DOES OPEN INNOVATION WORK BETTER IN REGIONAL CLUSTERS?

Fang Huang
Lecturer, School of Management and Governance, Murdoch University, Perth, Western Australia, 6150, Australia.
Email: a.huang@murdoch.edu.au

John Rice
Senior Lecturer, Griffith Business School, Griffith University, Gold Coast, Queensland, 4222, Australia.
Email: j.rice@griffith.edu.au

ABSTRACT: In this study, we link the research on open innovation with issues relating to geographical proximity and regional clustering. Based on our analysis of a sample of 3,468 European firms, we find that close geographical proximity tends to increase firm-university linkages, enhance inter-firm explicit and tacit knowledge flows and lead to comparatively less reliance on internal research and development. We attribute these effects to the underlying benefits created by reduced transaction costs and increased trust and reciprocity created within regional clusters. These cluster-based effects tend to facilitate the 'connect and develop' operational philosophy of open innovation. Our findings are highly relevant to the open innovation literature, and also potentially extend an open innovation perspective to the analysis of regional clustering's effects on innovation and organizational performance.

KEY WORDS: Open innovation, regional clusters, European firms

ACKNOWLEDGEMENTS: We thank two anonymous reviewers for their valuable comments on the earlier draft of this paper.

1. INTRODUCTION

The paradigm of open innovation has received considerable academic and practitioner attention since it was first popularized by Chesbrough (2003a, 2003b) as a counterpoint to the traditional 'closed innovation' approach. Although use of the term 'open innovation' itself is relatively recent, this does not signify the emergence of altogether new organizational phenomena (Christensen et al., 2005). Its principles and fundamental ideas build on a strong body of antecedent knowledge developed in the innovation management literature, including theories related to research and development (R&D) externalization, outsourcing, inter-firm collaboration, and organization-environmental interaction (Carr, 1995; Christensen et al., 2005; Freeman, 1991; Grönlund et al., 2010). Trott and Hartmann (2009) have suggested that the 'open innovation' embodies a repackaging and re-representation of old thoughts on R&D and innovation management in new theoretical bottles.

Among these previously existing factors that have explored the interconnectedness of innovating firms, the impact of regionality and proximity has also been discussed as an element of open innovation (Cooke, 2005a; Simard and West, 2006; Vanhaverbeke, 2006). However, little empirical research has been undertaken explicitly exploring the impact of proximity (to partner firms, and other agencies) on open innovation effectiveness (Vanhaverbeke, 2006). Thus, in the following section, we will expound the definitions and characteristics underpinning these two concepts, the linkage between them, and then identify the gap in existing literature regarding this important issue.

2. LITERATURE REVIEW

The Definition of Open Innovation

The open innovation model builds upon the notion that innovations are often not always inspired and developed entirely within a single firm. It entails "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough, 2006b, p. 1). In essence, open innovation theories suggest that the generation of innovative outputs is facilitated by more openness towards external sources of knowledge. This openness encourages the fluidity of knowledge and information flows between firms.

The emergence of the open innovation approach has been heavily influenced by changes in our thinking about the fundamental importance of firms' internal and external knowledge environments. Greater mobility of skilled workers and more ready transmission of knowledge by information technology increased the prevalence of inward and outward 'spillovers' between firms and their external environments (Chesbrough, 2003b). Implicit in this increased focus on knowledge flows was an acknowledgement of other core characteristics, including the permeability of firms' transactional and knowledge boundaries (Gassmann and Enkel, 2004; Pisano, 1990); the emphasis on strong and effective interactions between firms and their knowledge environment

(Laursen and Salter, 2006; Lichtenthaler, 2008); and the adoption of open search strategies spanning a wide range of external actors and players, including customers, suppliers, competitors and research institutions (Christensen, 2006; Knudsen, 2007; von Hippel, 1988; West and Gallagher, 2006).

In essence, the open innovation model has been associated with two major advantages over the closed innovation model. First, it has been shown to facilitate the transmission of complementary and hence synergistic, knowledge, expertise and resources across organizational boundaries (Arora and Gambardella, 1990; Chesbrough, 2005). Second, the successful integration of externally sourced knowledge with in-house resources can create complex, differentiated and often inimitable capabilities (Cassiman and Veugelers, 2006; Lichtenthaler, 2008) that could sustain competitive advantage over time.

The Definition of Regional Clusters

Derived from the phenomena of industrial agglomerations (Marshall, 1920), Italian industrial districts (Bagnasco, 1977) and studies on the impact of sectoral firm clustering in specific geographic zones (Callegati and Grandi, 2005), the definition of regional clusters is diverse. Porter's (1998b) definition is often used as the starting point to investigate the concept of clusters (Bergman and Feser, 1999). According to Porter (1998b, p. 199), a cluster is "a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities". Other researchers have also proposed general definitions such as "a process of firms and other actors co-locating within a concentrated geographical area, cooperating around a certain functional niche, and establishing close linkages and working alliances to improve their collective competitiveness" (Andersson et al., 2004, p. 7). Others have suggested clusters are "a concentration of competing, collaborating and interdependent companies and institutions which are connected by a system of market and non-market links" (DTI, 1998, p. 22).

Within the variety of these definitions, some common characteristics of clusters are evident. Summarized by Andersson et al. (2004), clusters are generally seen to involve geographical concentration (operationalized by the geographic proximity of firms' location; engagement between multiple actors — namely between firms, but also between firms and clients, suppliers, public authorities, universities and other institutions) (Breschi and Malerba, 2005; Leitão, 2007; Pickernell et al., 2007); and the presence of both competition and co-operation between these interlinked actors (Andersson et al. 2004; Ramirez-Pasillas, 2010).

The advantages to emerge from co-location in geographical clusters that have been observed by previous studies include the creation of opportunities for innovation and entrepreneurial activities (Eraydin and Armatli-Köroǧlu, 2005; Porter, 1998a; Snowdown and Stonehouse, 2006), the acceleration of innovation diffusion (Breschi and Lissoni, 2001a), the promotion of local business competitiveness (Van Geenhuizen, 2008), the advancement of local economic growth, and the enhancement of regional prosperity (Brown, 2000; Porter, 1998a, 2005), and the potential to influence, or indeed capture, regional industrial policy settings (Martin and Rice, 2010). These advantages are realized through a variety of the mechanisms within localized networks that are spatially concentrated and enhanced within clusters (Breschi and Malerba, 2005; Leitão, 2007). It has been found that knowledge can more readily spill over to close entities, in particular the spillover of tacit knowledge which needs to be transmitted through interpersonal contact or inter-firm mobility of skilled workers (Breschi and Lissoni, 2001a; Breschi and Malerba, 2005).

Open Innovation and Regional Clusters

Evident in the previous review of open innovation and regional clusters are the variety of complementary notions and thematic overlaps. These include the presence of inter-organizational network effects, knowledge flows and spillovers, collaboration within groups of firms and between firms and other institutions. As Cooke (2005a) has pointed out, open innovation may partially explain the competitiveness of regional innovation systems, and Vanhaverbeke (2006) has also noted that firms embedded regional clusters are more inclined to employ open innovation strategies than others.

Given these observations of co-occurrence, a further investigation of the linkage between these two concepts is timely. Vanhaverbeke (2006) has suggested that the link between open innovation and regional development is a promising area of research. Simard and West (2006) also recognized regional clusters as an ideal setting for the analysis of open innovation. However, other than the work of Cooke (1998, 2005a, 2005b), who explicitly studied the relationship between open innovation, clusters and regional innovation systems, there has been limited research around this issue so far.

In order to address this gap in the literature, we attempt here to establish a conceptual framework based on the intersection of these two theoretical streams. As discussed above, two key elements commonly observed in both concepts, namely the networking with multiple actors and agents, and the presence of knowledge spillovers and flows, will be the two areas of research focus for our study.

