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GEOGRAPHICAL PROXIMITY AND OPEN INNOVATION OF SMES IN CYPRUS

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Abstract. Open innovation implies that geographical proximity is irrelevant. However, we posit that any potential innovation outcome depends on the spatial constraints on openness. In this paper we add a geographical proximity dimension to open innovation by analysing how a domestic and international open innovation approach affects innovation outcomes. In particular, we hypothesise that domestic open innovation has positive effects on new-to-the-firm product innovation, due to easily accessible resources. We further posit that, through international open innovation, SMEs can access new and advanced knowledge which is not available locally, leading to more novel innovations. However, we expect that the relationship between openness, both domestic and international, and innovation is conditional on R&D activities. Our empirical analysis based on the Cyprus Community Innovation Survey supports these hypotheses. Our results underline the critical role of the spatial aspect on open innovation in SMEs, something which has remained surprisingly absent from the literature.

Keywords: Domestic open innovation; International open innovation; SMEs; Geographical Proximity; Innovation performance.

JEL classifications: D22; L17; M11; O32.

1. Introduction

A review of the literature on open innovation in small and medium-sized enterprises (SMEs) reveals a paradox. While studies support the idea that open innovation is greatly beneficial to SMEs, allowing them to overcome the 'liability of smallness' (Freeman et al., 1983), evidence shows that only 5-20% of SMEs in OECD (Organisation for Economic Co-operation and Development) countries engage in it (OECD, 2008). We argue that this paradox stems from the fact that the spatial aspect of openness has been neglected (Gassmann et al., 2010). Existing studies have examined open innovation in SMEs without making distinctions between domestic openness and international openness, suggesting that both types of openness have the same challenges and lead to the same innovation outcomes. In this paper we synthesise and extend this existing research to encompass open innovation in SMEs and geographical proximity. We raise important issues regarding the type of open innovation (domestic open innovation and international open innovation) needed for the different category of innovation output (new-to-the-firm product innovation and new-to-the-market product innovation), and address R&D (Research and Development) activities within the spatial aspect of open innovation.

In spite of the growing interest in open innovation in SMEs, one of the core questions that remain unanswered is how the geographical dispersal of partners affects the innovation outcome. This is an important lacuna since it leaves undecided whether open innovation is applicable and beneficial to product innovation in SMEs. In this paper, we explore how geographical proximity in open innovation influences product innovation in SMEs, thus adding a geographical proximity dimension to open innovation. 'Geographical proximity refers to spatial or physical distance between economic actors' (Boschma, 2005:13). Various difficulties are encountered when engaging in domestic and international openness. International open innovation may indeed provide access to advanced knowledge and

technology (Kotabe et al., 2008), but it also requires strong absorptive capabilities. On the other hand, domestic open innovation helps speed up the process of new product development through limited spatial distance (Boschma, 2005). This suggests that SMEs may engage more often in domestic partnerships, as they do not require the resources and capabilities needed in international partnerships. Open innovation in SMEs could therefore be limited to national boundaries. However, SMEs which focus on domestic open innovation may not have access to advanced knowledge which is not available locally, leading to the maintenance of a weak knowledge base and resulting in a lack of novelty. A strong knowledge base, on the other hand, may increase the negative attitude of employees towards acquiring external knowledge from national partners, inducing a substitution relationship between domestic open innovation and R&D activities (Laursen & Salter, 2006).

Our study offers a series of contributions. Firstly, we contribute to the literature on open innovation by further clarifying the role of spatial dimension in innovation outcomes. Specifically, we demonstrate that the configuration of international and domestic open innovation needs to be taken into account. We acknowledge geographical proximity as a significant measure of innovation. Secondly, we contribute to the literature on SMEs by clarifying that a spatial approach to open innovation advances our theoretical understanding of the ways in which innovation unfolds in SMEs. We support the contention that domestic open innovation is widely used in SMEs and has an important impact on innovation, but only on new-to-the-firm product innovation. Thirdly, the present study advances our understanding of absorptive capacity (Cohen & Levinthal, 1990) by demonstrating the importance of spatial proximity in this context. Given the limited resources of SMEs, national open practices are substitutes for R&D activities in the shaping of new-to-the-firm innovation. We highlight that, in contrast with domestic open innovation, international open innovation is critical for more novel products. Knowledge spillovers from international

partners encourage R&D investment, which is under-reported in SMEs (Kleinknecht, 1987), and also enable the company to assimilate knowledge from its global environment. Fourthly, the paper has important policy implications for SMEs, which emphasise the importance of encouraging international openness in tandem with innovation policies in order to stimulate economic growth. Those companies which are exposed to foreign knowledge could reinforce the advantages of openness when pursuing novel product innovation. Finally, we suggest that the promotion of R&D activities may be instrumental in increasing the benefits of international open innovation in SMEs.

The study is based on a statistical analysis of the Cyprus Community Innovation (CIS) for the period 2006–2008, which was chosen in order to examine how domestic and international open innovation among SMEs influence innovation outcomes. By employing measures that take into account the total number of different partners with which a company interacts domestically and internationally, we empirically link open innovation to innovative performance, exploring how differences in proximity among collaboration partners influence the ability of SMEs to achieve different innovation outcomes.

The remainder of the paper is structured as follows. Section 2 explores the theoretical background and describes the hypotheses that drive the analysis. In Section 3, an overview of the data used, the implemented variables and the methodology is given. This is followed by the presentation of the findings of the study in Section 4. Finally, the implications of the findings and the conclusions are discussed in Section 5.

