How Internal and External Sources of Knowledge Contribute to Firms' Innovation Performance

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This paper investigates the extent to which different knowledge sources contribute to firms' innovation performance. The empirical analysis estimates the relationships in the structural model of the influence of knowledge sources on innovative performance using data collected through personal interviews at 303 firms. The results reveal that internal sources have the most important influence on firms' innovative performance and confirm that, in their innovation process, firms mostly rely on knowledge developed through in-house R&D efforts, continuous improvement, and internal education and training programs. The data show that in-house learning is not sufficient for generating innovation and that firms need to supplement internal knowledge with knowledge acquired outside the firm. They mainly need to secure links with firms and institutions in the global environment if they want to secure the inflow of new ideas and approaches that will eventually lead to innovations.

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Introduction

An interactive view of innovation has been developed within the framework of a learning economy, in which innovation is seen as a technical and social process based on the complex interaction between firms and their environment (Asheim and Isaksen 1997). Most authors agree that the use of internal and external knowledge sources contributes positively to firms' innovation performance, but the relationship has been empirically tested only to a limited extent (Capello 1999; Caloghirou, Kastelli, and Tsakanikas 2004; Capello and Faggian 2005). This paper investigates the extent to which various knowledge sources contribute to firms' innovation performance. More specifically, it identifies on the one

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hand the level of importance of internal knowledge sources embodied mainly in in-house R&D efforts. On the other hand, it looks at external sources of knowledge and identifies how the use of local, national, and international knowledge sources determines firms' innovation performance. This paper extends the work of other scholars as to what are the sources of innovation, by considering how knowledge sources at different spatial levels influence the innovation performance of firms. While most authors analyzed the role of external knowledge sources in general (Caloghirou, Kastelli, and Tsakanikas 2004; Willoughby and Galvin 2005; Tsai and Wang 2007; Love and Mansury 2007), we divide them according to the geographical proximity to the observed firm. As such, this is one of the few empirical papers that assesses simultaneously to what extent internal, local, national and international knowledge sources contribute to firms' innovation.

The empirical analysis is based on a survey that was carried out in seven European countries: the Czech Republic, Germany, Italy, Poland, Romania, Slovenia, and the United Kingdom. The relationships in the structural model of the influence of sources of knowledge on innovation performance are estimated using data collected through personal interviews at 303 firms. The results reveal that internal sources have the most important influence on firms' innovative performance and confirm that, in their innovation process, firms mostly rely on knowledge developed through in-house R&D efforts, continuous improvements and internal education, and training programs. The data show that in-house learning alone is not sufficient for generating innovation and the firms need to supplement internal knowledge with knowledge acquired outside the firm. They mainly need to secure links with firms and institutions in the extra-local environment in order to secure the inflow of new ideas and approaches that will eventually lead to innovations.

The paper is structured in five sections. The next section presents the theoretical framework on which the empirical analysis is based. The main focus is on the literature describing the importance of internal and external knowledge sources and how they contribute to firms' innovative performance. Then four hypotheses are developed, which are later empirically tested. The third section describes the methodology used, including the sampling and data collection process, data analysis, and operationalization and measure validation. The fourth section is dedicated to presenting the empirical findings together with a graphic presentation of the structural model. The results are summarized and the main findings discussed in the last section.

Acquiring Knowledge for Innovation: Theory and Hypotheses Development

Until the 1980s, understanding of the innovation process was strongly influenced by the linear model of innovation, which suggested that development of innovations follows a straight research-to-market trajectory. In this model a central role was given to R&D activity, and firms' innovative performance was mainly seen as a consequence of R&D investment. This research-based and technocratic view of the innovation process could not explain the success of several SME firms that had limited resources for in-house R&D but were able to base their competitiveness on constant innovation. This phenomenon of innovative SMEs has become especially apparent in several SME clusters that have emerged all over Europe and the rest of the world. Since then, several scholars and practitioners have tried to reveal the dynamics behind small and medium-sized firms' innovativeness. More than a decade ago it became obvious that innovations rarely occur as creative acts of individual geniuses, but more often as a result of interactive processes. Individuals can not learn new things in a cognitive vacuum and learning always takes place in relation to some kind of social context (Johnson 1992; Lundvall 1992). From the perspective of innovation, new knowledge is not only developed in R&D departments but also in connection with ordinary production activities of firms and other actors through the interactive learning process (Eriksson 2005). Firms cooperate with their suppliers, customers, knowledge institutions (universities, laboratories, etc.), and even with their competitors when developing new products and services or improving production processes. The interactive model of innovation explains the process of innovation as a network of knowledge-flows both within the organization, and in the relationship between the organization and the environment (Santos 2000).