Another core issue underpinning the open innovation philosophy is the potential synergy by integrating internal and external innovations. Researchers have suggested that although the open innovation model underlines more external research efforts, in-house R&D need not be thus seen as obsolete (Chesbrough and Crowther, 2006; Lichtenthaler, 2008). This potentially synergistic relationship is of great importance in the context of regional clusters where both internal research and external sources of innovation are active, as is often the case in clusters focusing on high technology production and manufacturing.

Based on these considerations, these three main aspects — networking with multiple sources, knowledge spillovers and flows, and relationship between internal R&D and external research will be considered as the areas of focus for our research. An important question, which hitherto remains unanswered, is how geography affects open innovation practices of firms (West et al., 2006). We focus on the question regarding whether positive open innovation outcomes will be more evident in regional clusters.

Our study, based on empirical evidence from a sample of clustered and non-clustered firms, will assess these issues. Grounded on the theoretical framework which focuses on the three central dimensions to be explored, we will propose our hypotheses on the basis of both open innovation and regional clusters literature in the following section.

3. HYPOTHESES

Networking with External Sources

Clusters have typically been understood as networks of interconnected companies and institutions (Breschi and Lissoni, 2001b; Porter, 1998a). The general benefits of networking have been widely observed by previous literature. These include the mitigation of resource and capability absences (Ahuja, 2000; Powell et al., 1996; Vanhaverbeke, 2006); the sharing of complementary skills and resources (Hagedoorn and Duysters, 2002); the facilitation of knowledge and innovation diffusion

(Cowan, 2005); and the enhancement of the market power of participant firms, especially in nascent technologies (Human and Provan, 1996).

Open innovation theories underline the importance of networking that draws upon a wide range of external knowledge sources, including focal firms, universities, research labs, venture capitalists, and other knowledge generating agencies (Simard and West, 2006). It has been widely recognized that the diverse knowledge bases outside the firm's boundary act as a driver of a firm's internal growth, value creation and innovation performance (Grönlund et al., 2010; Laursen and Salter, 2006).

Open innovation strategy entails a diverse set of linkages leading to two basic types of networking. First are the inter-firm collaborations between focal firms and their suppliers, their customers and potentially their competitors (von Hippel, 1988; Vanhaverbeke, 2006; Vanhaverbeke and Cloodt, 2006). Inter-organizational networks and collaborations play a significant role in advancing the capacity of firms to promote innovation (Faems et al., 2005; Martin and Rice, 2012; Nieto and Santamaria, 2007; Porter and Ketels, 2003). Such network arrangements can assist firms in capturing complementary knowledge and capabilities, enhancing potential variety and availability of external knowledge, and creating values through the whole value chain from the early stages of technology development towards the commercialization of innovation outputs (Chesbrough and Rosenbloom, 2002). Inter-firm networks also signify the membership in a local community of knowledge which will increase the interdependence and mutual innovation benefits between member firms (Simard and West, 2006).

This contribution to innovativeness and performance of networked firms has been also widely supported by empirical studies (e.g. Deeds and Hill, 1996; Faems et al., 2005; Hagedoorn and Schakenraad, 1994). Given these advantages, it is believed that inter-firm networking namely the linkages between firms will generally have a positive effect on innovation performance of firms regardless of their localization. On the basis of that, we hypothesize:

H1a: – Inter-firm networking will have a significant effect on innovation performance of both clustered firms and non-clustered firms.

Universities and research institutes are also recognized as an important and primary source of knowledge that facilitate open innovation outcomes (Creplet et al., 2001; Simard and West, 2006). The close cooperation with these knowledge-based institutions can help firms to keep up with the latest technological breakthroughs and explore the application and commercial potential of these technologies (Vanhaverbeke, 2006). However, compared with inter-firm networking, the practicalities of university (research institute)-firm engagement as a source of innovation activities present some significant challenges.

First, universities and research institutes often focus on theoretical or fundamental research domains where the created knowledge may not be directly applicable to industries or specific innovation process of firms (Quintas et al., 1992; Simard and West, 2006). Moreover, they are usually linked with firms by the contractual arrangements (Breschi et al., 2005), which entails the accrual of search and transaction costs (Christensen et al., 2005). The cultural dissimilarities between firms and universities also create indirect costs involving extra search and negotiation efforts, and often resulting in constrained knowledge flows (Gallini, 2002; Katila and Ahuja, 2002).

There is some evidence that suggests that regional proximity between firms and universities can be an important driver of knowledge-based collaboration between these organizations (Chesbrough, 2003b; Fabrizio, 2006; West et al., 2006). Regionally co-located firms may have face-to-face contacts with university researchers, facilitating specialized research which accords with the firm's demand (Breschi and Lissoni, 2001a) and helping to mediate some of the cultural barriers to knowledge exchange discussed above (Jaffe et al., 1993). Furthermore, it also has been found that physical proximity tends to lower the direct and indirect transactional, search and knowledge transmission costs between network participants (Breschi and Malerba, 2005).

In summary, firms co-located near universities might tend to enjoy greater benefits from firm-university (firm-research institute) linkages than will non-clustered firms.

This discussion can be stated in the following hypothesis:

H1b: – The effect of firm–university (firm-research institute) networking on innovation performance of clustered firms will be greater than that of non-clustered firms.

Knowledge Flows and Spillovers

Knowledge spillover is an intentional, or unintentional, process whereby knowledge transfers between organizations. With the closed innovation model, knowledge spillovers were usually viewed as the unwanted and unintended byproduct of innovation processes. As a cost of doing R&D, spillovers may reduce the profits available from investment in innovation (Chesbrough, 2006b; von Hippel and von Krogh, 2003).

In contrast to this traditional model where spillovers were seen as a negative externality of knowledge creation and innovation, firms operating with an open innovation strategy purposively facilitate spillovers and enable the disclosure of knowledge and technology in order to participate in collaborative network arrangements (Schmidt, 2006). These spillovers become valuable opportunities for developing new business models and exploiting innovation commercialization channels (Chesbrough, 2006a). The openness of innovation enhances the fluidity of knowledge flows and catalysts the knowledge and information exchanges between firms. Spillovers can also help overcome the intra-firm knowledge asymmetries while diversifying the firm's knowledge bases (Chesbrough, 2006b; Cooke, 2005b).

Given the importance of knowledge flows and spillovers to open innovators, we hypothesize that:

H2a: – Knowledge flows and spillovers will have a significant effect on innovation performance of both clustered firms and non-clustered firms.

Proximity-driven knowledge flows are defined as localized knowledge spillovers (LKS) in regional clusters (Cooke, 2004; Zucker et al., 1998). The effects of LKS and general knowledge spillovers on open innovation performance might differ due to the heterogeneity of knowledge stocks, as well as the variety in the way in which knowledge flows between organizations (Audretsch and Feldman, 2004).

Audretsch's (1998) study indicated that there is a higher propensity for innovation within spatial clusters, with greater tacit knowledge that needs to diffuse through direct and repeated contacts. This suggests that the flows of knowledge between co-located entities discussed by some studies (e.g. Jaffe et al., 1993) are driven by various forms of inter-firm contacts and ready access to a pool of shareable tacit knowledge (Audretsch and Feldman, 2004).

This finding is consistent with Breschi and Malerba (2005) who pointed out the specific properties of tacit knowledge, namely its dependence on co-located agents to transit as opposed to the codified knowledge that can transfer without geographical constraints. Breschi and Malerba (2005) also note that social links and close contacts required by tacit knowledge flows would be fundamentally important to encourage individual firms to tap into the localized knowledge bases and engage in collective learning processes essential for their innovation.

In that sense, we hypothesize that the tacit knowledge will play a more important role in facilitating innovation among clustered firms than non-clustered firms.

