CESIS Electronic Working Paper Series

Paper No. 383

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November, 2014

The Royal Institute of technology
Centre of Excellence for Science and Innovation Studies (CESIS)
http://www.cesis.se

Innovation and firm collaboration -An exploration of survey data

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Abstract: Recent literature on firm innovation emphasize the importance of combinations of different knowledge sources in innovation processes. Moreover, the literature on firm collaboration has evolved stepwise: (1) knowledge networks tend to be geographically bounded, and (2) proximity in other dimensions than physical distance, such as cognitive and organisational proximity, may influence the evolution and influences of networks. The results from this empirical study support these ideas by indicating that firms' probability to innovate is enhanced when they collaborate. However, not all types of collaborations are as important. By using data from a survey on innovation and collaboration of 636 firms in the county of Jönköping, Sweden, we find that extra-regional collaboration matters the most for the innovation performance of these firms. Moreover, collaborations tend to be most favourable for innovation when the collaborators involved has some organisational or cognitive proximity. Collaborations that imply vertical linkages in the value added chain appear to more important than horizontal linkages.

Keywords: innovation, innovation networks, innovation survey, proximity, firm collaboration

JEL codes: R10, O31, C83

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Introduction

In a dynamic economy with strong competition at local, regional and global scales, firms continuously need to renew and upgrade their products, services and processes to keep a competitive position. There is an extensive literature on firm innovation and the role it plays for firm survival and growth. Over the last 25 years there has also evolved a path of literature on innovation and regional innovation networks. Most firms are small actors on large markets and most firms find that their internal capacities are insufficient in an innovation process. There are actually increasing evidence that firms combine local and global sources in their product renewal and innovation processes (Asheim & Isaksen, 2002; Moodysson, Coenen, & Asheim, 2008; Simmie, 2003; Trippl, 2011).

Knowledge networks can take many forms, ranging from informal industry or trade networks, to more rigid organizational structures in the shape of corporate groups. A large body of literature focuses on the role of proximity for knowledge exchange and find that knowledge networks tend to be geographically bounded (Anselin, et al., 1997; Asheim and Isaksen, 2002; among others). More recently, the perspectives of proximity are broadened to other dimensions, such as cognitive, organizational, institutional and social adjacency between collaborating agents (Boschma, 2005; Ponds, et al. 2007; Boschma and Frenken, 2010). As discussed by Boschma and Frenken (2010), several studies indicate that proximity in one of these non-geographical dimensions can reduce the importance of proximity in physical space. So, influences of spatial distances on knowledge exchange and formation of knowledge networks appear to be more complex than what have been indicated in most preceding literature on knowledge transfers and innovation.

This paper investigates these issues further. We explore the patterns of firm collaborations, with regard to the type collaborating firm *and* its spatial location. The purpose of the study is to analyse the effects of firm collaborations on firm probability to be innovative. The analysis is based on unique survey data including a sample of 636 firms with at least one employee, in the county of Jönköping, Sweden. The paper contributes to the research on firm collaboration and innovation processes in two ways. First, this survey data includes, in contrast to e.g. the *Community Innovation Survey*, also the smallest firms. Innovation activities in small firms are largely overlooked in current innovation research, partly because of lack of data but also because of a widespread view that small firms do not innovate. It might be that small firms carry out fewer innovations in absolute numbers but they are nevertheless important contributors to technological progress and economic renewal (Acs & Audretsch, 1988). In fact, small firms contribute significantly to the dynamics in local and regional economic structures, because new goods, services and other activities are most often brought to new places in small scales. Some innovative activities are also organized in small firms in the form of spin-offs from larger firms, for the purposes of handling risks, joint ventures etc. Small and medium sized firms are also particularly interesting in the context of knowledge networks. Their smallness limits the knowledge capacities within the firm but it also allows for far-reaching specialization and extensive flexibility. As a consequence, firm collaboration and participation in different types of knowledge networks may be crucial for innovation activities in SMEs and those firms

may play an important role in these types of networks (Ebersberger & Herstad, 2012; Gagliardi et al., 2013). This paper contributes to previous research by shedding some light on the role of small firms in regional innovation output and the collaboration patterns for such firms in local and inter-regional settings.