INTERNAL AND EXTERNAL SOURCES OF KNOWLEDGE

This section aims to show how complex the process of knowledge acquisition is, and to present the idea that firms need to acquire new knowledge from numerous internal and external sources in order to constantly generate innovations and maintain their competitive edge.

According to the general trend towards more composite knowledge, where new products and processes typically combine many technologies from several scientific disciplines, it is important to understand that firms today can hardly learn and innovate in isolation (Pavitt 1998; Johnson, Loren, and Lundvall 2002). While in large firms information and

knowledge are still mainly transferred through functional interaction among R&D, production, marketing, and organization departments and functional teams (Capello 1999), small and medium-sized firms increasingly need to rely on external knowledge sources. Accordingly, knowledge sources can be firstly divided into internal and external sources, whereas external sources can be further divided into local, national, and international sources, depending on where the source of knowledge is located (Belussi, McDonald, and Borrás 2002). Internally, firms acquire knowledge through in-house research and development activities and by learning from continuous improvements in processes. Employee skills represent another important source of new knowledge, and firms often organize internal education and training programs in order to further build and improve the internal knowledge base. If firms do not have appropriate knowledge inside the firm, they can acquire it externally by cooperating with customers and suppliers, as well as other firms, or by forming partnerships with public, semi-public, and private institutions. In terms of geographic location, these external actors can be located in close geographic proximity (locally), somewhere in the country (nationally), or elsewhere (internationally).

Among external sources of knowledge, inter-firm collaboration has probably received the most widespread research attention. It is widely recognized that the innovative process often involves interaction between the manufacturer and users of products. Usually such interaction between producers and end users involves not only an exchange of technical knowledge but also important information about market requirements and trends. Another important source of knowledge comes from the other side of the supply chain. Suppliers of equipment and material (Geenhuizen 1997) can bring important insight into the organization of production, logistics and other functions. But inter-firm cooperation extends far beyond the relationships that develop between supply chain partners. Studies of successful firms reveal that some sort of collaborative arrangements develop between business partners as well as between competitors. For example, a study of the Cambridge region revealed that 76% of firms possess close links with other firms (Keeble et al. 1998). When analyzing the nature of inter-firm cooperation they identified everything from joint ventures, subcontracting, and research collaborations to the sharing of equipment and information about customers. Accordingly, we perceive both vertical as well as horizontal inter-firm relationships as sources of important external sources of knowledge and

interactive learning (Camagni 1993; Yeung 2005; Steiner and Hartmann 2006).

Knowledge exchange not only appears between firms but can often be found between firms and institutions. Universities, research institutes, science parks, incubators, and other knowledge institutions are actively involved in a set of relationships occurring in the business environment (Gunasekara 2006) and are particularly seen as lead players in the innovative activity of firms providing scientific research inputs for innovating firms (Keeble and Wilkinson 2000). According to Gambarotto and Solari (2004), in addition to channeling information and knowledge, support organizations can also help translate academic codified knowledge into practical and accessible know-how. In line with the modern understanding of innovation, the research process is oriented toward problem-solving and as such requires two-way research interaction between knowledge organizations and industry actors combined with several other institutions.

Inter-firm collaboration, as well as partnerships with institutions, were long believed to be mainly limited to the local level and were studied within the context of clusters. However, with globalization and advances in information and communication technology, the geographic scope of this interaction is widening and often spreads across national borders. If firms want to succeed in the innovation race, they need to have access to the most advanced technical and organizational knowledge in their fields, which means they have to search for appropriate knowledge with no regard to its location. The use of geographically close sources has several benefits that stem from constant face-to-face interactions, knowledge spillovers, and the transmission of tacit knowledge (Camagni 1991; Keeble 2000; Capello and Faggian 2005). However, this does not imply that the mere use of local knowledge sources is sufficient in terms of knowledge creation and innovation. Research shows that limiting knowledge acquisition to the local level can lead to a lock-in effect (Grabher 1993; Keeble and Wilkinson 1999; 2000). In order to maintain a constant inflow of new knowledge, firms need to nurture links inside, as well as outside, the cluster.