H2b: – The effect of the spillovers and flows of tacit knowledge on innovation performance of clustered firms will be greater than that of non-clustered firms.

The Relationship between Internal R&D & External Research

From the above discussion it might be assumed that under the open innovation paradigm, firms might forego the role of internal R&D, while compensating for it by drawing on knowledge and expertise from a broad range of external sources (Laursen and Salter, 2006). This contention tends to ignore potential synergy-based complementarities which may be generated through a simultaneous combination of both 'in-house' research and the sourcing of external knowledge and technologies (Ettlie and Reza, 1992). Thus in-house R&D need not become obsolete when open strategies are followed — indeed openness may even stimulate internal research investments in search of such synergies (Howells, 1999; Veugelers, 1997). Further, in addition to the traditional role of generating innovation alone, in-house R&D may act as a catalyst to the transformative effectiveness once the external knowledge reaches the focal firm (Cohen and Levinthal, 1989; Lane et al., 2006). The overall status of knowledge base within the firm could be improved by such way of integrative knowledge management (Cassiman and Veugelers, 2006; Lichtenthaler and Lichtenthaler, 2009).

This complementarity between internal R&D and open innovation practices has also been illustrated in empirical studies on open innovation (e.g. Chesbrough and Crowther, 2006; Lichtenthaler, 2008). Based on these considerations, we hypothesize that internal R&D can generally benefit innovation performance in the contexts of open innovation for both clustered firms and non-clustered firms.

H3a: – Internal R&D will positively affect innovation performance as well as enhancing the role of external research, for both clustered firms and non-clustered firms.

Expanding on Hypothesis 3a, we would anticipate that the relative impacts of internal and external research might differ between clustered and non-clustered firms. The density of network ties among multiple actors and the fluidity of knowledge flows may create variance in the impacts of internal research between the two groups. According to Leitão (2007), firms in clusters may access significant research discoveries without carrying out much internal research of their own. This might be especially the case for start-ups who might survive by relying on external institutional and organizational networks while not deploying their scarce financial and operational resources as extensively to in-house R&D (Simard and West, 2006). Simard and West (2006) also noted that networks that are facilitated by geographic proximity could play a crucial role for member firms in building ties to the complementary knowledge while establishing commercialization pathways.

Thus internal R&D may have a comparatively lower impact on cluster-based firms than those that are not embedded in regional clusters. This discussion can be stated in the following hypothesis:

H3b: – Internal R&D will have a greater effect on innovation performance of non-clustered firms than that of clustered firms.

4. METHODS

Data

The data source for this study is from the Flash Eurobarometer 187 "Innobarometer among enterprises in the EU and other European countries" telephone survey. This survey was conducted in 2006 by the Gallup Organization on behalf of the DG Enterprise and Industry of the European Commission (The Gallup Organization, 2006).

This particular Flash Eurobarometer survey was designed to provide detailed information on the clustering-related issues among companies in the various European countries, and their managers' views on the opportunities and challenges of companies operating in clusters (The Gallup Organization, 2006). The target group for the survey was companies with 20 or more employees operating in the 25 Member States of the European Union, the accession countries Bulgaria and Romania, and the candidate countries Turkey and Croatia, as well as Switzerland, Norway and Iceland. Thus firms from 32 European countries were included in total (The Gallup Organization, 2006). The desired sample size was 100 in an average-sized country, although this number varied based on the size of the country. In Germany, Spain, France, Italy, Poland and the UK, it was around 200; while in Iceland and Malta, it was around 40; and for other smaller countries (i.e. Estonia, Cyprus, Latvia, Lithuania, and Luxembourg) and non-EU countries (i.e. Bulgaria, Croatia, Romania, Turkey, Switzerland and Norway), the target sample size was around 66 (The Gallup Organization, 2006).

The person surveyed in the target group was top-level executive(s) of each company such as the General Manager, Financial Director or significant owner. The original questionnaire in English was translated to the local national languages in different countries by rigorous back-translation and central verification procedures to ensure the validity of the localized questionnaires (The Gallup Organization, 2006).

This secondary database was valuable for this empirical research in two respects. First, Europe has a rich tradition of spatial clustering and industrial districts (Audretsch and Feldman, 2004; Breschi and Lissoni, 2001a, 2001b). The role of geographic networking in promoting entrepreneurship and overcoming size disadvantage for small and medium enterprises (SMEs) in Europe has been emphasized by many studies (e.g. Pyke et al., 1990). Europe thus provides a valuable context to study firms operating in regional clusters and to conduct a comparison with firms which are not co-located. Furthermore, the dataset provided firm-level unit record data of European firms, suitable for an analysis of the variance of organizational practices as proposed by our hypotheses, and an analysis of differentiated practices between the cluster/non-cluster subgroups.

Subsamples

In order to test our hypotheses, we divided the sample drawn from the survey of Flash Eurobarometer 187 into two sub-samples, namely firms belonging to clusters and firms not belonging to clusters. This division was on the basis of the survey question "do you consider that your firm is part of a cluster, or not?"

The following definition of clusters was clearly given to respondents: "Clusters are geographically close groups of interconnected companies, suppliers, service providers, and associated institutions in a particular field. In cluster all these actors are linked in several ways… Clusters are often working in a particular region, and sometimes in a single town" (The Gallup Organization, 2006, p. 2). This definition is consistent with the definition and scope of regional clusters employed in our study.

According to the binary responses (Yes or No) to this question, we divided the whole sample into subsamples consisting of 2,297 clustered firms and 1,171 non-clustered firms. The basic attributes of observations in these two subsamples such as age, size and country distributions are presented in the appendices.

5. MEASURES

Dependent Variable

The dependent variable (*Innovation*) in this study is the dichotomous response to the question of whether a company had introduced new or significantly improved products or services in the last two years, namely during the period 2004-2006 for respondents in this study. The original responses (value 1 for yes and value 2 for no) were recoded into more semantically appropriate dichotomous variables with a value of zero (0) if no such innovation had occurred, and one (1) if it had. Given the binary feature of the dependent variable (coded 0 or 1), the binary logistic regression model was employed in the analysis.

Independent Variables

Data was gathered on inter-firm networking (*Interfirm*). The survey provided differentiated evidence regarding the size of firms that the focal firm cooperated with. Firms were asked whether they had cooperated with large firms (*Interfirm1*) or small and medium enterprises (*Interfirm2*) in the cluster (or in the wider region, for non-clustered firms). From this survey question, two variables regarding the networking with large firms and SMEs were derived. Both of these are dummy variables, taking the value of one (1) when the firm indicated that it had used such form of inter-firm networking and zero (0) otherwise.

Data was also gathered on the linkages with universities (*Uni*) and research institutes (*RI).* Firms were also asked whether they cooperated with "universities and other education institutions"; or "public laboratories or research centers". The answers to these two questions form the constructs of variables in regard to the linkages with universities (*Uni*) and research institutes (*RI).* These were provided as binary responses, which take the value of 1 for the response yes and 0 for no, after recoding of the original responses.

The construct of knowledge flows and spillovers involved in Hypothesis 2a and 2b is measured based on three survey questions. Firms were asked whether they exchanged information on technology (*Explicit1*); whether they exchanged information on market characteristics (*Explicit2*); and whether they exchanged information and knowledge on best practices (*Tacit*). The original responses were recoded into dummy variables with a value of zero (0) if no such form of knowledge exchange had occurred, and one (1) if it had. We interpreted the first two forms of knowledge exchange as being focused on explicit knowledge, and the third as being a measure of tacit knowledge, although we acknowledge the limitation of this typology.

Firms were also asked to report on the role of internal R&D (*Internal*) and external research (*External*). Internal R&D was measured by the question relating to whether the firm carried out research in its own laboratories. Firms were also asked whether they contracted out research to other firms, universities or research institutes. These are included in our model as dummy variables taking the value one (1) for yes and zero (0) for no.