2. Theoretical Background and Hypotheses

Innovation is the fundamental driver of the economic performance of small and medium-sized enterprises (SMEs) (Freel, 2000; Rosenbusch et al., 2011). However, innovation requires significant resources and knowledge which most SMEs lack. In the

knowledge-based economy within which companies now operate, no single company can possibly possess all the resources and capabilities necessary for innovation (Chesbrough, 2003a). This is particularly true of small companies which depend on external resources for innovation (Hadjimanolis & Dickson, 2001). Small companies need to look outside to find the resources and technological capabilities they lack (Foreman-Peck, 2013; Freel, 2000; Van de Vrande et al., 2009). The implementation of the open innovation model, which emphasises the open and distributed nature of innovation (Chesbrough, 2003a, 2003b) could be a way in which SMEs could overcome their challenges and improve their new product development (Spithoven et al., 2013).

Laursen and Salter (2006; 2014) first examined open innovation at the company level using a large- scale dataset. They define open innovation as the use of a wide range of external actors and sources for innovation performance. Collaborations with different partners enable companies to implement additional capabilities and develop their initial resource and skill endowments (Becker and Dietz, 2004; Belderbos et al, 2004). Open innovation creates complementarity between different cooperations that is beneficial to innovative output. For example, collaborations with suppliers may lead to improved quality, and reduce the time to market, while collaborations with university and research institutes may produce complementary knowledge and capabilities that a company does not possess. As the range of external partners increases, so does the likelihood of new product development (Faems et al., 2005).

Existing studies argue that SMEs should adopt an open innovation approach to access the external knowledge, resources and complementary assets that they lack, in order to develop innovations (Dahlander & Gann, 2010; Lee et al. 2010). However, they engage in open innovation practices much less than large companies (Gassmann et al., 2010; Lee et al, 2010; van de Vrande et al., 2009). Open innovation requires considerable time and effort in

searching the external environment, as well as a significant internal knowledge base, in order to turn externally acquired knowledge into product innovation. We argue that the challenges of open innovation in SMEs could vary, based on the spatial perspective of open innovation. The lack of resources and capabilities is the main motive which forces SMEs to look for partners within close physical proximity to them. However, they may miss the advanced knowledge necessary for developing novel products which is available internationally.

It is critical to empirically evaluate the impact of the different types of open innovation when investigating innovation outcomes. Moreover, it is important to examine the relationships that national and international open innovation have with product innovation in new-to-the-market and new-to-the-firm products, as the results may be significantly different.

2.1 Domestic Open Innovation and Product Innovation

Open innovation has implied that, in an era of information and communications technology (ICT), distance is irrelevant. However, distance is critical and close proximity ensures knowledge creation and innovation. Boschma (2005) stresses that collaborations between actors do not necessarily require spatial proximity, which could be replaced with other forms of proximity, such as social and institutional. However, Malmberg and Maskell (2006) acknowledge that the significant attention given to the effect of geographical proximity is due to the indirect impact of common institutions, social norms and cultures. While external knowledge can be acquired on different spatial scales (cognitive, organisational, social, institutional, geographical), there are strong theoretical arguments suggesting that geographical proximity is critical for knowledge transfer. These arguments are based on the partly tacit nature of knowledge (Malmberg & Maskell, 2006), which is shared more easily when actors are at an appropriate distance from each other; on the embeddedness of knowledge in sociocultural and institutional settings (Gertler 2003), which

implies that the understanding of tacit knowledge demands common social and cultural comprehension; and on social networks, which emphasise the critical role of trust that can be developed more effectively through face-to-face contacts (Granovetter, 2005).

Proximity is particularly important for SMEs, which face a scarcity of resources, including human resources and time, and therefore have a reduced capacity to manage external resources. Geographical proximity helps small companies to cope with the costs and risks associated with open innovation activities. Proximity keeps the transaction costs of searching for relevant partners and of negotiating and monitoring contracts to a minimum (Robertson and Langlois, 1995:35).

Domestic open innovation is of great importance for those SMEs developing new-to-the-firm innovations, as the resources needed for this kind of innovation are easily found. Local network partners create local advantages. For instance, they speed up the innovation process through proximity (Patel et al., 2014). While proximity is critical, SMEs may not find the relevant knowledge close to them when they are making new-to-the-market innovations. According to Laursen and Salter (2006:136), radical innovation or new-to-the-market innovation 'may involve a higher degree of discontinuity in the sources of innovation, since knowledge sources previously used may be obsolete in the new context'. As a product becomes more mature within a particular market, more actors in the innovation system have knowledge of it, and companies are expected to work with domestic sources (Laursen & Salter, 2006). In other words, domestic openness is more likely to lead to new-to-the-firm innovation than to new-to-the-market innovation. In the light of the above arguments, it is expected that:

Hypothesis 1: Domestic open innovation in SMEs is positively associated with new-to-the-firm product innovation in SMEs.

2.2 International Open Innovation and Product Innovation

International open innovation enables global knowledge sourcing and a varied set of knowledge elements. However, a trade-off comes in the form of additional costs for SMEs in terms of the time and resources required to coordinate such efforts. According to Malecki (2010:1033), international partners 'have added costs as firms communicate across national, cultural, and linguistic boundaries, using both information and communication technology networks and face-to-face interaction'. Together with these high costs, SMEs need time, employees and knowledge to organise and manage these external networks. Small companies face the dilemma of whether to prioritise international open innovation through international partners or proximate-based efficiencies through domestic partners (Patel et al., 2014).

Based on the Transaction Cost theory, it would appear that SMEs prefer paths of actions that present the smallest transaction cost (Parkhe, 1993). Companies therefore do not engage in collaborations with international partners in order to access information available locally. Proximity may serve as a catalysing factor for new-to-the-firm innovation in SMEs. However, the absence of existing competencies within close spatial proximity means that collaborations can come from many directions. Using global collaborations, SMEs can access new and more advanced knowledge and technology which is not available locally, leading to new-to-the-market innovations (Kotabe et al., 2008). Therefore, we examine the following hypothesis:

Hypothesis 2. International open innovation in SMEs is positively associated with new-to-the-market product innovation.