TOWARD THE RESEARCH HYPOTHESES

The following paragraphs present the main theoretical arguments for the role of knowledge sources in firms' innovation performance, and develop four hypotheses.

In-house R&D efforts have been consistently proven to contribute to firms' innovative potential. A systematic review of studies investigating the use of knowledge in SMEs has shown that internal managerial and entrepreneurial teams, as well as other employees, play a crucial role in knowledge creation and, consequently, innovation (Thorpe et al. 2005). Additionally, a firm's in-house expertise for R&D has a considerable positive effect on the absorptive capacity of firms. Cohen and Levinthal (1990) define absorptive capacity as 'the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends.' This means that continuous improvements in its internal knowledge base are also important for increasing a firm's capability to assimilate and transform external knowledge and information into new products, services, and processes. As Lundvall and Nielsen (1999) argue, a strong internal knowledge base is the key to successful innovation. In line with their arguments, we posit that the greater the use of internal knowledge sources, the more innovations the firm will be able to create, as well as exploit knowledge from external sources and transform it into innovation. Therefore, we have formulated the following hypothesis:

H1 *The extent of usage of internal knowledge positively influences firms' innovative performance.*

What collective and interactive learning literature argues in general is that a firm's learning capacity does not depend solely on individual skills and the organization of the firm (internal to the firm), but it is also context dependent on the institutional set-up of its business environment (Lorenzen 1998; Tomassini and Sarcina 2005). In recent decades companies have been facing an increase in uncertainty and risk (Geenhuizen 1997). Firms in many industries are facing a turbulent environment with changes taking place in market, technology, and industrial organization. Responding to various uncertainties, companies have increasingly externalized their sources of knowledge. In order to increase or deploy their own knowledge effectively, firms often need to supplement their knowledge with that of other firms and organizations, which often happens in some form of collaborative arrangements. The growing importance of inter-organizational collaboration can be explained by the nature of contemporary knowledge (Dunning 2000): the development of new knowledge can be highly expensive; the outcome of much investment in augmenting knowledge (by R&D) is highly uncertain; many kinds of knowledge become obsolete quite quickly; and complex prob-

lems require multi-disciplinary team solutions. In addition, competitive pressures are forcing firms to introduce new products and services to the market at an increasing pace, and for many (especially small and medium-sized) firms it is impossible to rely only on internal resources for necessary knowledge production. Consequently, firms and other organizations are increasingly engaging in inter-organizational cooperation projects (Eriksson 2005).

There are several institutional environments in which firms acquire knowledge and learn. Lundvall (1992) emphasizes the national level as an institutional framework for learning and innovation, because of its homogeneity with respect to culture, technical and educational institutions, and historically-built relations between actors and firms. Other researchers focus on the regional and local levels as the most important environments for knowledge acquisition and innovation. Recently an increasing number of scholars have proven that firms often search for knowledge internationally (Malmberg and Power 2005). What these theories have in common is the fact that external knowledge sources provide an important complement to in-house learning and innovation efforts, and thus contribute to improved innovative performance (Caloghirou, Kastelli, and Tsakanikas 2004).

The importance of inter-organizational relationships has been mainly developed and studied in the context of localized clusters, where a number of firms, knowledge and research institutions, and other actors are located in close geographic proximity. The literature on localized and collective learning argues that the local level is the most appropriate environment for knowledge exchange and interactive learning due to cultural, social, and organizational proximity (Lundvall 1992; Belussi and Pilotti 2000; Steiner 2006), which has led to formulation of the following hypothesis:

H2 *The more a firm uses local sources of knowledge, the more it develops knowledge sharing that positively contributes to innovative performance.*

The main problem of the localized learning literature is that it has sometimes been read in a way that places local knowledge acquisition as a superior form that might sometimes take the place of knowledge acquisition and learning at the national and international levels; some authors even believe that it can replace internal R&D efforts (Capello and Faggian 2005). This stream of literature describes clusters and other local net-

works as being somehow self-sufficient in knowledge terms. This has led to a rather heated debate in recent years (Malmberg and Maskell 2006), proving that interactions with distant partners are at least as important as those with local actors. Several authors have empirically proven that learning might be best understood as a combination of close and distant interactions (Malmberg and Maskell, 2006; Wolfe and Gertler 2006; Britton 2003; Cumbers, MacKinnon, and Chapman 2003; Henry and Pinch 2001; Tödling and Kaufmann 1999).