Control Variables

Basic organizational attributes which have been utilized as control variables in this study are firm size and firm age. Firm size (*Size*) is expressed as a categorical variable with ordinal values of the number of employees — 0 (less than 20, which had been excluded from the original microdata by the survey conductors), 1 (20-49), 2 (50-249), 3 (250-499), 4 (500 or more). Firm age (*Age*) is also a categorical variable based on an ordinal scale of measurement, taking the value from 3 (before 1986), 2 (between 1986 and 2001) to 1 (after 2001).

Another two control variables included in this are industry dummies (*Industry*), and a measure of density of the given industry (*Density*). While widespread across industries, the open innovation phenomenon is influenced by industry-specific characteristics (Audretsch and Feldman, 2004; Chesbrough and Crowther, 2006; Laursen and Salter, 2006). In order to control for the different effects of industry heterogeneity on open innovation practices and clustering activities, our study include 14 dummy variables for industry categories. The original single variable with aggregated responses of industry categories was transformed to fine-grained measures of industry dummies, namely (1) ICT and Communication equipment; (2) Aeronautics and Space; (3) Pharmaceuticals & medical devices; (4) Construction (materials, equipment, heavy construction); (5) Automotive; (6) Metal manufacturing; (7) Plastics; (8) Chemical products; (9) Textiles, leather, footwear; (10) Energy; (11) Production equipment (machinery, electrical); (12) Food; (13) Entertainment; and (14) Services.

Associated with the industry dummy, the effect of the density of this industry (*Density*) was also included. This was measured by the question of whether the concentration of firms working in the same business sector as the focal firm's was higher, similar, or lower than elsewhere in the country. The original responses were recoded from 1 to 3 to ensure that the larger values represented a higher density of the given industry.

6. RESULTS

Descriptive statistics and correlations for both subsamples are displayed in Table 1 and Table 2. Table 3 shows our results of binary logistic regressions on the two subsamples. These lead to our findings with regard to previously-stated hypotheses. For the subsample of clustered firms, the values of Cox & Snell R Square (16.3%) and Nagelkerke R Square (23.0%) indicate a reasonable goodness of fit for the model. This is also the case for the non-clustered firm subsample where the Cox & Snell R Square is 18.9% and Nagelkerke R Square is 25.3%. The significant Chi-square ($p < .001$ for both) for both models also provides evidence of their overall significance.

Table 1. Means, Standard Deviations, and Correlations for the Sample of Clustered Firms.

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12
1. *Innovation*	0.70	0.46												
2. *Interfirm1*	0.71	0.45	.18**											
3. *Interfirm2*	0.82	0.38	18**	.45**										
4. *Uni*	0.61	0.49	.21**	.21**	.20**									
5. *RI*	0.42	0.49	.19**	.23**	.18**	.40**								
6. *Ecpilict1*	0.72	0.45	.21**	.20**	.23**	.20**	.22**							
7. *Explicit2*	0.77	0.42	.18**	.20**	.27**	.13**	.10**	.36**						
8. *Tacit*	0.74	0.44	.21**	.23**	.26**	.22**	.17**	.41**	.37**					
9. *Internal*	0.38	0.48	.27**	.13**	.02	.23**	.31**	.12**	.01	.07**				
10. *External*	0.37	0.48	.22**	.12**	.08**	.28**	.30**	.13**	.07**	.16**	.30**			
11. *Size*	1.99	1.00	.14**	.15**	.05*	.19**	.14**	.05**	.02	.07**	.22**	.20**		
12. *Age*	2.48	0.61	-.01	-.10**	-.10**	.07**	.07**	-.03	-.03	-.04*	.06**	.02	.13**	
13. *Density*	2.71	0.57	.01	-.02	-.07**	-.05**	.00	-.01	-.10**	-.04*	.05**	-.01	-.08**	-.03

n=2297; ** Correlation is significant at the 0.01 level (one-tailed); * Correlation is significant at the 0.05 level (one-tailed)
Source: the Authors.

Table 2. Means, Standard Deviations, and Correlations for the Sample of Non-Clustered Firms.

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12
1. *Innovation*	0.61	0.49												
2. *Interfirm1*	0.62	0.49	.17**											
3. *Interfirm2*	0.77	0.42	15**	.51**										
4. *Uni*	0.51	0.50	.15**	.21**	.20**									
5. *RI*	0.31	0.46	.15**	.14**	.11**	.32**								
6. *Ecpilict1*	0.51	0.50	.15**	.17**	.14**	.13**	.14**							
7. *Explicit2*	0.56	0.50	.19**	.17**	.15**	.12**	.09**	.46**						
8. *Tacit*	0.50	0.50	.10**	.16**	.11**	.19**	.14**	.45**	.47**					
9. *Internal*	0.31	0.46	.32**	.09**	.04	.19**	.32**	.09**	.05	.08**				
10. *External*	0.28	0.45	.21**	.16**	.13**	.27**	.28**	.17**	.11**	.16**	.30**			
11. *Size*	1.87	0.94	.11**	.10**	.02	.23**	.10**	.-.01	.08**	.06*	.17**	.21**		
12. *Age*	2.48	0.57	.01	-.01	-.06*	.03	.03	-.07*	-.02	-02	.05*	.-00	.17**	
13. *Density*	2.79	0.51	.00	-.06*	-.08**	-.09**	-.04	-.04	-.02	-.04	-.03	-.08**	-.04	.01

n=1171; ** Correlation is significant at the 0.01 level (one-tailed); * Correlation is significant at the 0.05 level (one-tailed)
Source: the Authors.

Table 3. Results of Binary Logistic Regression Analysis for Innovation Performance.

Dependent Variable →	**Innovation Performance (*Innovation*)**	
Independent Variables & Control Variables ↓	**Clustered**	**Non-Clustered**
INDEPENDENT VARIABLES		
Inter-firm Networking		
With Large Firms (*Interfirm1*)	0.184	0.319 +
With SMEs (*Interfirm2*)	0.367 *	0.394 *
Linkage with Universities & Research Institutes		
Universities (*Uni*)	0.276 *	0.058
Research Institutions (*RI*)	0.129	0.032
Knowledge Flows and Exchanges		
Explicit Knowledge on Technology (*Explicit1*)	0.373 **	0.254
Explicit Knowledge on Market (*Explicit2*)	0.538 ***	0.749 ***
Tacit Knowledge on Best Practices (*Tacit*)	0.356 **	-0.248
The Role of Internal & External Research		
In-house R&D (*Internal*)	0.999 ***	1.494 ***
Contracting-out Research (*External*)	0.543 ***	0.593 **

+ $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$; Two-tailed tests. Source: the Authors.

Table 3. Continued.

Dependent Variable →	**Innovation Performance (*Innovation*)**	
Independent Variables & Control Variables ↓	**Clustered**	**Non-Clustered**
CONTROL VARIABLES		
Firm Size (*Size*)	0.159 **	.083
Firm Age (*Age*)	-0.040	0.111
Industry		
ICT and Communication Equipment	0.488	0.561
Aeronautics and Space	-0.198	-1.597
Pharmaceuticals & Medical Devices	0.676	
		0.152
Construction (Materials, Equipment, Heavy Construction)	-0.112	0.061
Automotive	0.055	0.289
Metal Manufacturing	-0.063	1.062 *
Plastics	0.452	0.309
Chemical Products	-0.265	0.766
Textiles, Leather, Footwear	0.556 *	0.292
Energy	0.458	0.425
Production Equipment (Machinery, Electrical)	1.041 **	0.635 $^{+}$

$^{+}$ p < .10; * p < .05; ** p < .01; *** p < .001; Two-tailed tests. Source: the Authors.

Table 3. Continued.