A second contribution of this paper is found in the analysis of collaborations. To our knowledge there are limited firm-level evidences on the implications of different proximity dimensions on innovative performance. The survey data used in this study includes information about firm's collaborating partners that allow us to distinguish between intra-and inter-firm collaborations, intra- and inter-industry collaborations and vertical and horizontal linkages between firms in the value added chain. Moreover, information about the location of collaborating firms allows us to identify intra- and inter-regional co-operations as well as international links. This information is used to analyse the influences of cognitive, organizational and spatial proximity on the probability that firms are innovative. The empirical results show that collaboration overall matters for innovation. However, when the forms of collaboration are disentangled we find that extra-regional collaboration matters and firm tend to do collaborations characterized by organisational and cognitive proximity.

The paper is organized as follows: Section 2 presents the theoretical background to our study, which is followed by a presentation of the survey on innovation and collaborations among firms in the county of Jönköping in section 3. Section 4 presents some descriptive statistics from the survey data and explores the patterns of firm collaborations. The importance of these collaborations for firms' innovation performance is further analysed in the following sections, which present the empirical methods (Section 5) and results (Section 6). Conclusions that can be drawn from this study and directions for further research are finally discussed in Section 7.

Internal and external knowledge

One of the primary reasons for firms to engage in innovation activities is to enhance firm performance (increase revenues or reducing costs). The main motivation for firms to invest in innovation activities is the possibility to gain monopoly profits. The uniqueness of an innovation tends to fade over time, and becomes obsolete when new versions pop up in the market. Such cyclical behaviour of life and death of products can be described through product life cycle theories. These offer an illustrative picture of how a market-leading position constantly needs to be fed with new knowledge and new innovations and one way to do this is to invest in new knowledge and more research and development. [3] These activities can be performed within the firm, in collaboration with other actors, or be fully outsourced to external parties. Recent research suggests that firm innovation and renewal result from processes that exploit knowledge from a mix of internal and external knowledge sources (Andersson & Johansson, 2010; Cantwell & Zhang, 2012).

[3] Product life cycle theory was introduced by Norton and Rees (1979).

Access to external knowledge

External knowledge can be accessed from various sources. Knowledge is an input factor that is primarily embedded in the mind of people. Still, this input factor is not only found in labour markets but also transacted on markets for goods and services. The exchange of goods and intermediates implicitly contains an exchange of knowledge and technologies. These findings are most prevalent in studies on international trade flows but more local markets for business services have also been shown of significant importance for mediating knowledge input for innovation and renewal (Johansson et al. 2014). In related research, there are ample evidences of the importance of multinational firms as disseminators of technologies across borders (Blomström and Kokko, 1998; Keller and Yeaple, 2009, among others). Firms that are part of a larger organizational structure, i.e. a corporate group, often find useful knowledge sources within the corporate group. Linkages between firms in the same corporate group are therefore important channels for knowledge transfers and one can say that they are specific types of knowledge networks. Empirical studies have shown that firms within these networks are, in fact, more innovative than independent corporations (Ebersberger and Lööf 2005; Johansson and Lööf, 2006; among others).

Networks of innovation and knowledge spillovers

Firms can also get access to external knowledge by finding collaborating partners outside the corporate group and a widespread explanation for firm collaboration is pooling of research resources where firms can act as complements to each other (Wernerfelt, 1984). Innovation is an activity with both high costs and high risks and these two variables can be reduced through collaboration with others (Hagedoorn, 1993; Pfeffer & Salancik, 1978).

One type of knowledge networks that frequently appears in the innovation literature is systems for collaborations between industry and knowledge producing organizations. From there, the step to talk about the regional (or national) ability to innovate is not very far. This ability does not only depend on the performance of firms, organizations and institutes in a country or region but rather on how they interact as parts of a system (Freeman 1995, Gregersen et. al., 1996). This type of systems of production and diffusion of knowledge and ideas is what is often referred to as *innovation systems* (Acs, Audretsch, & Feldman, 1992, 1994; Feldman, 1994; Jaffe, 1986; Lundvall, 1988). These networks facilitate generation, transmission and assimilation of knowledge, and are presumed to stimulate pooling of resources for innovation (Fischer & Fröhlich, 2001).