2.3 Absorptive Capacity and Open Innovation

Research has supported the idea that companies need to rely on openness and engage in R&D activities in order to develop product innovations (Dahlander & Gann, 2010).

Companies build in R&D, not only to manage innovation but also so that they can access and absorb external knowledge inputs to innovation. R&D denotes a firm's ability to 'identify, assimilate and exploit knowledge from the environment' (Cohen & Levinthal, 1989:569). A company with a high level of R&D investments and therefore absorptive capacity (Cohen & Levinthal, 1989; 1990) is better able to create and exploit a host of linkages with other companies, so this is essential to companies' innovation performance.

Existing studies have suggested a complementary effect of R&D on open innovation (Chesbrough & Crowther, 2006). The learning process requires a significant level of absorptive capacity. However, absorptive capacity may not be equally important for domestic and international openness in SMEs. Because they are less likely to spend on R&D than larger companies (e.g., Harris et al., 2009), SMEs can successfully innovate without R&D by drawing in knowledge and expertise from domestic external sources (Laursen & Salter, 2006). A national open innovation strategy could allow companies that do not have the resources or the abilities to undertake R&D to engage in deep relationships with actors and innovate. According to Liu et al. (2013), knowledge is easier to find in geographically close networks. Moreover, domestic external knowledge is easily understood (Nooteboom, 2000).

The literature contains many countervailing theoretical arguments primarily inspired by work on Not Invented Here (NIH) syndrome (Katz & Allen, 1982) that suggests a substitution relationship between R&D and open innovation (Laursen & Salter, 2006). Not Invented Here syndrome (NIH) is defined as 'the tendency of a project group of stable composition to believe that it possesses a monopoly of knowledge in its field, which leads it to reject new ideas from outsiders to the detriment of its performance' (Katz & Allen, 1982:7). Staff in companies with high R&D intensity are likely to be biased against ideas generated outside the company. This bias results from the belief of managers and staff that knowledge and ideas generated internally are superior to the knowledge of national partners

(Laursen & Salter, 2014). In addition, a fear that collaboration with national partners may threaten the secrets of their success and their competitive position will strengthen this negative attitude. NIH syndrome will induce a substitution relationship between the use of national open innovation and R&D activities. Accordingly, NIH syndrome and the internal resistance from the staff of a company to the use of external sources will reduce the benefits of open innovation (Laursen & Salter, 2006).

A substitution relationship between national open innovation and R&D investments may also be the result of an attention allocation problem (Simon, 1947). Focusing on too many tasks at any point in time is costly and may lead to managerial attention being diverted (Laursen and Salter, 2006). Managers need to 'concentrate their energy, effort and mind-fullness on a limited number of issues' in order to achieve high innovation performance (Ocasio, 1997:203).

International openness provides access to unique resources, which can produce significant complementary knowledge that domestic openness may not be able to offer. SMEs will need to invest in R&D activities in order to understand and assimilate the influx of knowledge that comes from other national innovation systems, with different cultures, norms and values (Salomon & Shaver, 2005). Therefore, the ego-defence mechanism of NIH syndrome is becoming less relevant. International partners reduce companies' fears of opportunistic behaviour. Exposure to advanced foreign knowledge and technology produces experience and learning which help to boost new-to-the-market product innovation (Kobrin 1991).

Therefore, we hypothesise that:

Hypothesis 3a. R&D negatively moderates the relationship between domestic open innovation and new-to-the-firm product innovation in SMEs.

Hypothesis 3b. R&D positively moderates the relationship between international open innovation and new-to-the-market product innovation in SMEs.

3. Data, Variables and Methodology

3.1 Data

The data set used in this study comes from the Community Innovation Survey (CIS), the main instrument for data collection on business innovation. The CIS provides measures and produces indicators that can be applied in tracking innovation achievement and progress and setting policy objectives with better knowledge of how the innovation system as a whole may respond (OECD, 1997). The Community Innovation Survey is based on a standard core questionnaire developed by the European Commission (Eurostat) and Member States to ensure international comparability.

The data set used in this study comes from the Cyprus CIS, with the reference period 2006-2008. The Cyprus Innovation Survey is conducted through personal interviews at the premises of each enterprise studied, and covers enterprises with ten or more employees across the manufacturing and service sectors. There are several advantages of using data from the Cyprus CIS when examining the role of spatial dimension in innovation outcomes. Domestic partners indicate proximity because the island has a total population smaller than that of many European cities. In addition, because Cyprus is an island with no land borders with other states, 'international' genuinely indicates distance. The CIS provides significant data for over 1,300 businesses, making it a valuable resource for government and academic users alike. Since SMEs which are actively engaged in manufacturing and services industries are the focus of our study, our estimation sample is restricted to about 985 companies. Of these respondents, 450[1] companies are characterised as being innovative, i.e. companies that claim

[1] Examination of the data for unusual observations resulted in the removal of an outlier.

to have launched an innovative product which is either new-to-the-market or the new-to-the-firm and/or have applied a new process, to be engaged in innovation investments or to have ongoing or abandoned innovative activities.

The following sub-sections describe the variables and methodology used in this paper.

3.2 Dependent Variables

Following previous studies based on the CIS, this study uses the share of sales revenue of innovative products as a proportion of total sales revenue, in order to observe the direct association between the innovative activities of companies and the performance of those companies. The turnover of innovative products provides a measure of the extent of commercial success, in contrast to innovation indicators, which provide only a minimum measure of innovation success (Leipomen, 2006) [2]. It is argued that the development of new market innovations is a rare phenomenon in SMEs (Nelson, 1993). Because of that, this study adopts measures for both new-to-the-market products that constitute market novelties, and new-to-the-firm products that are not new-to-the-target-market, to obtain a comprehensive picture of openness and new product development in SMEs.