Recently many authors have stressed the importance of linkages with external firms, institutions, or even networks, which provide access to external knowledge and technology, and prevent the lock-in effect. The most recent contribution to this discussion comes from Malmberg and Maskell (2006), who submit that neither the argument for localized interactive learning nor the existence of localized capabilities in any way presupposes that most knowledge exchange and learning interaction should be local. They believe that extra-local knowledge flows can be expected to connect to the local knowledge flows so that the two become mutually reinforcing. This happens when the external sources 'pump' information and news about markets and technologies into the local environment and consequently intensify the local interaction and benefit the local actors.

The main idea of this literature is that intense localization within a certain local environment does not mean isolation from the extra-local environment. Firms form networks and partnerships with firms and other organizations at the local, national and international levels in order to enhance their knowledge base and innovation potential. Business and social contacts can be more frequent, intensive, and easier to maintain if they are facilitated by proximity (all types); however, firms must nurture their relationships with firms and organizations outside the local area and even try to engage in global networks (Malmberg and Maskell 2006; Bathelt, Malmberg, and Maskell 2002). This will provide them with access to information on rapidly changing technologies and market opportunities and provide a constant influx of new knowledge needed in the innovation process. The role of the national knowledge sources was extensively discussed in the literature dealing with national systems of innovation (Lundvall, 1988; 1992; Lundvall et al. 2002), while the role of international sources has mainly been studied in the context of R&D partnerships (Knudsen 2006). Based on this literature, both national and international sources of knowledge are expected to positively contribute to firm's innovation performance. As Simmie (2006) suggests, innovation

must be understood in terms of trading nodes in an international system that encompasses local, national and international knowledge spillovers and multilayered economic linkages that extend over several different spatial scales.

The above discussion underpins the last two hypotheses:

H3 *The more a firm uses national sources of knowledge, the more it develops knowledge sharing that positively contributes to innovative performance.*

H4 *The more a firm uses international sources of knowledge, the more it develops knowledge sharing that positively contributes to innovative performance.*

Methodology

The methodology is discussed in terms of the sampling and data collection process, data analyses, operationalization, and measure validation.

SAMPLING AND DATA COLLECTION PROCESS

Data for testing the structural equation model for explaining the influence of knowledge sources on innovation activity were collected within the research project WEID (West-East ID: Industrial Districts' Re-Location Processes; Identifying Policies in the Perspective of the European Union Enlargement) conducted under the 5th EU Framework Program. Eleven European research partners were included in the project: Fondazione Istituto Guglielmo Tagliacarne (Italy), Eurochambres Aisbl (Belgium), Istituto per lo Sviluppo della Formazione dei Lavoratori (Italy), Libera Università Internazionale degli Studi Sociali 'Guido Carli' (Italy), Manchester Metropolitan University (United Kingdom), Omnimotio s. r. o. (Czech Republic), Landesinstitut Sozialforschungsstelle Dortmund (Germany), University of Ljubljana (Slovenia), University of Reading (United Kingdom), University of Roskilde (Denmark), and University of Aurel Vlaicu in Arad (Romania). Based on the literature review, interviews with managers, and work with focus groups within the WEID research group, a questionnaire for in-depth interviews was developed. The questionnaire was initially prepared in English and then first translated into the local languages (Czech, German, Italian, Polish, Romanian, and Slovenian), and after that back-translated into English (Brislin 1970; Brislin 1980; Hambleton 1993). The translation followed the 'etic approach' – an approach where there is little or no attempt to decenter or adapt the measure to another cultural context (Craig and

Douglas 2005). In-depth interviews with top executives from manufacturing firms from the Czech Republic, Germany, Italy, Poland, Romania, Slovenia, and the United Kingdom were conducted on the basis of the structured questionnaire developed. For the analyses, 303 usable responses were obtained. The composition of the sample was comparable to the population.

