutes 4. private research organizations	Likert scale 1-5: Degree of experienced risks; 1 = very low, 5 = very high
	Market information sources	Use frequency of market information source 5. consumers, 6. other clients / users, 7. suppliers, 8. competitive firms, 9. (non-competitive) networks of entrepreneurs	Likert scale 1-5: Degree of experienced risks; 1 = very low, 5 = very high
<i>Prior related knowledge</i>	Educational level of employees	Total number of employees	Ratio scale
		Percentage of high-educated employees	Ratio scale
	Patents	Number of patents (the last three years)	Likert scale 1-5. 1 = 0 patents, 2 = 1 patent, 3 = 2 patents, 4 = 3 patents, 5 = more than 3 patents.
	Knowledge documentation	Time used for documentation of knowledge	Likert scale 1-5 from 1 = very less time to 5 = many time
	R&D expenditures	Expenditures in innovation activities (last year) (e.g. in-house R&D, acquisition of R&D & external knowledge, training, etc.)	Euros
<i>Mediating factors</i>	Perceived costs	The perceived costs of an information source in terms of financial costs, labor time, effort, etc. 1. universities and other high educational institutes, 2. other public research organizations (e.g. TNO), 3. other public institutes 4. private research organizations, 5. consumers, 6. other clients / users, 7. suppliers, 8. competitive firms, 9. (non-competitive) networks of entrepreneurs	Likert scale 1-5 1 = very low; 5 = very high
	Perceived accessibility	The perceived accessibility of an information source 1. universities and other high educational institutes, 2. other public research organizations (e.g. TNO), 3. other public institutes 4. private research organizations, 5. consumers, 6. other clients / users, 7. suppliers, 8. competitive firms, 9. (non-competitive) networks of entrepreneurs	Likert scale 1-5: 1 = very easy, 5 = very demanding
	Perceived risk	The perceived risks of an information source 1. universities and other high educational institutes, 2. other public research organizations (e.g. TNO), 3. other public institutes 4. private research organizations, 5. consumers, 6. other clients / users, 7. suppliers, 8. competitive firms, 9. (non-competitive) networks of entrepreneurs	Likert scale 1-5: Degree of experienced risks; 1 = very low, 5 = very high
	Perceived benefits	The perceived benefits of an information source 1. universities and other high educational institutes, 2. other public research organizations (e.g. TNO), 3. other public institutes 4. private research organizations, 5. consumers, 6. other clients / users, 7. suppliers, 8. competitive firms, 9. (non-competitive) networks of entrepreneurs	Likert scale 1-5: Degree of experienced risks; 1 = very low, 5 = very high
	Perceived comprehensibility	The comprehensibility of an information source 1. universities and other high educational institutes, 2. other public research organizations (e.g. TNO), 3. other public institutes 4. private research organizations, 5. consumers, 6. other clients / users, 7. suppliers, 8. competitive firms, 9. (non-competitive) networks of entrepreneurs	Likert scale 1-5: 1 = very incomprehensible; 5 = very comprehensible
<i>Control variable</i>	Sector	Firm's sector	Based on SBI code

Appendix B

Indicator	Median	Minimum	Maximum
Number of Product innovations	3	1	5
Number of Process innovations	2	1	5

a: Indicators are measured on a five-point scale.

Appendix C

Table 9: Descriptive statistics of indicators related to use of external information sources and mediating factors^a

Indicator	Use (N=164)			Costs (N=164)			Accessibility (N=164)			Risks (N=164)			Search benefits (N=164)			Comprehensibility (N=164)		
	Media n	Minimum	Maximum	Media n	Minimum	Maximum	Media n	Minimum	Maximum	Media n	Minimum	Maximum	Media n	Minimum	Maximum	Media n	Minimum	Maximum
Universities and other high educational institutes	4	1	5	3	1	5	4	1	5	3	1	5	4	1	5	4	1	5
Other public research organizations (e.g. TNO)	3	1	5	3	1	5	3	1	5	3	1	5	3	1	5	4	1	5
Other public institutes	3	1	5	2	1	5	3	1	5	3	1	5	3	1	5	3	1	5
Private research organizations	3	1	5	4	1	5	3	1	5	3	1	5	3	1	5	3	1	5
Consumers	3	1	5	2	1	5	3	1	5	3	1	5	3	1	5	3	1	5
Other clients or users	4	1	5	2	1	5	4	1	5	3	1	5	4	1	5	4	1	5
Suppliers	4	1	5	2	1	5	4	1	5	3	1	5	4	1	5	4	1	5
Competitive firms	4	1	5	3	1	5	3	1	5	3	1	5	4	1	5	4	1	5
(Non-competitive) networks of entrepreneurs	4	1	5	2	1	5	4	1	5	3	1	5	4	1	5	4	1	5

a: Indicators are measured on a five-point scale.

Appendix D

Table 10: Descriptive statistics of indicators related to prior related knowledge (N=164)

Indicator	Mean / Median	Minimum	Maximum
Number of high-educated employees	252	0	6000
Number of registered patents (the last three years)	1 ^a	1	5
Time used for documentation of knowledge	4 ^a	1	5
R&D expenditures (natural logarithm)	9	0	19,6

a: Indicators are measured on a five-point scale.