3.3 Independent Variables

We define open innovation in similar ways to the definition used in well-known existing studies (Laursen & Salter, 2006; Leiponen & Helfat, 2010; Leiponen, 2012); however, in contrast with previous studies, we introduce the national and international dimensions of open innovation. In this study, the openness of a company is measured using

[2] Product innovation was also examined using innovation indicators. The results were similar.

the number of collaborative arrangements with domestic partners and the number of collaborative arrangements with international partners[3].

Domestic open innovation In our study the concept of domestic openness is defined as the extent to which companies engage in collaborations with a range of national external actors as part of their internal innovation process. Laursen and Salter's inspirational work (2006) constructed a variable for the breadth of collaboration by adding up the number of six different external partners, including suppliers; clients; competitors; consultants, commercial laboratories and private R&D institutions; universities or other higher education institutions; governmental and other public research institutes. This measure has been used extensively for company-level openness (e.g., Laursen and Salter, 2014; Lee et al., 2010). This research follows Laursen and Salter's measure and adds six dummies, so that each company receives a score of 0 when it does not use national partners, but a value of 6 when it engages in collaborations with all potential national collaboration partners (Cronbach's alpha coefficient = 0.8).

International open innovation International open innovation is defined as the extent to which companies engage in collaborations with a range of international external actors from countries including the EU, US, China, India, as part of their innovation process. As with Laursen and Salter's measure, we add the number of six different partners, including suppliers; clients; competitors; consultants, commercial laboratories and private R&D institutions; universities or other higher education institutions; governmental and other public research institutes, so that each company receives a score of 0 when it does not use foreign partners, but a value of 6 when it engages in collaborations with all potential international collaboration partners (Cronbach's alpha coefficient = 0.8).

[3] The variables 'National Open Innovation' and 'International Open Innovation' are derived from the following question in the CIS: 'Please indicate the type of innovation co-operation partner by location' (see Appendix A).

3.4 Moderating variable

Research and Development (R&D) investments A company's absorptive capacity is largely a function of its R&D investments (Cohen & Levinthal, 1990). R&D activities allow companies to identify innovation opportunities, and to internalise and apply external knowledge (Cohen & Levinthal, 1990). A company with a high level of R&D investments, and therefore greater absorptive capacity (Cohen & Levinthal, 1989; 1990), is better able to create and exploit a variety of linkages with other companies, and hence is more open.

This study uses the amount of R&D expenditure divided by total annual revenues.

3.5 Control Variables

The choice of the control variables is partly based on theoretical grounds and partly on the significance of the estimated regression coefficients.

Sector of activity Innovation activity differs across the manufacturing and service sectors (Griliches, 1990). In addition, there is great variation in innovation activity within the sectors. Companies within the manufacturing and service sectors are not internally homogeneous (Amable and Palombarini, 1998; Kirner et al., 2009). We classify the industries into four categories according to technological intensity following the high-tech aggregation by NACE Rev.2[4]: high-tech manufacturing industry; low-tech manufacturing industry; knowledge-intensive service industry; and less knowledge-intensive service industry[5]. We are using industry dummies coded 1 if the company belongs to the relevant group, and 0 otherwise. We use low-tech manufacturing industry as the baseline category in all models.

Company Size The interrelation between company size and innovation has long been discussed. Smaller companies are the least innovative as they may lack economies of scope

[4] NACE stands for "Nomenclature statistique des activités economiques dans la Communauté Européenne" and is a Classification of Economic Activities in the European Community.

[5] Low-tech manufacturing: NACE C10-C18, C31-C32; High-tech manufacturing: NACE C19-30, C33; Low knowledge- intensive service: NACE G45-47, H52-H53; Knowledge-intensive services: NACE H50-H51, J58-J63, K64-K66, M69-75.

and scale (Gilbert, 2006). For the purposes of our research, we have focused on the SMEs of the dataset. To control for company size, a dummy variable is included, which differentiates between small companies (with fewer than 50 employees) and medium-sized companies (with between 50 and 250 employees)[6]. The benefits of open innovation may be different for small companies compared to medium-sized companies.

Public funding The development of funding mechanisms encourages investment in innovation (Czarnitzki & Delanot, 2015). In the presence of uncertainty and information asymmetry, public financial support effectively reduces financial constraints (Carreira & Silva, 2010). A binary variable is therefore used to indicate whether an enterprise has received any public financial support for its innovation activities.

Importance of knowledge sources from clients Using clients for information is a popular practice among SMEs, whose small customer base and flexibility enable the integration of users (Van de Vrande et al., 2009; Lee et al., 2010). The survey measures companies' perception of the importance of knowledge gained from clients. Companies were asked to assess the importance of these sources for innovation success, using a four-point scale (from 'not used' (0), to 'very important' (3)). The variable is transformed from a categorical to a binary variable by associating 1 when the company in question reports that it uses the source to a medium or high degree, and 0 in the case of no or low use (Laursen & Salter, 2006). The use of binary values will alleviate potential measurement errors that might arise from a Likert scale and will alleviate the problem by which an ordinal Likert scale cannot be interpreted as an interval scale (Leipomen & Helfat, 2010:228).

Breadth of information sources Laursen and Salter (2006) introduce the concept of 'open' search strategies and construct a 'breadth' variable by adding up the number of external sources of information used by the company. A total of nine external sources may

[6] The results were rather similar when we considered both medium and large companies together. Large companies with 250 and more employees comprise about 2% of the dataset.

have been used by the company: suppliers; clients; competitors; consultants, commercial labs, and private R&D institutions; universities and other higher education institutions; government and other public research institutes; conferences, trade fairs, and exhibitions; scientific journals and trade/technical publications; and professional and industry associations. Therefore, a company could register a score between 0, when no information sources are used, and 9, when all information sources are used. Companies which use greater numbers of external sources will be more open than those which do not (Laursen & Salter, 2006).