DATA ANALYSES

Reliability was assessed using Cronbach's (1951) alpha. Construct and discriminant validity, as well as convergent validity, were assessed using exploratory and confirmatory factor analysis (Floyd and Widaman 1995). Exploratory factor analysis and reliability analysis was conducted in SPPS. The EQS Multivariate Software version 6.1 (Bentler and Wu 2006) was utilized for confirmatory factor analysis and testing of the proposed structural model. Since a small amount of non-normality was found in the data, the Elliptical Reweighted Least Square (ERLS) estimation method was used (Sharma, Durvasula, and Dillon 1989). As recommended by Shook, et al. (2004), the fit of the model was assessed with multiple indices: NFI (the normed-fit-index), NNFI (the non-normed-fit index), CFI (the comparative fit index), GFI (the goodness-of-fit index), SRMR (the standardized root mean square residual), and RMSEA (the root mean square error of approximation). Values of NFI, NNFI, CFI, and GFI greater than 0.90 indicate a good model fit (Hair et al. 1998; Byrne 2006). Hu and Bentler (1999) suggest that values of SRMR smaller than 0.08 indicate an acceptable fit. Values of RMSEA less than 0.05 indicate good fit, and values as high as 0.08 represent reasonable errors of approximation in the population (Browne and Cudeck 1992). The chi-square is reported, but is not given major consideration because it is highly sensitive to sample size and the number of items in the model (Bentler and Bonett 1980).

OPERATIONALIZATION AND MEASURE VALIDATION

In this study, independent and dependent variables were measured through scales previously tested and developed by the WEID research group.

Internal Sources of Knowledge

Internal sources of knowledge were measured with six items. Respondents were asked to indicate (on a 5-point Likert-type scale ranging from

'not important at all' to 'very important') how important the following internal sources of knowledge are for their company: knowledge gained through in-house research and development (INT01), knowledge gained from continuous improvement of production processes (INT02), knowledge developed through their company's internal education and training programs (INT03), organizational skills learned from continuous improvement of their production processes (INT04), organizational skills of the professional managers within their local company (INT05), and organizational skills gained from their company's internal education and training programs. The factor analysis indicated that all factor loadings were above 0.4 and significant. Cronbach's alpha of 0.80 indicates strong internal consistency of six items operationalized to measure this construct.

Local, National, and International Sources of Knowledge

Local, national, and international sources of knowledge were each measured with 10 items. Respondents were asked to indicate (on a 5-point Likert-type scale ranging from 'not important at all' to 'very important') how important the following local, national, and international sources of knowledge are for their company: knowledge derived from interactions with clients and/or suppliers (local clients and/or customers – LOC01; national clients and/or customers – NAT01; and international clients and/or customers – INAT01), knowledge derived from cooperation with other companies (LOC02, NAT02, and INAT02), knowledge gained from interactions with public institutions such as universities, public research centers, local government, and so on (LOC03, NAT03, and INAT03), knowledge gained from interactions with semi-public institutions such as chambers of commerce, industry associations, trade unions, and so on (LOC04, NAT04, and INAT04), knowledge provided by consultants and private research centers (LOC05, NAT05, and INAT05), organizational skills gained from interactions with clients and/or suppliers (LOC06, NAT06, and INAT06), organizational skills gained from cooperation with other companies (LOC07, NAT07, and INAT07), organizational skills learned from interactions with public institutions such as universities, public research centers, local government, and so on (LOC08, NAT08, and INAT08), organizational skills learned from interactions with semi-public institutions such as chambers of commerce, industry associations, trade unions, and so on (LOC09, NAT09, and INAT09), and organizational skills learned from consultants and pri-

vate research centers (LOC10, NAT10, and INAT10). The factor analysis indicated that all factor loadings were above 0.4 and significant for all three constructs. To test for convergent validity of the constructs and to compare the one-factor structure with the three-factor structure (where factors are correlated), the confirmatory factor analysis was conducted. The results showed that one-factor structure is not appropriate because of the overall poor model fit (chi-square = 1420.029, 368 df, probability 0.000; NFI = 0.80; NNFI = 0.81; CFI = 0.84; GFI = 0.69; SRMR = 0.12; and RMSEA = 0.10). The confirmatory factor analysis showed that the three-factor structure fits the data reasonably well, with the following fit indices: chi-square = 681.457, 365 df, probability 0.000; NFI = 0.90; NNFI = 0.94; CFI = 0.95; GFI = 0.82; SRMR = 0.08; and RMSEA = 0.05. Cronbach's alphas of 0.85 (local sources of knowledge), of 0.86 (national sources of knowledge), and of 0.86 (international sources of knowledge) indicate strong internal consistency of items operationalized to measure these constructs.

Innovation Performance

Innovation performance was measured with five items. Respondents were asked to indicate whether their company had registered patents abroad in the last three years (IP01), and to indicate whether their company had introduced or adopted any major changes to their products (IP02), processes (IP03), organization of production (IP04), and organization of sales and distribution (IP05). The factor analysis indicated that all factor loadings were above 0.4 and significant. Cronbach's alpha of 0.75 indicates strong internal consistency of five items operationalized to measure this construct.