Dependent Variable →	**Innovation Performance (*Innovation*)**	
Independent Variables & Control Variables ↓	**Clustered**	**Non-Clustered**
CONTROL VARIABLES		
Food	0.227	0.620 $^{+}$
Entertainment	0.529	0.211
Services	0.267 $^{+}$	0.189
Industry Density (*Density*)	0.177 $^{+}$	0.249 $^{+}$
(Constant)	-2.036 ***	-2.288 ***
n	2297	1171
Chi-square	348.98 ***	204.84 ***
-2 Log likelihood	2068.69	1086.33
Cox & Snell R Square	16.3%	18.9%
Nagelkerke R Square	23.0%	25.8%

$^{+}$ p < .10; * p < .05; ** p < .01; *** p < .001; Two-tailed tests. Source: the Authors.

With regards to Hypothesis 1a, which suggests that inter-firm networking will improve firms' innovation performance, we find that only the variable *Interfirm2* (i.e. networking with smaller firms) positively and significantly (p < .05 for both) affects with the dependent variable of both subsamples. Thus H1a is not fully supported. We suggest that this may be an artefact of the limited number of large companies available for collaboration for many of the responder firms (evidence of which is provided in the descriptive statistics of firm size in appendices). Regarding H1b, that hypothesizes that the use of firm-university (firm-research institute) linkages will have greater impact on innovation performance of clustered firms than that of their non-clustered counterparts, the variable *Uni* is positive and significant ($p < .05$) in the model of clustered firms, while insignificant ($p > .10$) in the non-clustered subsample. We note, however, that the coefficients of research institutes (variable *RI*) are not significant ($p > .10$) for observations from both subsample groups. Therefore, H1b is partially supported.

H2a suggests that the flows and exchanges of knowledge will positively affect the innovation performance of firms in both subsamples. The variables *Explicit1*, *Explicit2* and *Tacit* are all significant and positive in anticipating the innovation performance of clustered firms ($p < .01$, $p < .001$ and $p < .001$ respectively) while only *Explicit2* (namely the knowledge on market) is significant for non-clustered firms ($p < .001$). H2a is thus partially supported, while H2b is fully supported, as tacit knowledge (variable *Tacit*) is only significant and positive ($p < .001$) for the subsample of clustered firms. This suggests that spillovers of tacit knowledge will have greater impact on innovation for clustered firms in comparison to non-clustered firms.

The coefficients for the variable measuring internal R&D (variable *Internal*) are found to be positive with strong significance (both $p < .001$) for both of the subsample groups. This supports our assertion in H3a that even in the context of openness, internal R&D is still a positive antecedent to innovation performance for both clustered firms and non-clustered firms. Moreover, we note that the magnitudes of the use of external research between both subsamples are similar, while the coefficient of internal R&D for non-clustered firms is larger than for clustered firms. As such, H3b predicting that clustered firms might have a lower reliance on internal R&D for innovation, finds support from our data.

Of our control variables, the firm size (variable *Size*) seems to only affect the innovation performance of clustered firms, and Firm age (variable *Age*) does not present significantly for either of the subsamples. It is shown that for clustered-firms, their belonging to the Textiles, Leather, Footwear; and Production Equipment (Machinery, Electrical) sectors have highly significant effect ($p < .01$ and $p < .05$ respectively) on innovation performance. Services sector status has a relatively weak positive impact ($p < .10$) on innovativeness. For non-clustered firms, there is a significant positive effect ($p < .05$) for Metal Manufacturing, and a weak significant effect for Production Equipment (Machinery, Electrical) and Food sectors.

We interpret these results as an indicator that, for most European firms, the effects of geography are still crucial to the innovative capacity of the manufacturing industries. However, the relationship between high-technology industry status and innovation performance is not evident for observations in both our subsamples. Moreover, whatever industry the firm operates in, the density of that given industry (variable *Density*) is likely to positively affect the innovation performance ($p < .10$ for both subsamples).

7. DISCUSSION

This study attempts to empirically investigate an under-explored area in the open innovation literature, namely the relationship between open innovation and geographical clustering. We have explored whether open innovation is more pervasive and effective in firms within regional clusters.

We examine this question from three crucial themes underpinning open innovation philosophies, namely firms accessing external sources within network, the presence of knowledge flows and spillovers, and the relationship between internal R&D and external research.

According to the results of our study, generally speaking close geographical proximity within regional clusters provides positive, and significant, enhancements to open innovation practices in terms of firm innovativeness. This finding is consistent with many theoretical propositions in the open innovation literature (e.g. Simard and West, 2006; West et al., 2006).

Specifically, we find evidence that cluster-based (vis-à-vis non-cluster based) firms are found to have more beneficial firm-university linkages, more efficient knowledge flows and tacit knowledge exchanges, and are comparatively less reliant on internal research. This suggests that the advantages arising from the open innovation strategy can be enhanced in the context of regional clusters. This finding is also expected to provide insights into the effectiveness of open innovation in different regions or countries, and in turn the connection of open innovation to local innovation systems, regional economics and national competitiveness (Vanhaverbeke, 2006).

Many of the enhancements regarding open innovation’s impacts can be attributed to some of the supportive general features of regional clusters. Clusters are characterized by active knowledge flows among a diverse set of sources from organizations and institutions (Cooke, 2005b; Simard and West, 2006). These key sources are of great importance in terms of their supporting of either formal information exchange or tacit knowledge flows across multiple entities to facilitate innovation (Bierly and Daly, 2007). The localized knowledge spillovers are considered to have more advantages than other spillovers because knowledge always tends to transmit more efficiently among closely located actors (Breschi and Malerba, 2005; Jaffe et al., 1993), whether through inter-organizational contact or through individual mobility (Almeida and Kogut 1999). Furthermore, geographical proximity can stimulate the absorption of knowledge spillovers and establish a thick network of knowledge sharing through effective communication means within clusters (Breschi and Malerba, 2005; Cooke, 2004). Other than these explanations, our study also tries to shed light on some underlying determinants and mechanisms to explain why regional clusters are favourable for the application of open innovation.

The economic profits of open innovation can be optimized by the direct sales of technology (outbound licensing) and indirect returns through open standards, relatively fluid information flows and free knowledge exchange with limited transaction costs and potentially fewer royalty requirements (West, 2006; West and Gallagher, 2006).

Despite its advantages over the closed innovation model, open innovation is not problem-free (Elmquist et al., 2009). Its potential drawbacks have been addressed by recent research. First, some open innovation approaches might be associated with high coordination costs resulting from involving external parties in the innovation process, and transaction costs arising from contractual negotiations and information access (Christensen et al., 2005). These costs also include indirect costs and risks if the knowledge inflows (to firms) are less valuable than the outflows to the firms' competitors (Simard and West, 2006). In this sense, the difficulty in finding the right balance between disclosing certain knowledge to benefit from openness and protecting core knowledge to maintain an organisation's competitiveness exposes firms to the 'paradox of openness' (Laursen and Salter, 2005; West and Gallagher, 2006). As a result, firms are more likely to benefit from openness only when these potential returns from knowledge spillovers can outweigh the risks and costs related to open practices (Schmidt, 2006).

Regional clusters are likely to offset the downsides of open innovation and overcome the potential disadvantages of this new innovation mode in a variety of ways. Primarily, we show that the costs associated with open strategies could be reduced in clusters. Spatial proximity lowers the direct costs or relational collaboration, including search and negotiation with partners, assessing information and knowledge bases, as well as the costs of knowledge transmission, particularly for firm-university ties (Audretsch and Feldman, 2004; Breschi and Malerba, 2005; Simard and West, 2006).