International Markets Companies that operate in international markets are exposed to a higher level of competition and access to foreign knowledge bases which enhances innovation capabilities. Participation in exports influences the companies' engagement in R&D and innovation (Esteve-Perez & Rodriquez, 2013). A binary variable is used to indicate whether an enterprise operates in the international market.

Group Member Companies Companies that are members of business groups benefit through sharing resources with other member companies (Chang & Hong, 2000). A dummy variable is included to indicate whether a company is a member of a group.

Table 1 presents the operational definitions of the variables with their abbreviations.

Table 1 Definition of the Variables and Abbreviations

Abbreviation	Variable	Definition
TINF	Sales of new to the firm products	Fraction of the firm's turnover relating to products new-to-the-firm
TINM	Sales of new to the market products	Fraction of the firm's turnover relating to products new-to-the-market
INN	Innovator	1 if the firm is innovative-active, 0 otherwise
NCOOP	Domestic open innovation	Total of six different national external partners used by the firm
ICOOP	International open innovation	Total of six different international external partners used by the firm
RD	R&D intensity	R&D expenses divided by total annual revenues
FUND	Public Funding	1 if the firm participated in funded projects, 0 otherwise
INFCL	Importance of knowledge sources from clients	1 if the firm declared clients as high important source of information, 0 otherwise
BINFO	Breadth of information sources	Total of nine different external information sources used by the firm
IND1	Low-tech manufacturing	1 if the firm is in the low tech manufacturing industries, 0 otherwise
IND2	High-tech manufacturing	1 if the firm is in the high tech manufacturing industries, 0 otherwise
IND3	Less Knowledge intensive services	1 if the firm is in the less knowledge-intensive services,0 otherwise
IND4	Knowledge intensive services	1 if the firm is in the knowledge-intensive services, 0 otherwise
SIZE	Enterprise size	1 if the firm has a number of employees more than 50 and less than 250, 0 otherwise
COMP	International Market	1 if the firm operated in international markets, 0 otherwise
GP	Company Group	1 if the firm is part of a company group, 0 otherwise

3.6 Methodology

Our dependent variable, innovation performance, is observable only for companies engaged in the innovation process. Analysis restricted to innovating companies would have ignored information regarding non-innovating companies, and the subsequent results would therefore be difficult to extrapolate to the whole population of companies. To handle a potential self-selection bias, a Heckman selection model (Heckman, 1979) was used. The Heckman model follows a two-step approach. In the first stage, a probit regression is used to estimate the probability that a company is innovation-active. Based upon the results, the value for the inverse Mill's ratio is predicted and incorporated into the second stage, in which innovation performance is examined.

The model used can be expressed as follows:

Let $i = 1,..,N$ index companies.

$$(1) \qquad Inn_i = \begin{cases} 1 \;\; if \; I_{nni} * = \;\; \beta_0 + \beta_1 x_i + \; z_i \; > \; 0 \\ 0 \quad if \; I_{nni} * = \;\; \beta_0 + \beta_1 x_i + \; z_i \; \leq \; 0 \end{cases}$$

where Inn_i is an indicator function that takes value 1 if company i is characterised as being innovative. A company is characterised as innovative if it reports innovation success (i.e. product and/or process innovation) or any innovation activities between 2006 and 2008. $I_{nni} *$ is a latent indicator variable that expresses the decision to engage in innovation activities. x_i is a vector of explanatory variables. β_1 is the associated coefficient vector. z_i is a random error term.

$$(2) \qquad TIN_i = \begin{cases} TIN_i * = \;\; \delta_0 + \delta_1 w_i + \delta_2 IMR_i + \varepsilon_i \;\; if \;\; Inn_i > 0 \\ 0 \; if \;\; Inn_i = 0 \end{cases}$$

where TIN_i is the unobserved latent variable accounting for the fraction of the companies' turnover relating to innovation which is new-to-the-firm or new-to-the-market. w_i is the vector of independent and control variables. IMR_i is the inverse Mills ratio. ε_i is the disturbance term that summarises omitted determinants and other sources of unobserved heterogeneity. We specify separately in the second stage an equation for new-to-the-firm innovation performance and one for new-to-the-market innovation performance.

A Harman's single-factor test was conducted on all variables to assess the extent of common method bias (CMB) (Podsakoff & Organ, 1986). A number of factors were identified and it was found that the first unrotated single factor accounted for around 25% of the variance. This is below the threshold of 50% for exhibiting common method bias and therefore shows that this study does not suffer from CMB (Podsakoff et al., 2003).

4. Results

In addition to the usual descriptive statistics, a correlation analysis was performed. This was performed to identify relationships between the dependent and independent variables. Table 2 presents the descriptive statistics and the simple correlations between our variables.

Table 2 shows that on, average, 9% of companies' turnover can be attributed to products new to the market, while about 20% of it relates to new-to-the-firm innovations. Moreover, companies use, on average, about one national partner for their innovative activities, while they engage less in international open innovation. There are no significantly strong correlations, suggesting that it is unnecessary to examine further potential multicollinearity problems.