In fact, knowledge- and R&D activities tend to agglomerate in space for a number of reasons. One of them is knowledge transfers, which is central in economics of agglomeration, suggesting that knowledge diffuses, intentionally or unintentionally. Most empirical studies indicate that knowledge transfers are hindered by geographical distances as the exchange of complex knowledge requires face-to-face interaction. Interpersonal meetings are sensitive to geographical distance as the transaction cost and alternative cost of meetings increases with physical distance as well as time distances. Hence, the cost of

acquiring external knowledge through market-based transactions, inter-organizational collaborations or in the form of pure spillover is often larger if the agents involved are located far from each other.

Knowledge can also spill over between economic agents and these contribute significantly to knowledge creation, firm performance and economic development. There are ample evidences of knowledge spillovers being spatially localized (Feldman et. al., 1998). In view of spatial clustering of knowledge intensive activities and the localized nature of knowledge spillovers, regional innovation systems (RIS) have attracted a lot of interest in the literature as well as in innovation policy making. A RIS is generally characterized by two key features; a core regional cluster of firms and a supportive institutional infrastructure (Asheim & Isaksen, 2002).

Whereas the implications of spatial proximity for knowledge transfers are well established in the literature, the importance of other dimensions of proximity is not. Boschma (2005) argue that several other dimensions of proximity can explain the magnitude and strength of firm networks. In brief, these dimensions relates to technology and knowledge bases (cognitive proximity), hierarchical structures (organizational proximity), legal frameworks (institutional proximity) and personal relations (social proximity). Boschma (2005) claims that proximity in space is neither a necessary nor a sufficient condition for knowledge transfers and innovation. Instead, proximity dimensions in innovation networks can be expected to be substitutes rather than complements. Empirical studies in this area suggest that proximity in one of these non-geographical dimensions is sufficient for reducing the importance of proximity in physical space[4].

Knowledge proximity

In view of firm collaborations, it should be noted that external knowledge can be completely new to the firm or of complementary character to what already exists in the firm (Mowery & Rosenberg, 1989). A key factor for successful implementation of external knowledge is the absorptive capacity of the recipient firm (Cohen & Levinthal, 1990). Hence, the role of cognitive proximity between agents may be of specific interest in the context of innovation collaboration. That is, their cognitive base must be close enough to the new knowledge in order to communicate, understand and process it successfully. Nooteboom et al. (2007), among others, have demonstrated that cognitive adjacency is an important determinant in R&D alliances. With regard to innovative output, most previous research considering cognitive proximity has analyzed its' implications for patent production and patent citations. For example, Breschi and Lissoni (2006) found that most patent citations occur within the same 12 digit patent class, which supposedly reveal that cognitive proximity matters for knowledge spillovers.

The importance of external knowledge sources may vary across firms due to variations in knowledge and technology bases and organizational settings. Related to this is also firm size which since Schumpeter has played an important role in research on technological progress and innovation. Schumpeter argued that the small firms show the vitality in terms of innovativeness and are the engine of entrepreneurship.

[4] See Boschma and Frenken (2010) for an overview of this literature.

In the late 1980s and the early 1990s, a line of research was presented arguing that the small firm is the engine of sharing ideas in terms of both magnitude and diversity (Gilder, 1988; Rogers, 1990). Those who traditionally proclaim small firm advantages argue that it is the lack of bureaucracy that provides them with the freedom in mind and action in terms of innovation incentives. Larger firms have on the other hand the physical and human capital to carry out large innovation activities. For the purposes of handling risks, joint ventures etc., some innovative activities are organized in the form of small firm spin-offs from larger firms.