As a result of these reduced costs, firms could gain more benefits from the linkages with universities and research centres. The localization also tends to reduce the indirect costs originating from the uncertainty in the relationship with collaborated firms, and tends to mitigate conflicts between inbound and outbound knowledge flows (Rice and Juniper, 2003). As the tacit knowledge flows among firms mainly take the means of informal contact between, and inter-firm mobility of, skilled workers (Breschi et al., 2005), there is probability that knowledge might flow to, and be utilized by, potential competitors. Firms thus may choose to stop knowledge disclosure and sharing in order to avoid unintended knowledge spillovers. This means the transfer of tacit knowledge requires a high degree of mutual trust and interdependence between partners.

Clusters can alleviate this uncertainty and unwillingness through the involvement of close social networks based on reciprocal trust and a co-operative relationship (Breschi and Lissoni, 2001a; Breschi and Malerba, 2005). Firms, and people, in regional clusters are more likely to establish trust based on their past interactions with others (Simard and West, 2006). This could encourage more frequent and repeated interactions between firms, and strengthen the formal or informal ties among them (Breschi and Lissoni, 2001b). Trust acts as a coordinating mechanism among networked firms in clusters (Powell, 1990). Reciprocal trust and reduced costs can also be used to explain greater reliance on external research providers such as partner firms, universities or research institutes than their in house R&D for clustered firms.

Clearly, there is some endogeneity in this analysis. By definition, a combination of competition and co-operation is one of the core characteristics of clusters (Breschi, and Malerba, 2005; Callegati and Grandi, 2005). It is suggested that facing vigorous local competition, co-operation among interconnected entities can greatly benefit knowledge sharing in clusters and boost the regional productivity (Brown, 2000; Leitão, 2007). This is also in essence akin to the philosophy involved in open innovation theories. Open innovation emphasizes the significant synergy effects of shared knowledge creation to exchange various forms of codified or tacit knowledge (Lavie and Rosenkopf, 2006; Chesbrough, 2003b). With the core of this process termed as “connect and develop”, open innovation is especially concerned with the benefits brought by cooperative relationship between firms in their competition for innovation (Sakkab, 2002).

8. CONCLUSION

Most benefits proposed by the advocates of open innovation are based on the ideas of interdependence, trust, and mutual reciprocity which greatly facilitate knowledge sharing, transfer and benefits appropriation. The findings of our research illustrate the importance of cluster-based context within which these underpinning benefits of open innovation are expected to be optimized.

Regional clusters are believed to provide an environment within which the direct costs associated with open strategies (such as contractual, knowledge search costs and indirect costs particularly in terms of knowledge transmission costs), the uncertainty in collaborative relationships and the conflicts between inbound and outbound knowledge flows, could be minimised.

This research provides positive evidence regarding the circumstances by which open innovation's benefits could be enhanced. We find that the effectiveness of open innovation could be greatly enhanced when the advantages of openness outweigh its costs and potential risks. In such circumstances, firms will optimize the benefits from adopting open strategies. Our findings show that regional clusters present a highly supportive setting where unrestricted knowledge transfers can occur, sustained by a higher degree of expected reciprocity and limited transactional and other costs.

This facilitated knowledge transfer is realized by the more efficient firm-university linkages and freer flow of tacit knowledge between cluster-based firms. However, the main limitation of this research lies in the simplification of the sources of explicit and tacit knowledge, which could be addressed in future research when data allows.

This research not only makes valuable theoretical contributions to both the regional studies and open innovation literatures, based on empirical evidence from a large sample, but also provides practical implications for policy makers and organizations. It is strongly suggested that the open innovation mode could be effectively implemented and actively encouraged within regional clusters to drive regional innovation performance, and also to create a collaborative arrangement among firms in a competitive local environment. Under such circumstances, local entrepreneurs in regional clusters also are more likely to take advantage of external knowledge sources to successfully innovate their start-ups.

REFERENCES

Ahuja, G. (2000). The duality of collaboration: Inducements and opportunities in the formation of interfirm linkages. *Strategic Management Journal*, 21(33), pp. 317–343.

Almeida, P. and Kogut, B. (1999). Localization of knowledge and the mobility of engineers in regional networks. *Management Science*, 45(7), pp. 905–917.

Andersson, T., Serger, S. S., Sörvik, J. and Hansson, E. W. (2004). *The Cluster Policies Whitebook*. International Organisation for Knowledge Economy and Enterprise Development (IKED).

Arora, A. and Gambardella, A. (1990). Complementarity and external linkages: The strategies of the large firms in biotechnology. *The Journal of Industrial Economics*, 38(4), pp. 361–379.

Audretsch, D. B. (1998). Agglomeration and the location of innovative activity. *Oxford Review of Economic Policy*, 14, pp. 18–29.

Audretsch, D. B. and Feldman, M. P. (2004). Knowledge spillovers and the geography of innovation. In J. V. Henderson, & J. F. Thisse (Eds.), *Handbook of Urban and Regional Economics: Cities and Geography*, vol. 4: 2713–2739. North Holland Publishing, Amsterdam.

Bagnasco, A. (1977). *The Three Italies*. II Mulino, Bologna.

Bergman, E. and Feser, E. (1999). *Industrial and Regional Clusters: Concepts and Comparative Applications*. West Virginia University, Regional Research Institute.

Bierly, P.E. III, Daly, P.S. (2007) "Alternative knowledge strategies, competitive environment, and organizational performance in small manufacturing firms", *Entrepreneurship Theory and Practice*, 31(4): 493-516.

Breschi, S. and Lissoni, F. (2001a). Knowledge spillovers and local innovation systems: A critical survey. *Industrial and Corporate Change*, 10(4), pp. 975–1005.

Breschi, S. and Lissoni, F. (2001b). Localised knowledge spillovers vs. innovative milieux: Knowledge "tacitness" reconsidered. *Papers in Regional Science*, 80, pp. 255–273.

Breschi, S., Lissoni, F. and Montobbio F. (2005). The geography of knowledge spillovers: Conceptual issues and measurement problems. In S. Breschi, & F. Malerba (Eds.), *Clusters, Networks & Innovation*: 343–378. Oxford University Press Inc, New York.

Breschi, S. and Malerba, F. (2005). Clusters, networks, and innovation: Research results and new directions. In S. Breschi, & F. Malerba

(Eds.), *Clusters, Networks & Innovation*: 1–28. Oxford University Press Inc, New York.

Brown, R. (2000). Cluster dynamics in theory and practice with application to Scotland. Regional and Industrial Policy Research Paper No. 38, University of Strathclyde, European Policies Research Centre.

Callegati, E. and Grandi, S. (2005). Cluster dynamics and innovation in SMEs: The role of culture. Working paper No. 03/2005, International Centre for Research on the Economics of Culture, Institutions, and Creativity (EBLA).

Carr, C. S. (1995). Does outsourcing (outside contracting) provide a strategic advantage? *InTech*, 42, pp. 72–79.

Cassiman, B. and Veugelers, R. (2006). In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Management Science*, 52(1), pp. 68–82.

Chesbrough, H. (2003a). The era of open innovation. *MIT Sloan Management Review*, 44, pp. 35–41.

Chesbrough, H. (2003b). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press, Boston.

Chesbrough, H. (2005). Open innovation: A new paradigm for understanding industrial innovation. Paper presented at the DRUID Tenth Anniversary Summer Conference, Copenhagen, Denmark, June 27-29.

Chesbrough, H. (2006a). O*pen Business Models: How to Thrive in the New Innovation Landscape*. Harvard Business School Press. Boston.

Chesbrough, H. (2006b). Open innovation: A new paradigm for understanding industrial innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open Innovation: Researching a New Paradigm*. Oxford University Press, Oxford.

Chesbrough, H. and Crowther, A. K. (2006). Beyond high tech: Early adopters of open innovation in other industries. *R&D Management*, 36(3), pp. 229–236.

Chesbrough, H. and Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: Evidence from Xerox Corporation's technology spin-off companies. *Industrial and Corporate Change*, 11(3), pp. 529–555.