Control Variables

Control variables were also included and operationalized as follows: (1) firm's size was operationalized as the number of employees, and (2) the region was operationalized as a dichotomous variable, where '0' represented western European countries (Italy, Germany, and United Kingdom) and '1' represented eastern European countries (Czech Republic, Poland, Romania, and Slovenia).

Findings

The structural relationships in the model of the influence of sources of knowledge on the innovation performance were estimated using the El-

liptical reweighted least square (ERLS) method in EQS 6.1 (Bentler and Wu 2006). EQS reported that parameter estimates appeared in order, and that no special problems were encountered during the optimization. The resulting model goodness-of-fit indices indicated a moderately good model fit (chi-square = 1600.305, 812 df, probability 0.000; NFI = 0.86; NNFI = 0.92; CFI = 0.93; GFI = 0.76; SRMR = 0.08; and RMSEA = 0.06). The variance explained for the innovation performance was 20%.

The model, which includes hypothesized relationships and results of the model test, is depicted in figure 1. An examination of our hypotheses is presented in the following section.

HYPOTHESES TESTING

Hypothesis H1 proposed that the extent of the usage of internal sources of knowledge is positively related to the innovation performance. The results presented in figure 1 show that the internal sources of knowledge have a significant, positive, and high path coefficient of 0.31. The result thus provides strong support for hypothesis H1.

Hypothesis H2 proposed a positive relationship between local sources of knowledge and firms' innovation performance. Hypothesis H2 was not supported by the findings (significant standardized path coefficient of –0.26), because the result was the opposite of what was predicted, indicating that local sources of knowledge are negatively related to innovation performance.

Hypothesis H3 assessed the relationship between national sources of knowledge and firms' innovation performance. Hypothesis H3 was not supported by the findings (non-significant standardized coefficient of –0.01).

Hypothesis H4 predicted that the extent of international sources of knowledge would be positively related to firms' innovation performance. The results indicate a significant relationship between international sources of knowledge and firms' innovation performance (positive significant standardized coefficient of 0.25). The results thus support hypothesis H4.

OTHER FINDINGS

Other findings will be discussed in terms of the impact of control variables and the relationships between variables.

The impact of firm size and region as a dichotomous control variable was assessed (western European countries versus eastern European