A recent line of research focuses on diversification strategies and its relation to firm size. In terms of technological advances and innovation, there are arguments supporting a real trade-off between industry diversity and firm size. Industries composed by smaller firms tend to have a more rapid technological change since more ideas come out in daylight to be tested. An industry with fewer, but larges firms tend to have a more rapid *rate* of technological advances on those innovation approaches that are actually pursued (Cohen & Klepper, 1992). Studies indicate that there is a firm size threshold that matters the most for innovation performance. As long as the firms under study are of a modest size one does not observe that larger firms are more research intensive nor more innovative than smaller firms (Baldwin & Scott, 1987; Kamien & Schwartz, 1982). The relative innovation advantage between small and large firms is rather determined by the degree of competitiveness in the industry. Smaller firms are, however, generally more limited with regard to internal resources that are useful in innovation processes. As a consequence, external knowledge may be of specific importance for these firms (Asheim and Isaksen, 2002). The patterns of collaboration for small and large firms and the importance of such network activities for innovation performance is further analysed in the sequel of this paper.

A survey on firm innovation and collaboration

The first challenge posed to everyone that does empirical studies on innovation is how to define an innovation. Innovations can be identified and studied with respect to knowledge input but also as innovation output (Abernathy & Utterback, 1978; Porter, 1986). A common perspective in the literature is that a product invention is not an innovation until it has reached a market. Similarly, a new technology is not a process innovation until it has been applied in the production system. A common distinction is between innovations that build on knowledge that already exist (incremental), and innovations that build on completely new knowledge (radical) (Schumpeter, 1934). In the Schumpeterian tradition, innovation activities are viewed as experiments which eventually are successful and create ground breaking technological changes at the market.

Moving from theory to practice, it is still not an easy task to determine what output from creative processes that actually can be regarded as an innovation. What is a *new* product and what can be considered as a *new* production process? The Oslo manual is a collaboration between 30 countries on guidelines for collecting and interpreting innovation data and from this, the community innovation survey (CIS) has been devised. The results from the CIS have, over the years refined the Oslo manual and what

can be considered as an innovation. Four types of innovations are now distinguished in the manual: *product innovations*, *process innovations*, *marketing innovations*, and *organisational innovations*. An innovation is thereby defined as:

> "……the implementation of a new or significantly improved (good or service), or process, a new marketing method, or a new organisational method in business practice, workplace organisation or external relations……., where the minimum requirement for an innovation is that the product, process, marketing method or organisational method must be new (or significantly improved) to the firm" Oslo Manual, (2005, p. 46)

CIS is based on the Oslo Manual and constructed in such way that firms easily can be categorized into innovating and non-innovating firms even though the definition behind it is complex. This has opened up for critique on the CIS but foremost on the usage of the results. When surveys are sent out, the problem is that the respondent is alone responsible of interpreting the definition of what is an innovation. This becomes problematic in the sense that the threshold of what is an innovation can differ between nations but also between sectors and individual firms. A small change may qualify as an innovation from one person's point of view, while such change is mere routine in the view of someone else (Tether, 2001). One can therefore say that it is easy to distinguish between innovators and non-innovators in theory but from a firm perspective it can be difficult to put themselves into either of the categories. Firms can have an interest in change and engage in creative processes but still not regard themselves as innovators.

The present paper is based on a survey on firms' innovation and collaborations in the county of Jönköping, Sweden and has a number of similarities with the CIS, particularly in the way questions are formulated. CIS is a survey of innovation activities in enterprises and is designed with the ambition to provide information on innovativeness of sectors, different types of innovations, and various aspects of innovation development. The CIS questionnaire is unfortunately only sent out to firms with at least 10 employees. Since the county of Jönköping host many small firms the CIS data miss important parts of the business activities going on in this region. Hence, our survey of innovations and firm collaborations was sent out to firms in all size classes with the minimum restriction of 1 employee.

The fact that also the smallest firms were included called for some modification of the survey method in terms of formulation of survey questions and method of collecting responses. Instead of written postal questionnaires, we used telephone interviews as this method allows for some guidance from the part of the interviewer and requires less reading from the respondent. Moreover, in telephone interviews, questions must be formulated and posed in a more direct manner than what is necessarily the case in written questionnaires. Accordingly, our respondents have been asked three central questions on innovations such as:

During the years 2008 to 2011, did your enterprise introduce…….:

1. ……*any new or significantly improved goods?*
2. ……*any new or significantly improved services?*
3. ……*any new or significantly improved production processes?*

These questions are structured in the same way as in CIS with the difference that the quite wordy definitions of product- and process innovations provided to the respondents of the CIS were completely left aside in our interviews, simply because this information is of no relevance for the respondents of the above questions. Rather, the issue of definitions is a problem for the researchers analysing the responses. The interview period was split into two with one test round (November-December 2012) and one final round after some minor adjustments in the questionnaire (January-February 2013).