Christensen, J. F., Olesen, M. H. and Kjær, J. S. (2005). The industrial dynamics of open innovation – Evidence from the transformation of consumer electronics. *Research Policy*, 34(10), pp. 1533–1549.

Christensen, J. F. (2006). Wither core competency for the large corporation in open innovation world? In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open Innovation: Researching a New Paradigm*. Oxford University Press, Oxford.
Cohen, W. M. and Levinthal, D. A. (1989). Innovation and learning: The two faces of R&D. *The Economic Journal*, 99, pp. 569–596.
Cooke, P. (1998). Introduction: Origins of the concept. In H.-J. Braczyk, P. Cooke & M. Heidenreich (Eds.) *Regional Innovation Systems*: 2–25. UCL Press, London.
Cooke, P. (2004). Systemic innovation: Triple helix, scalar envelopes, or regional knowledge capabilities, an overview. Proceedings of the International Conference on Regionalisation of Innovation Policy – Options & Experiences, Berlin, June 4-5.
Cooke, P. (2005a). Regional knowledge capabilities and open innovation: Regional innovation systems and clusters in the asymmetric knowledge economy. In S. Breschi, & F. Malerba (Eds.), *Clusters, Networks & Innovation*: 80–112. Oxford University Press Inc, New York.
Cooke, P. (2005b). Regionally asymmetric knowledge capabilities and open innovation: Exploring 'globalisation 2' – A new model of industry organization. *Research Policy*, 34, pp. 1128–1149.
Cowan, R. (2005). Network models of innovation and knowledge diffusion. In S. Breschi, & F. Malerba (Eds.), *Clusters, Networks & Innovation*: 29–53. Oxford University Press Inc, New York.
Creplet, F., Dupouet, O., Kern, F., Mehmanpazir, B. and Munier, F. (2001). Consultants and experts in management consulting firms. *Research Policy*, 30(9), pp. 1517–1535.
Deeds, D. L. and Hill, C. W. L. (1996). Strategic alliances and the rate of new product development: An empirical study of entrepreneurial biotechnology firms. *Journal of Business Venturing*, 11, pp. 41–55.
Department of Trade and Industry (DTI) (1998). *Our Competitive Future: Building the Knowledge Driven Economy*. London: HMSO.
Elmquist, M., Fredberg, T. and Ollila, S. (2009). Exploring the field of open innovation. *European Journal of Innovation Management*, 12(3), pp. 326–345.
Eraydin, A. and Armatli-Köroğ lu, B. (2005). Innovation, networking and the new industrial clusters: The characteristics of networks and local innovation capabilities in the Turkish industrial clusters. *Entrepreneurship and Regional Development*, 17(4), 237–266.

Ettlie J. E. and Reza, E. M. (1992). Organizational integration and process innovation. *Academy of Management Journal*, 35(4), pp. 795–827.

Fabrizio, K. R. (2006). The use of university research in firm innovation. In H. Chesbrough, W. Vanhaverbeke, and J. West (Eds.), *Open Innovation: Researching a New Paradigm*: 134–160. Oxford University Press, Oxford.

Faems, D., Van Looy, B. and Debackere, K. (2005). Inter-organizational collaboration and innovation: Toward a portfolio approach. *Journal of Product Innovation Management*, 22(3), pp. 238–250.

Freeman, C. (1991). Networks of innovators: A synthesis of research issues. *Research Policy*, 20, pp. 499–514.

Gallini, N. T. (2002). The economics of patents: Lessons from recent U.S. patent reform. *Journal of Economic Perspectives*, 16(2), pp. 131–154.

Gassmann, O. and Enkel, E. (2004). Towards a theory of open innovation: Three core process archetypes. Paper presented at 2004 R&D Management Conference, Lisbon, Portugal.

Grönlund, J., Sjödin, D. R. and Frishammar, J. (2010). Open innovation and the stage-gate process: A revised model for new product development. *California Management Review*, 52(3), pp. 106–131.

Hagedoorn, J. and Duysters, G. (2002). External sources of innovative capabilities: The preference for strategic alliances or mergers and acquisitions. *Journal of Management Studies*, 39(2), pp. 167–188.

Hagedoorn, J. and Schakenraad, J. (1994). The effect of strategic technology alliances on company performance. *Strategic Management Journal*, 15(4), pp. 291–309.

Howells, J. (1999). Research and technology outsourcing. T*echnology Analysis & Strategic Management*, 11(1), pp. 17–29.

Human, S. E. and Provan, K. G. (1996). External resource exchange and perceptions of competitiveness within organizational networks: An organizational learning perspective. *Frontiers for Entrepreneurship Research*, 45(2), pp. 327–669.

Jaffe, A., Trajtenberg, M. and Henderson, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics*, 108, pp. 557–598.

Katila, R. and Ahuja, G. (2002). Something old, something new: A longitudinal study of search behaviour and new product introduction. *Academy of Management Journal*, 45(8), pp. 1183–1194.

Knudsen, M. P. (2007). The relative importance of interfirm relationships and knowledge transfer for new product development success. *Product Innovation Management*, 24, pp. 117–138.

Lane, P. J., Koka, B. R. and Pathak, S. (2006). The reification of absorptive capacity: A critical review and rejuvenation of the construct. *Academy of Management Review*, 31(4), pp. 833–863.

Laursen, K. and Salter, A. (2005). The paradox of openness: Appropriability and the use of external sources of knowledge for innovation. Proceedings of the Academy of Management Conference 2005, Hawaii, USA, August 5-10.

Laursen, K. and Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal*, 27(2), pp. 131–150.

Lavie, D. and Rosenkopf, L. (2006). Balancing exploration and exploitation in alliance formation. *Academy of Management Journal*, 49, pp. 797–818.

Leitão, J. (2007). Open innovation clusters: The case of Cova da Beira region (Portugal). MPRA Paper No. 488. University Library of Munich, Germany.

Lichtenthaler, U. (2008). Open innovation in practice: An analysis of strategic approaches to technology transactions. *IEEE Transactions on Engineering Management*, 55(1), pp. 148–157.

Lichtenthaler, U. and Lichtenthaler, E. (2009). A capability-based framework for open innovation: Complementing absorptive capacity. *Journal of Management Studies*, 46(8), pp. 1315–1338.

Marshall, A. (1920). *Principles of Economics*. MacMillan, London.

Martin, N. and Rice, J. (2010) Analysing emission intensive firms as regulatory stakeholders: a role for adaptable business strategy, *Business Strategy and the Environment*, 19 (1), pp. 64-75.

Martin, N. and Rice, J. (2012) Developing renewable energy supply in Queensland, Australia: A study of the barriers, targets, policies and actions, *Renewable Energy*, 44 (1), pp. 119-127.

Nieto, M. J. and Santamaria, L. (2007). The importance of diverse collaborative networks for the novelty of product innovation. *Technovation*, 27(6-7), pp. 367–377.

Pickernell, D., Rowe, P. A., Christie, M. J. and Brooksbank, D. (2007). Developing a framework for network and cluster identification for use in economic development policy-making. *Entrepreneurship and Regional Development*, 19(4), pp. 339-358.

Pisano, G. P. (1990). The R&D boundaries of the firm: An empirical analysis. *Administrative Science Quarterly*, 35(1), pp. 153–176.

Porter, M. E. (1998a). Clusters and the new economics of competition. *Harvard Business Review*, 76(6), pp. 77–90.

Porter, M. E. (1998b). *On Competition*. Harvard Business School Press, Boston.

Porter, M. E. (2005). Building the microeconomic foundations of prosperity: Findings from the business competitiveness index. In M. Porter, K. Schwab, & A. Lopez-Claros (Eds.), *The Global Competitiveness Report 2005-2006* (World Economic Forum): 43–47. Palgrave Macmillan, New York.