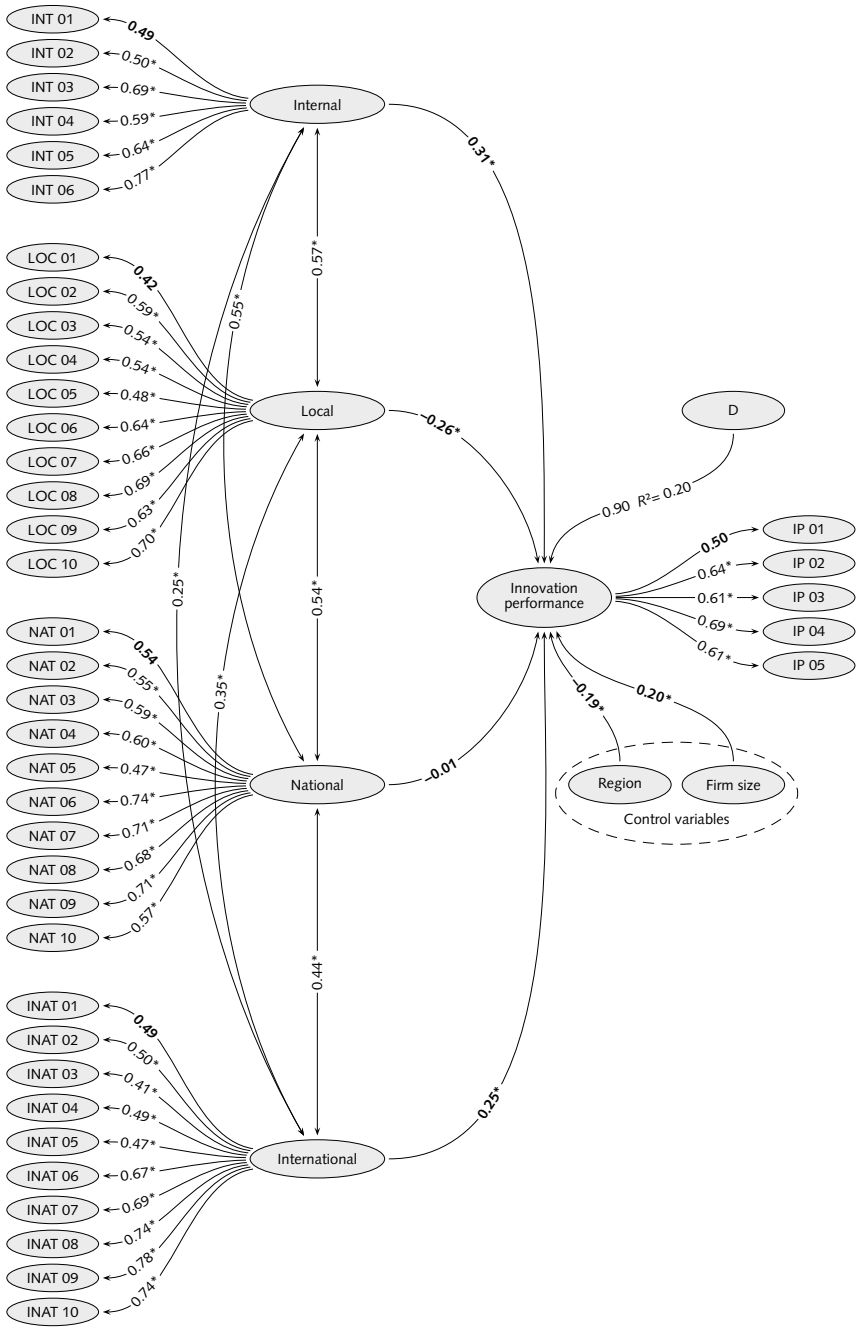

FIGURE 1 The model of the influence of sources of knowledge on the innovation performance (bolded parameters are fixed; * sig. < 0.05)

countries). Although the model fit indices and the structural coefficients of the relationship between independent variables and innovation performance did not reveal substantial variations with the introduction of control variables, both control variables were found significantly related to the innovation performance. The results indicate that firms from eastern European countries are significantly less innovative than firms from western European countries (negative significant standardized coefficient of –0.19), and that larger firms are significantly more innovative than smaller firms (positive significant standardized coefficient of 0.20).

The results also show that internal, local, national, and international sources of knowledge are significantly correlated among each other. While the correlations between internal and international, local and international, and national and international sources of knowledge were moderate (correlation coefficient of 0.25, 0.35, and 0.44 respectively), the correlations among internal, local, and national were somewhat higher (correlation coefficient between 0.54 and 0.57). Nevertheless, multi-collinearity was not detected among any of the variables in the multivariate model.

Discussion and Conclusion

The results presented in the previous section reveal that internal knowledge sources are only some of the sources of innovation. Our research confirmed that in-house learning is crucial for firms' innovation performance; however, interactive learning outside the firm also significantly contributes to innovativeness. According to these results, it is mainly cooperation with international business partners that contributes to innovation.

The significant, positive, and high path coefficient confirms the importance of in-house R&D activities, continuous process improvements, and internal education programs, which together boost firms' innovativeness. This means that innovation performance to a great extent depends on a firm's own efforts. This is not surprising, given the fact that innovations strongly influence a firm's competitive position in the market. Consequently, firms try to keep the innovation inside the firm, mainly relying on internal knowledge sources. Know-how historically was – and in large measure remains – a kind of knowledge developed within the confines of a firm (already discussed in Hudson 1999), and our results have proven that the boundaries of the firm are still signif-

icant for knowledge related to innovations that are central to the core competencies and strategic goals of the company.