The sample of firms that were interviewed were randomly selected form a large sample of 3 313 out of a total population of 8151 firms with at least one employee in the county of Jönköping. This sample of firms was delivered by Statistics Sweden and was stratified with respect to firm size. This data also provided us with information about basic firm characteristics such as revenue, number of employees, legal type, industry and age. From this sample we draw a random subsample of 985 firms, which were contacted for an interview. 636 of the firms that were contacted were actually interviewed. Respondents and non-respondents in the sampling process are presented in Table 1. Appendix Table A1 shows the complete sampling process from the set of 3 300 firms.

Table 1 Respondents and non-respondents

	N	%
Responded to survey	636	65
Refuse to participate	237	24
Lack of time	98	10
Switchboard not allowed to give out name and number	14	1
Sum	985	100

Innovation and firm collaboration in the County of Jönköping

Before analysing the survey with econometric tools, this section presents some interesting outcomes of the survey, with regard to innovation and firms' collaboration patterns. Table 2 shows that a little more than one third of the respondents consider themselves as having introduced a product innovation and around 40 percent a new (or significantly improved) service. Nearly 20 percent of the firms have introduced a new product *as well as* a new service. The final row shows that 69 percent of the respondents are categorized as innovators, adding product- and/or service- and/or process innovations together. As shown in the last row in Table 2, 77 percent of the large firms are innovative in at least one respect, whereas the corresponding share for small firms are 59 percent.

Table 2 Type of innovation in all firms, small firms and large firms respectively

	ALL FIRMS		LARGE FIRMS		SMALL FIRMS	
Type of innovation	N	Share of 636 respondents (%)	N	Share of 326 respondents (%)	N	Share of 310 respondents (%)
Product	229	36	143	44	86	28
Service	274	43	161	49	113	36
Process	224	35	143	44	81	26
Product *and* service	119	19	78	24	41	13
Product *or* service	384	61	226	69	158	51
Product *and/or* service *and/or* process	**436**	69	252	77	184	59

If any of the questions stated above where answered affirmative, the firms were asked to answer some follow up questions. These questions consider the objectives and impacts of innovation but also on cooperation related to the development of this particular innovation (Table 3).

Table 3 Innovative firms, novelty of innovation and general questions on innovation collaboration

	N	Share of 436 innovators (%)
*Highest objectives for innovation***		
Increase scope of products	209	48
Replacing obsolete products	173	40
Enter new markets/increase market shares	214	49
Improve quality	202	46
Improve flexibility	194	44
Reduce labour costs	124	28
Reduce material and energy costs	91	21
Reduce environmental impact	102	23
Improve health or safety for employees	130	30
*Innovation novelty**		
Was any of the innovations 2008-2011 new to the market?	117	27
Where all innovations 2008-2011 only new to the firm?	225	51
*Innovation collaboration**		
Innovation/-s was only developed within the firm	219	50
Innovation/-s was not only developed within the firm	130	30

* Not all innovative firms choose to answer all questions why the sums not always add up to 436
**This was a question with multiple response opportunities with six alternatives on each objective (1) high, (2) medium, (3) low, (4) not relevant, (5) Do not know, (6) Refuse to answer. Thus, in the present table does N show the number of firms that answered *high* importance on each objective.

As additional information, the survey responses also reveal that out of those firms who are *not* innovative about half of them (53 %) have not been doing any efforts to develop any new products, services or production processes. Slightly more than one fifth (21 %) of them have done small efforts. Only 9,5 % have done large efforts to be innovative but failed.