Appendix E

Table 11: Descriptive statistics of indicators related to control variable sector (N=164)			
Answer possibilities	Frequency	Percentage	Cumulative Percentage
1: Supplier dominated	39	23.8	23.8
2: Scale intensive	27	16.5	40.2
3: Specialized supplier	27	16.5	56.7
4: Science based	16	9.8	66.5
5: Information intensive	55	33.5	100.0

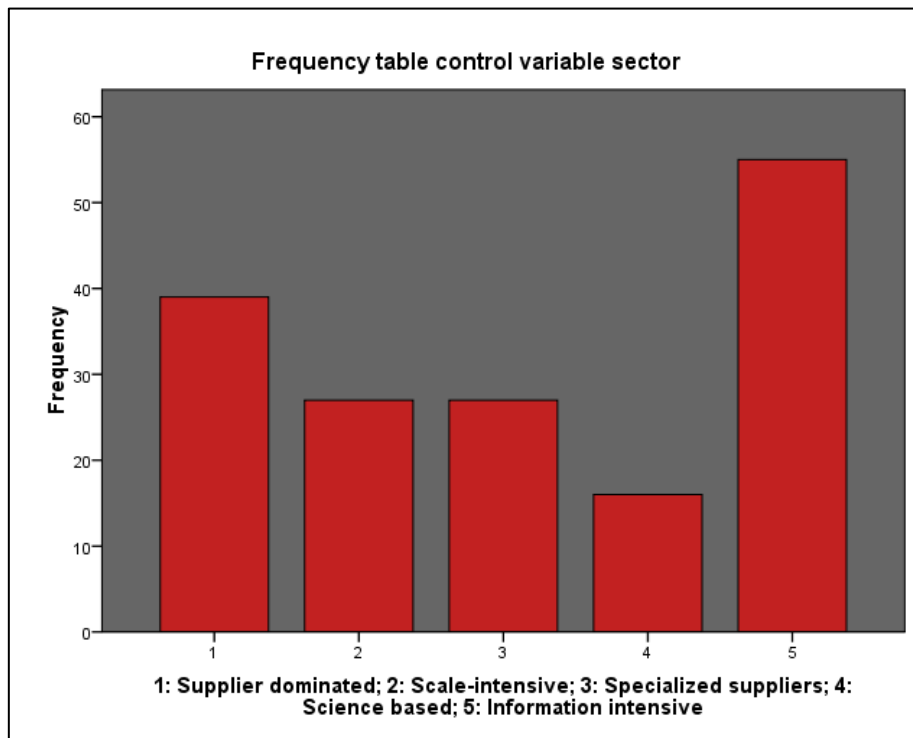


Figure 3: Frequency table control variable sector (N=164).

Appendix F

Table 12: Pearson Correlation matrix

Variable	Pavitt sectors	Prior related knowledge	Use of institutional sources	Perceived benefits (institutional sources)	Perceived accessibility (institutional sources)	Perceived costs (institutional sources)	Perceived risks (institutional sources)	Perceived Comprehensibility (institutional sources)	Use of market sources	Perceived benefits (market sources)	Perceived accessibility (market sources)	Perceived costs (market sources)	Perceived risks (market sources)	Perceived Comprehensibility (market sources)
Pavitt sectors	1.000													
Prior related knowledge	-0.033	1.000												
Use of institutional sources	-0.052	0.439**	1.000											
Perceived benefits (institutional sources)	-0.036	0.411**	0.823**	1.000										
Perceived accessibility (institutional sources)	0.053	0.219**	0.394**	0.433**	1.000									
Perceived costs (institutional sources)	0.005	0.100	0.177*	0.230**	0.024	1.000								
Perceived risks (institutional sources)	-0.052	-0.306**	-0.542**	-0.621**	-0.516**	-0.263**	1.000							
Perceived Comprehensibility (institutional sources)	-0.081	0.354**	0.483**	0.489**	0.478**	0.169*	-0.638**	1.000						
Use of market sources	-0.008	-0.176*	0.456**	0.462**	0.031	0.212**	-0.339**	0.175*	1.000					
Perceived benefits (market sources)	0.078	0.188*	0.348**	0.523**	0.017	0.224**	-0.325**	0.175*	0.764**	1.000				
Perceived accessibility (market sources)	0.019	0.018	0.115	0.167*	0.416**	0.026	-0.275**	0.170*	0.380**	0.394**	1.000			
Perceived costs (market sources)	-0.022	0.087	0.189*	0.185*	0.089	0.541**	-0.262**	0.179*	0.091	0.067	-0.138	1.000		
Perceived risks (market sources)	-0.033	-0.161*	-0.232**	-0.346**	-0.135	-0.295**	0.504**	-0.282**	-0.540**	-0.591**	-0.525**	-0.139	1.000	
Perceived Comprehensibility (market sources)	-0.057	0.221**	0.234**	0.266**	0.106	0.199*	-0.341**	0.525**	0.380**	0.407**	0.383**	-0.018	-0.478**	1.000

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Appendix G

Table 13: Output table for exploratory linear regression analysis of perceived benefits			
		Perceived benefits of an external information source	
		Perceived benefits of institutional information source	Perceived benefits of institutional information source
	Perceived costs	0.089	0.018
	Perceived accessibility	0.142	0.094
	Perceived risks	-0.447 ***	-0.469 ***
	Perceived comprehensibility	0.121	0.147 *
Model performance	Adjusted R ²	0.404	0.360
	Sig.	0.000 ***	0.000 ***

* p < 0.05
 ** p < 0.01
 *** p < 0.001