Table 2. Descriptive Statistics and Correlation Analysis

	Mean	Std. Dev.	TINF	TINM	INN	NCOOP	ICOOP	RD	FUND	BCLIENTS	BINFO	IND1	IND2	IND3	IND4	SIZE	COMP	GP
Dependent Variables																		
TINF	0.204	0.219	1															
TINM	0.088	0.175	0.304	1														
INN	0.457	0.498			1													
Independent Variables																		
NCOOP	1.256	1.535	0.189	0.013		1												
ICOOP	0.467	0.985	0.142	0.036		0.322	1											
RD	0.029	0.166	0.057	0.180		0.034	0.003	1										
Control Variables																		
FUND	0.353	0.479	0.041	0.121		0.132	0.098	0.102	1									
BCLIENTS	0.576	0.495	0.207	0.107		0.398	0.183	0.039	-0.024	1								
BINFO	5.476	1.801	0.151	0.180		0.339	0.337	0.008	0.200	0.372	1							
IND1	0.245	0.430	-0.080	-0.033	0.104	-0.117	-0.157	-0.039	0.116	-0.168	-0.124	1						
IND2	0.191	0.393	0.062	0.142	0.094	-0.091	0.040	0.103	0.157	-0.009	0.066	-0.353	1					
IND3	0.353	0.478	-0.037	-0.028	-0.213	-0.057	0.032	-0.094	-0.179	-0.008	-0.034	-0.364	-0.310	1				
IND4	0.211	0.408	0.062	-0.078	0.050	0.275	0.096	0.034	-0.100	0.197	0.102	-0.355	-0.303	-0.312	1			
SIZE	0.237	0.425	0.057	0.048	0.199	0.059	0.154	-0.087	0.047	0.056	0.167	0.037	-0.193	0.024	0.128	1		
COMP	0.287	0.453	0.083	0.062	0.161	0.021	0.300	0.079	0.103	-0.009	0.165	-0.014	0.020	0.000	-0.006	0.164	1	
GP	0.255	0.436	0.016	0.062	0.100	-0.012	0.189	0.014	-0.021	0.037	0.203	-0.105	-0.085	0.080	0.118	0.343	0.202	1

Number of observations is 985 with 450 uncensored observations.

* significant at 10%, **significant at 5%, ***significant at 1%

Table 3 presents the regression results which test our hypotheses. We note that the Inverse Mills ratio is statistically insignificant, suggesting that selection biases do not affect innovation activity and performance. The first stage of the model discusses the likelihood that a company is innovation-active. When discussing the effects of the control variables, we find that the probability of being an innovation-active company increases with company size. The likelihood of being an innovation-active company is higher if a company is active in the international market, while companies in the low knowledge intensive business services category are less likely to innovate.

The second stage of the model analyses the innovation performance of companies. Those that use domestic open innovation increase new-to-the-firm innovation performance. The results are consistent with Hypothesis 1: that domestic open innovation is positively associated with new-to-the-firm product innovation in SMEs. The pressure imposed on SMEs to invest in R&D is reduced because of domestic open innovation. SMEs, which do not have funds or capabilities to invest in R&D for new-to-the-firm innovation, engage in domestic collaborations in order to adopt and generate new knowledge.

Table 3 Regression Results

	First stage (1): Likelihood of being an innovation-active firm	**Second stage (2): TINF**	**Second stage (2): TINM**
Independent variables			
NCOOP		0.019**(0.008)	-0.002(0.006)
ICOOP		0.010(0.012)	-0.013(0.010)
RD		0.166**(0.083)	0.258***(0.065)
NCOOP*RD		-0.077**(0.035)	-0.079***(0.028)
ICOOP*RD		0.001(0.109)	0.200**(0.086)
FUND		0.001(0.023)	0.023(0.018)

INFCL		0.063***(0.023)	0.030(0.018)
BINFO		0.003(0.007)	0.014***(0.005)
Control Variables			
IND2	0.106 (0.126)	0.035(0.029)	0.040 *(0.023)
IND3	-0.640***(0.110)	0.039(0.046)	0.019(0.036)
IND4	-0.143(0.122)	0.015(0.030)	-0.024(0.024)
SIZE	0.557***(0.103)	-0.014(0.041)	0.014(0.032)
COMP	0.378***(0.095)		
GP	0.128(0.102)		
Inverse Mill's ratio		-0.094(0.089)	-0.026(0.070)
Intercept	-0.151**(0.089)	0.185**(0.085)	-0.006 (0.067)
Pseudo R-squared	0.082	0.085	0.121
No. of obs	985	450	450

* significant at 10%, **significant at 5%, ***significant at 1%
Robust standard errors reported in parentheses.

It can be observed that the joint implementation of domestic collaborations and R&D has a negative impact on new-to-the-firm and new-to-the-market innovation. Our observations are in line with Hypothesis 3a: R&D negatively moderates the relationship between domestic open innovation and new-to-the-firm product innovation. One likely interpretation of this result is the NIH syndrome, which is a prominent barrier against external knowledge acquisition and product innovation. Strong R&D capabilities increase bias against ideas generated from national partners. Companies face a negative attitude among employees to the acquisition of external knowledge from national partners. This may also be the result of an additional attention allocation problem (Simon 1947; Ocasio, 1997). The decision of companies to allocate their attention to R&D activities and national open innovation has a negative impact on innovation performance. The results also show that the interaction between national openness and R&D is negatively

significant in new-to-the-market innovation. Excessive national openness does not add learning for new-to-the-market innovation and can even distract R&D focus.

The results contrast with Hypothesis 2, suggesting that international open innovation in SMEs is not positively associated with new-to-the-market product innovation and support Hypothesis 3b: that R&D positively moderates the relationship between international open innovation and new-to-the-market product innovation. R&D complements international open innovation in new-to-the-market innovation. Small companies can use R&D to drive new-to-the-market innovation, which is more complex than new-to-the-firm innovation.

Regarding the basic control variables technology classes do show the expected pattern; firms in high-tech manufacturing industries do realize a higher innovation output than in other industries. Our results show that the benefits of openness in innovation are not different for small firms compared to medium ones. In addition, public funding does not improve the innovation performance of SMEs. Government subsidy programs may substitute for and crowd out private investment (Radicic et al., 2016). Finally, using clients for information positively impact new-to-the-firm product innovation, whereas breadth of information appears to have bearing only on new-to-the-market product innovation.