All firms, innovative and non-innovative were asked with whom they collaborates with for developing their businesses, without any strict relations to innovation activities. 472 out of the 636 respondents said that they have collaborated with someone else during the time period in question. Figure 1 presents the distribution of the answers to the question: *"which of the following actors has your company collaborated with for the purpose of developing your firm during 2008 to 2011, and where are these collaborators located?"* (Observe that respondents may provide multiple answers)

Figure 1 Distribution of firms' collaborations **not** exclusively related to innovation activities (Respondents are allowed to give multiple responses). 472 of the respondents say that they collaborate.

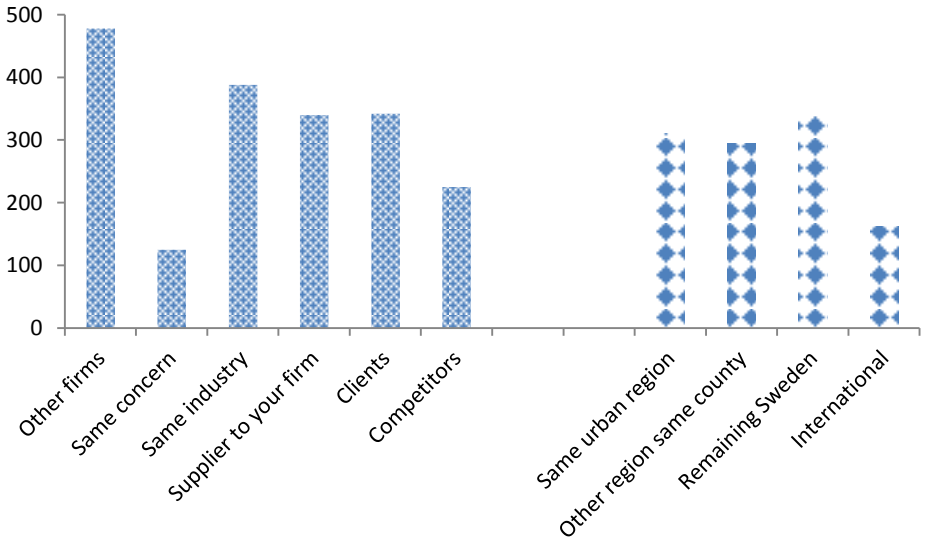

Figure 1 reveals that the majority of firm collaborations take place between firms in the same industry, and often involve partners at other stages in the value added chain. Hence, collaborations seem to create vertical linkages both backward and forward in the value chain. Horizontal linkages i.e. collaboration between competing firms seem to be less pronounced. Turning the interest to the location of collaborating partners, the group of bars to the right in the chart shows that local, intra-regional and extra-regional collaborations are equally frequent. As many as 162 out of 472 respondents say that they collaborate with partners in other countries.

Econometric Methods

The purpose of this study is to analyse how internal and external knowledge sources affect firms' innovation performance, with specific focus on the influences of firm collaboration. With regard to innovation performance, our prime interest is whether firms are innovative or not, independent of type of innovation or level of novelty etc. Accordingly, the dependent variable is binary: innovative or not innovative. The most common empirical strategy in this situation is to use a logistic regression, assuming linear relationship between the outcome variable and the explanatory variables. The logistic model

estimates the logit-transformed probability of the relationships through a maximum likelihood method, and is in our case specified as:

Equation 1

$$logit(P_{innov}) = log\left(\frac{P_{innov}}{(1 - P_{innov})}\right)$$
$$= \alpha_i + [Firm\ character]'\beta_i + [Regional\ character]'\gamma_i + [Collaboration]'\delta_i$$

where the dependent variable *innovative* (1 or 0) is incorporated as the probability of it to be 1: P_{innov} . The explanatory variables are grouped into three types: firm characteristics, regional characteristic and collaborations. In Equation 1 they are expressed as 3 vectors of predictor groups. However, prior to a detailed description of the content of these, one has to fully understand the sampling method, survey method as well as the need of post stratification.