Nevertheless, the increasing complexity of the knowledge base upon which the production process depends is increasing the social division of labor in knowledge production, yet is also resulting in growing long-term cooperation between firms (Hudson 1999). According to localized learning literature, we expected local knowledge sources to positively contribute to firms' innovation performance; however, the results proved the opposite. The findings might at first seem surprising because they indicate that the use of local knowledge sources impedes innovation. However, much of the literature warns that sole dependence on local knowledge sources can lead to the lock-in effect, whereby firms are 'locked' into the existing technological trajectory of the local environment and are unable to continuously develop new products and services and implement innovations in processes and organization (Visser and Boschma 2004; Malmberg and Maskell 2006). Camagni (1991) has already stressed that firms need linkages with the external business environment. Especially in times of rapid technological change, external (non-local) links might provide local firms with the complementary assets that are needed to adapt to the changing economic and technological environment. In areas of production characterized by fast innovation and technological change, 'local firm involvement in wider national and global networks is absolutely essential for long-term regional growth,' and 'the milieu has to open up to external energy in order to avoid 'entropic death' and a decline in its own innovative capacity' (Camagni 1991, 139). Our results are not in line with the older literature on localized learning (Capello 1999), which often positioned learning at the local level as somehow superior to that at other spatial levels. Nevertheless, our study confirms what most of the recent literature is arguing by saying that innovation performance is a result of combining several internal as well as external knowledge sources, the latter coming from different geographical levels. Local knowledge sources are important for firms to a certain extent, as geographic proximity and concentration of firms can provide enormous opportunities for the transmission of sticky, non-articulated forms of knowledge between firms (Tödling, Lehner, and Trippl 2004). However, localized learning does not necessarily lead to innovation. Our results indicate that access to codified external knowledge should be secured through interaction with firms and institutions outside the local environment, and

we show that new value is created by combining these various types of knowledge.

In today's globalized economy, where supply chains are distributed all around the globe and specialized knowledge and research institutions are scattered in numerous locations, there is no reason to believe that a firm will find the precise knowledge needed in its innovation process within the local environment. Accordingly, firms search for the necessary knowledge elsewhere and often look for appropriate innovation partners irrespective of the geographic space. While our research did not reveal a significant influence of national knowledge sources, it has proven that international sources have a strong, positive, and significant influence on firms' innovation performance. Keeble and Wilkinson (2000) have already supported these ideas with the empirical findings of the European network. Numerous firms possess close functional links with firms and knowledge centers in their countries and abroad, and view such wider networks as very important for successful research and innovation. Extra-local networking appears to be an important process whereby high-tech firms sustain their innovative activity and competitive advantage.

Our research confirms that firms need to incorporate the internal learning process with knowledge acquired outside the firm. They need to secure extra-local links in order to secure the inflow of new knowledge needed in the innovation process and prevent the lock-in effect. As Oinas and Malecki (2002) suggest, the innovation system can be understood as being internationally distributed and not only as an activity primarily confined within a given local environment. In line with their approach, Simmie (2006, 133) suggests that 'innovation must be understood in terms of trading nodes in an international system that encompasses both local and international knowledge spillovers and multilayered economic linkages extending over several different spatial scales.' To sum up, one can conclude that internal learning and interactive learning with firms and institutions in a wider business environment mutually reinforce each other and bring optimal results in terms of innovation performance. In this respect, our results are in line with existing studies (Caloghirou, Kastelli, and Tsakanikas 2004; Love and Mansury, 2007) that verify the importance of external sources and imply that innovations come from a number of sources and develop in a number of ways (Willoughby and Galvin 2005). However, those studies mainly focus on the type of sources (for example suppliers and customers, scien-

tific system, public institutions, etc.) but do little to explain how location of those knowledge sources influences the innovation performance of firms. In this respect our study brings additional insight into the complex process of innovation and proves that not all external knowledge sources are equally important for innovation. According to our results, firms need to establish and nurture collaboration with different partners in the wider international environment in order to boost their innovativeness.

Although this study has many strengths, it also has some limitations that need to be acknowledged. Firstly, with regard to local knowledge sources, the problem of knowledge internalization deserves mention; that is, when firms overestimate the role of in-house activities and downgrade the role of the local environment in which they operate. The knowledge exchange between local firms and institutions mainly happens in a socialized way in the form of knowledge spillovers. As soon as a firm acquires this local knowledge, it incorporates it into the existing knowledge base, making it internal to the firm (Henry and Pinch 2000; Cole 2007). Accordingly, firms might underestimate the importance of being located in the local environment, because they take for granted the benefits of the specialized local labor market, the proximity of similar firms, and close linkages with local universities and other knowledge organizations. Secondly, the model of the influence of sources of knowledge on innovation performance is not comprehensive (it includes a limited number of elements in order to make the empirical examination feasible) because it ignores some other factors that influence innovation performance. Thirdly, although the causal directions hypothesized in the model were suggested by the theory, the cross-sectional nature of this study cannot prove the causation but can only support a set of hypothesized paths (Kline 2005). Therefore, the possibility of reverse causality cannot be eliminated.

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