For illustration purposes, we use interaction plots of the variables of interest. We show innovation performance in a graph, plotting changes in each corresponding variable. The R&D variable is continuous, but only the lines representing one standard deviation above and below the mean are plotted, for ease of visualisation. Confirming the hypothesised moderating effects, the slopes of the regression lines in Figures 1 and 2 vary significantly as the Z-values vary (mean plus/minus one standard deviation). Figure 1 shows that a high level of R&D intensity negatively reinforces the relationship between national open innovation and new-to-the-firm innovation

performance. The slope for the effect of national openness on new-to-the-firm innovation is stronger when R&D intensity is low, and weaker when R&D intensity is high. Figure 2 shows that a high level of R&D positively affects the relationship between international open innovation and new-to-the-market innovation performance. The slope indicates that international open innovation has a strong positive association with new-to-the-market innovation when the level of R&D activities is high.

Figure 1 The Moderating Effect of R&D Intensity on the Relationship Between Domestic Open Innovation and New-to-the-Firm Product Innovation

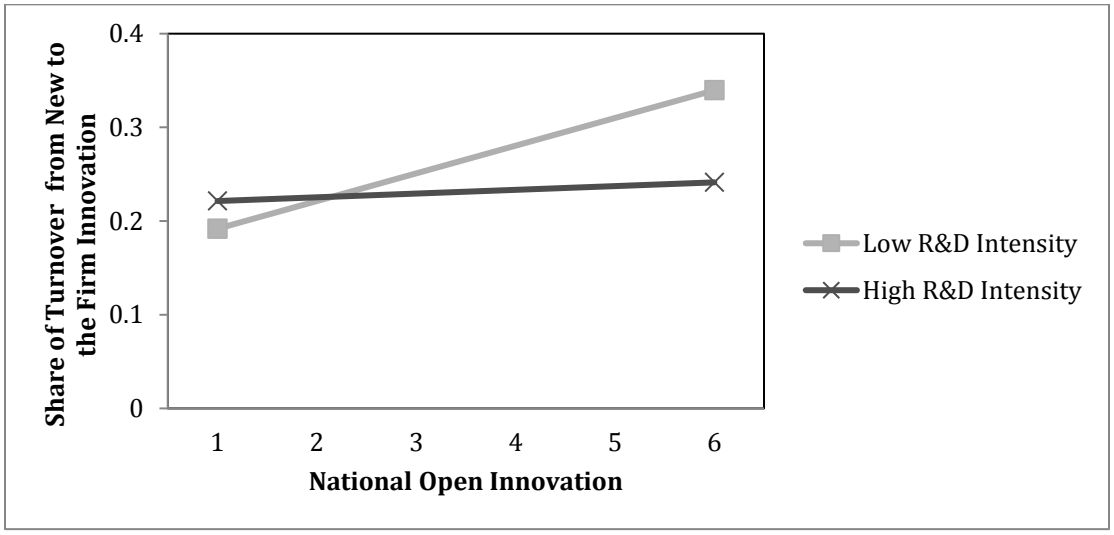
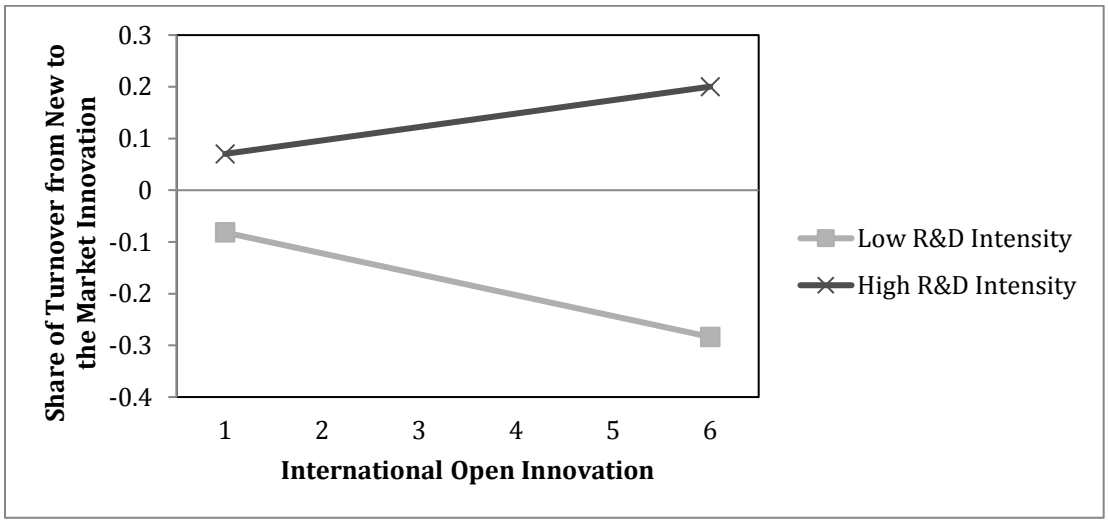


Figure 2 The Moderating Effect of R&D Intensity on the Relationship Between International Open Innovation and New-to-the-Market Product Innovation



5. Implications and Conclusions

In this paper, we have focused on the link between open innovation by SMEs and spatial proximity. In particular, we have explored how proximity in open innovation influences product innovation within SMEs, thus providing a new dimension to the link between openness and innovation. Our results have significant implications for the literature on open innovation in SMEs. The existing literature suggests that the implementation of open innovation could be a means for SMEs to fill gaps in terms of information, resources and competencies (Romijn & Albaladejo, 2002). Nevertheless, open innovation requires considerable time and effort to be spent in searching the external environment for valuable information, a strong internal knowledge base and the additional capabilities required to turn externally acquired knowledge into innovation. This suggest that SMEs, which have limited human resources and time, and lack an internal knowledge base, by comparison with large companies, are engaging less in open

innovation (Gassmann et al., 2010; Lee et al, 2010; van de Vrande et al. 2009). Our study contributes to this discussion.