The full sampling procedure is illustrated in table A1. Following this, we also know that going from the 8 151 firms with at least 1 employee to 638 respondents, we have to consider the distribution of respondents across different firm size groups and its correlation with firm distribution across different size groups in the whole population. As many as 5 226 of the 8 151 firms are small firms (less than 5 employees). Only 314 of them are large firms (more than 50 employees). In the set of respondent firms we have 126 small firm and 108 large firms. By going from our population (8 151) to our set of respondents (638) we lose a bit more than 40 % of the smallest firms and close to 30 % of the largest firms. Such unbalance needs to be treated by adding sampling weights to reduce biases in the regression estimates. For this purpose, we do a post-stratification with 4 strata based on firm size groups. The data set needs not to be stratified with respect to firms' geographical location as the sample of respondents reflects the geographical distribution of the whole firm population.

Table 4 presents the variables in the analysis. They are divided into three types of variables: firm characteristics, regional characteristics, and collaboration. Previous research has shown that large firms stand for the predominant part of R&D investments in the private sector and, consequently, large firms contribute with the majority of innovations. Hence, one would expect that small firms have limited resources to spend on R&D activities and we therefore include a dummy variable for firms with less than 10 employees. This variable is expected to have a negative impact on the probability that a firm is innovative. The knowledge and experience *within* the firm is another key variable, which is here approximated by the share of the labour force with at least three years of university education. As argued in the theoretical background, internal knowledge often needs to be accompanied with external competences. At the firm level, external interactions can take many forms. Our data reveal two types of external linkages at the level of the firm that are not a result of collaboration, namely export activities and ownership structures. As discussed in Section 2, knowledge and technology transfers are embedded in trade in goods and services. Moreover, previous research has found that exporters are more likely to invest in R&D because these firms already have a larger market to reap monopoly profits from. Being part of a multinational enterprise gives a similar type of knowledge and market advantages.

Substantial parts of the literature on location and economic agglomeration explain the effects of the local and regional milieu for firm innovativeness. This literature generally emphasizes the role of different knowledge sources and the accessibility of local firms to these sources. Possible knowledge effects can be captured in various ways and a variation of variables has been controlled for in the present analysis. Accessibility to knowledge, share of business services and accessibility to knowledge intensive business services in the surrounding economy are variables that are correlated with it each other. Hence, inclusion of one of them in the regression model is enough to capture the effect of the regional milieu, and following results from previous research (e.g. Johansson et al. 2014) we include accessibility to knowledge intensive business services since this variable reflects the local supply of knowledge mediated in markets for services.

The third set of variables is those describing collaboration. They are derived from two main questions in the survey: with whom does the firm cooperate and where does the firm find collaborating partners? So to the extent that collaboration is of any significance: *who* is the principal collaborator in order to offshoot innovation? This question is very much associated with cognitive proximity in terms of knowledge within the firm and knowledge in hands of the collaborator. For some types of innovations, collaboration needs to add knowledge in relation to what is already at place in-house. For other types of innovations, collaborator's knowledge needs to be completely different.

Collaborating with suppliers and clients represents what sometimes is referred to as backward and forward integration. This is often a result of strategic alliances by firms with an ambition to improve efficiency and cut costs. Backward integration can for instance be a collaboration to cut transportation costs, improve profit margins and therefore be more competitive. Such integration may result in new products but, more likely, also in new processes. In contrast to this, forward integration is a type of vertical collaboration involving distributors and clients.

Turning to the second question about collaboration: *where* is the collaborator located? This is split into three geographical levels: within the region where the firm is located, outside this particular region but still within the country, and outside the country. The majority of municipalities in the Jönköping County are rural and one can therefore expect that firms in this region need to compensate the low density regional milieu with extra-regional collaborations.