Porter, M. E. And Ketels, C. H. M. (2003). *UK competitiveness: Moving to the next stage*. DTI Economics Paper No. 3.

Powell, W. W. (1990). Neither market nor hierarchy: Network forms of organization. In B. M. Staw, & L. L. Cummings (Eds.), *Research in Organizational Behavior*, vol. 12: 295–336. JAI Press, Greenwich.

Powell, W. W., Koput, K. W. and Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, 41(1), pp. 116–145.

Pyke, F., Becattini, G. and Sengenberger, W. (Eds.) (1990). *Industrial Districts and Inter-firm Co-operation in Italy*. International Institute for Labour Studies, Geneva.

Quintas, P., Wield, D. and Massey, D. (1992). Academic-industry links and innovation: Questioning the science park model. *Technovation*, 12(3), pp. 161–175.

Ramírez-Pasillas, M. (2010). International trade fairs as amplifiers of permanent and temporary proximities in clusters. *Entrepreneurship and Regional Development,* 22(2), pp. 155-187.

Rice, J. and Juniper, J. (2003) High technology alliances in uncertain times: The case of Bluetooth, Knowledge, Technology & Policy, 16 (3), pp. 113-124.

Sakkab, N. (2002). Connect & Develop complements Research & Develop at P&G. *Research Technology Management*, 45(2), pp. 38–45.

Schmidt, T. (2006). An empirical analysis of the effects of patents and secrecy on knowledge spillovers. ZEW Discussion Papers No. 06-048, ZEW–Center for European Economic Research.

Simard, C. and West, J. (2006). Knowledge network and geographic locus of innovation. In H. Chesbrough, W. Vanhaverbeke, & J.

West (Eds.), *Open Innovation: Researching a New Paradigm*. Oxford University Press, Oxford.

Snowdown, B. and Stonehouse, G. (2006). Competitiveness in a globalised world: Michael Porter on the microeconomic foundations of the competitiveness of nations, regions, and firms. *Journal of International Business Studies*, 37(2), pp. 163–175.

The Gallup Organization. (2006). Flash-EB No. 187 – Innobarometer on Clusters.

Trott, P. and Hartmann, D. (2009). Why 'open innovation' is old wine in new bottles. *International Journal of Innovation Management,* 13(4), pp. 715–736.

Van Geenhuizen, M. (2008). Knowledge networks of young innovators in the urban economy: Biotechnology as a case study. *Entrepreneurship and Regional Development*, 20(2), pp. 161–183.

Vanhaverbeke, W. (2006). The inter-organizational context of open innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open Innovation: Researching a New Paradigm*. Oxford University Press, Oxford.

Vanhaverbeke, W. and Cloodt, M. (2006). Open innovation in value networks. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open Innovation: Researching a New Paradigm*. Oxford University Press, Oxford.

Veugelers, R. (1997). Internal R&D expenditures and external technology sourcing. *Research Policy,* 26, pp. 303–316.

von Hippel, E. (1988). *The Sources of Innovation*. Oxford University Press, New York.

von Hippel, E. and von Krogh, G. (2003). Open source software and the "private-collective" innovation model: Issues for organization science. *Organization Science*, 14(2), pp. 209–223.

West, J. (2006). Does appropriability enable or retard open innovation? In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open Innovation: Researching a New Paradigm*. Oxford University Press, Oxford.

West, J., and Gallagher, S. (2006). Challenges of open innovation: The paradox of firm investment in open-source software. *R&D Management*, 36 (3), pp. 319–331.

West, J., Vanhaverbeke, W. and Chesbrough, H. (2006). Open innovation: A research agenda. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *Open Innovation: Researching a New Paradigm*. Oxford University Press, Oxford.

Zucker, L. G., Darby, M. R. and Armstrong, J. (1998). Geographically localized knowledge: Spillovers or markets? *Economic Inquiry*, 36 (1), pp. 65–86.

APPENDICES

Sample Attributes of Clustered Firms and Non-Clustered Firms

A. In which year the company was established.

Sample of Clustered Firms

	Frequency	Valid Percent	Cumulative Percent
Before 1986	1217	53.0	53.0
1986 - 2001	923	40.2	93.2
After 2001	135	5.9	99.0
DK/NA	22	1.0	100.0
Total	2297	100.0	

Sample of Non-Clustered Firms

	Frequency	Valid Percent	Cumulative Percent
Before 1986	606	51.8	51.8
1986 - 2001	514	43.9	95.6
After 2001	46	3.9	99.6
DK/NA	5	.4	100.0
Total	1171	100.0	

Source: the Authors.

B. How many employees in the company.

Sample of Clustered Firms

	Frequency	Valid Percent	Cumulative Percent
20-49	875	38.1	38.1
50-249	859	37.4	75.5
250-499	277	12.1	87.5
500 or more	286	12.5	100.0
Total	2297	100.0	

Sample of Non-Clustered Firms

	Frequency	Valid Percent	Cumulative Percent
20-49	487	41.6	41.6
50-249	465	39.7	81.3
250-499	104	8.9	90.2
500 or more	115	9.8	100.0
Total	1171	100.0	

Source: the Authors.

C. Country distribution of observations in sample.

Sample of Clustered Firms

	Frequency	Valid Percent	Cumulative Percent
Belgium	82	3.6	3.6
Czech Rep.	23	1.0	4.6
Denmark	52	2.3	6.8
Germany	105	4.6	11.4
Estonia	45	2.0	13.4
Greece	50	2.2	15.5
Spain	40	1.7	17.3
France	149	6.5	23.8
Ireland	148	6.4	30.2
Italy	195	8.5	38.7
Cyprus	5	.2	38.9
Latvia	47	2.0	41.0
Lithuania	38	1.7	42.6
Luxembourg	25	1.1	43.7
Hungary	53	2.3	46.0
Malta	31	1.3	47.4
Netherlands	26	1.1	48.5
Austria	51	2.2	50.7
Poland	56	2.4	53.2
Portugal	97	4.2	57.4
Slovenia	44	1.9	59.3
Slovakia	73	3.2	62.5
Finland	90	3.9	66.4
Sweden	84	3.7	70.0
UK	270	11.8	81.8
Bulgaria	82	3.6	85.4
Croatia	68	3.0	88.3
Romania	63	2.7	91.1
Turkey	86	3.7	94.8
Norway	54	2.4	97.2
Switzerland	37	1.6	98.8
Iceland	28	1.2	100.0
Total	2297	100.0	

Sample of Non-Clustered Firms

	Frequency	Valid Percent	Cumulative Percent
Belgium	18	1.5	1.5
Czech Rep.	22	1.9	3.4
Denmark	17	1.5	4.9
Germany	45	3.8	8.7
Estonia	16	1.4	10.1
Greece	18	1.5	11.6
Spain	39	3.3	14.9
France	75	6.4	21.3
Ireland	77	6.6	27.9
Italy	164	14.0	41.9
Cyprus	1	.1	42.0
Latvia	13	1.1	43.1
Lithuania	27	2.3	45.4
Luxembourg	12	1.0	46.5
Hungary	55	4.7	51.2
Malta	10	.9	52.0
Netherlands	8	.7	52.7
Austria	51	4.4	57.0
Poland	24	2.0	59.1
Portugal	56	4.8	63.9
Slovenia	44	3.8	67.6
Slovakia	47	4.0	71.6
Finland	10	.9	72.5
Sweden	20	1.7	74.2
UK	136	11.6	85.8
Bulgaria	12	1.0	86.8
Croatia	57	4.9	91.7
Romania	17	1.5	93.2
Turkey	29	2.5	95.6
Norway	13	1.1	96.8
Switzerland	29	2.5	99.2
Iceland	9	.8	100.0
Total	1171	100.0	

Source: the Authors.