Our results suggest that any use of open innovation and any potential innovation outcomes depend on the spatial perspective of openness. Although open innovation has implied that distance is irrelevant in open innovation, proximity is vital for SMEs. Lack of time and internal knowledge are the main motives of SMEs to search within a short geographical distance. Our results show that SMEs, which do not have the capability to invest in R&D for new-to-the-firm innovation, engage in domestic collaborations to generate new knowledge. We support the contention that domestic open innovation has a significant impact on new-to-the-firm innovation. Geographical proximity helps small companies to cope with the costs and risks associated with open innovation activities. We find that while proximity is critical, SMEs may not find the relevant knowledge in close proximity to them in the case of new-to-the-market innovation. SMEs use international open innovation to access new and more advanced knowledge and technology which is not available locally, leading to novel innovations (Kotabe et al., 2008).

The present study advances our understanding of absorptive capacity by acknowledging the importance of proximitiy in this context. Our results show that absorptive capacity is not equally important for domestic and international openness in SMEs. We find that R&D does not strengthen the relationship between national openness and product innovation. SMEs do not need to invest in R&D to understand and assimilate the influx of knowledge from national partners. However, companies that invest highly in R&D are biased against ideas generated from national partners, reducing their impact on new-to-the-firm innovation performance. Not-Invented Here syndrome induces a substitution relationship between national openness and R&D activities. In addition, a focus on both R&D and national openness may lead to a diversion of managerial

attention. Since knowledge and expertise could be generated both internally and externally, managers should concentrate their attention on a limited number of activities in order to improve new-to-the-firm innovation performance. The results are different in the case of international open innovation, for which we find a complementary effect of R&D on open innovation for new-to-the-market innovation performance. International knowledge spillovers encourage R&D investment, which is under-reported in SMEs, and enable the company to assimilate knowledge from its global environment. SMEs need to invest in absorptive capacity in order to exploit the knowledge spillovers that come from different national innovation systems, with different cultures and values (Salomon & Shaver, 2005). Our results suggest that experience with engaging with international open innovation helps SMEs to build their knowledge and utilise R&D to launch novel products.

The implications for practitioners and policymakers arise from a deeper understanding of the role of geographical proximity on the relationship between openness and innovation in SMEs. Differences in spatial proximity between companies influence the ability of SMEs to achieve different levels of novelty in their innovation activity. Proximity serves as a catalysing factor for SMEs. Given their limited resources and lack of a strong knowledge base, SMEs could still successfully innovate new-to-the-firm products by drawing on knowledge and expertise from domestic external sources. International open innovation is critical for more novel products. The exposure of companies to foreign markets influences the knowledge accumulation and innovation capabilities of SMEs (Blind & Jungmittag, 2004). However, SMEs need to deal with the high costs and risks associated with their ongoing interactions with international partners. As a result, the biggest task of governments and policy-makers is to promote international open innovation, focusing on the needs of SMEs. Although domestic openness creates local

competitiveness, public policy-makers should design funding programmes which promote international openness and leverage SMEs resources and capabilities (Coe et al., 2008). If, as our results suggest, exposure to international markets is significant for the generation and absorption of new knowledge, then there is a potential role for policy-making in primarily promoting the international partnerships and then giving incentives to those companies that implement international open innovation practices which encourage them to share and distribute their knowledge nationally.

Despite the significance of the results, there are limitations that show that further research is required. Firstly, some limitations arise from the CIS datasets, which comprise a cross-section of a single period of time and cannot capture innovation dynamics. Future research needs to take a longitudinal perspective to examine the dynamics that are likely to shape the interplay between domestic and international open innovation in SMEs and innovation outcomes over time. Secondly, the CIS is not explicitly focused on open innovation practices, and so may not provide a complete picture of the openness of companies (Drechsler & Natter, 2012). For example, the CIS does not quantify the number of cooperation agreements which an enterprise is engaged in nor the importance of each collaborative arrangement for the SME, which can have an impact on the degree of knowledge transfer and innovation performance. A survey explicitly focused on open innovation practices should be conducted to construct a comprehensive picture of openness. Thirdly, study results should be carefully examined to determine whether they can be generalised, and whether its findings can be applied to other countries. Cyprus is an island so the term ‘international’ indicates genuine distance. The same tests would therefore not necessarily produce the same results for countries such as Germany, where the term ‘domestic’ would cover greater distances, while an ‘international’ location might be almost adjacent, on the other side of

a land border. The findings are therefore worthy of examination in other contexts. Fourthly, we assume that international open innovation is a vital choice for SMEs. However, openness practices may be limited by other factors. The wave of nationalism sweeping the world may influence the open innovation activities of SMEs. The different forms of nationalism, and in particular economic nationalism, which include policies favouring domestic companies and trade barriers, imply that international partnerships will be discouraged. Future research should consider in more detail how ethnocentrism will hinder the decisions of companies to open up to international external partners, thus influencing their innovation performance.

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Appendix A. CIS question related to the variables 'domestic open innovation' and 'international open innovation'

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

(Tick all that apply)

Type of co-operation partner	[Your country]	Other Europe*	United States	China or India	All other countries
A. Other enterprises within your enterprise group	☐ *Co11*	☐ *Co12*	☐ *Co13*	☐ *Co14*	☐ *Co15*
B. Suppliers of equipment, materials, components, or software	☐ *Co21*	☐ *Co22*	☐ *Co23*	☐ *Co24*	☐ *Co25*
C. Clients or customers	☐ *Co31*	☐ *Co32*	☐ *Co33*	☐ *Co34*	☐ *Co35*
D. Competitors or other enterprises in your sector	☐ *Co41*	☐ *Co42*	☐ *Co43*	☐ *Co44*	☐ *Co45*
E. Consultants, commercial labs, or private R&D institutes	☐ *Co51*	☐ *Co52*	☐ *Co53*	☐ *Co54*	☐ *Co55*
F. Universities or other higher education institutions	☐ *Co61*	☐ *Co62*	☐ *Co63*	☐ *Co64*	☐ *Co65*
G. Government or public research institutes	☐ *Co71*	☐ *Co72*	☐ *Co73*	☐ *Co74*	☐ *Co75*

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