Table 4 Explanatory variables reflecting firm characteristics, regional characteristics and forms of collaboration

Variable	Description	Motivation
Dependent variable		
Innovative	1=innovative 0=otherwise	
Firm characteristics		
Small firm	Firms with 1 to 9 employees	
High education	Share of employees with a university education	Innovative capability/absorptive capacity
Exporter	Sell on international markets	International market access and knowledge linkages
Multinational	Belongs to a multinational corporate group (with locations in at least two countries)	Structural access to knowledge, experiences, and markets
Industry dummy*		Control for industry effects
Regional characteristic		
KIBS access	Accessibility to people employed in knowledge intensive business services	Regional knowledge milieu
COLLABORATION		
Collaboration	Any type of collaboration with other organizations not restricted to innovation activities	Positive effect on firm innovation
Collaboration: with whom		
Collaboration	Any type of collaboration	Positive effect on firm innovation
Same corporate group	Collaboration partner within the same corporate group	A knowledge source accessible through organizational proximity.
Same industry	Collaboration partner within the same industry	Knowledge source accessible through cognitive proximity.
Supplier	Collaboration with a supplier	Backward vertical integration
Client	Collaboration with a client	Forward vertical integration
Competitor	Collaboration with a competitor	Horizontal ties
Collaboration: where		
Inter regional	Collaboration partner within the same region	
Extra regional	Collaboration partner outside the region	
International	International collaboration partner	

* Industry dummy (manufacturing, service and agriculture, fishery, forestry. Not included: others)
Table A2 presents the pair-wise correlations for all variables.

Empirical results

The empirical analysis is divided into two steps. The first step is to specify a model who best describes the effect of collaboration when we also consider firm, and regional characteristics. Based on previous studies we have some prior expectations on how firm size, internal knowledge, exporting- and multinational firms affect innovativeness. Previous empirical results concerning firm collaboration is, on the other hand, rather limited. In the second step we develop the model to also include the effects of different types of collaborations.

Estimation results are presented as odds ratios instead of the estimated coefficients to emphasize the focus on *probabilities* for firms to be innovative. In our multiple logistic regression, the estimated coefficients for all variables: $\widehat{\beta_i}$ (firm variables), $\widehat{\gamma_i}$ (region variables) or $\widehat{\delta_i}$ (collaboration variables) are related to their conditional odds ratio. The odds ratio of being innovative is defined as the ratios of the probability of *innovate* over the probability of *not innovate*. For a multiple regression this has to be expressed as the relation between the dependent variable (innovative) and one of the predicting variables, holding the other variables constant. It is a way to generalize the odds ratios beyond only two binary variables. So, by looking at the first example in Table 5: "small firm". This is also a binary variable and the odds ratio is 0.53. This is calculated from the estimated coefficient $\widehat{\beta_i}$ for the variable "small firm" such as:

$$exp(\hat{\beta}_x) = \frac{P(innov = 1 \,|\, Small\ firm = 1, other\ variables)/P(innov = 0 \,|\, Small\ firm = 1, other\ variables)}{P(innov = 1 \,|\, Small\ firm = 0, other\ variables)/P(innov = 0 \,|\, Small\ firm = 0, other\ variables)}$$

Following this, we interpret $exp(\hat{\beta}_x)$ as an estimate of the odds ratio between the dependent variable and the predictor when the other predicting variables are held constant. The end result of this manipulation is that the odds ratio can be computed by raising e to the power of the logistic coefficient. In other words, the exponential function of the estimated coefficient is the odds ratio associated with a one-unit increase in the predicting variable.

Firm characteristics, regional characteristics and any type of collaboration

Table 5 presents the estimation results for the first of the two steps in the empirical analysis. Table 5 presents five models (1-5) which are specified through step-wise introduction of the variables. Estimated results in model specification 1 are all following prior expectations; being a small firm has a negative effect on the probability of being an innovating firm (an odds ratio below 1) whereas a high share of educated employees has a positive effect, though close to ambivalent (an odds ratio close to 1). Being an exporter increases the probability of being innovative, which supposedly reflects that exporting firms have market access and networks outside the national boundaries, which can be an important source of new knowledge.

Following theory on firm knowledge and innovation, we also expect that ownership structures that involves multinational enterprises influences innovation performance. Being a part of a larger corporate group, with multi locations can be a large advantage, specifically for small firms with limited internal resources for exploiting new market potentials. The second specification includes the variable reflecting multinational firm ownership and this variable has the expected positive impact on innovation probability and is highly robust across all model specifications. Interestingly, the effect of being a small firm becomes insignificant when multinational firm ownership is included in the model. This strengthens prior expectations that small firms may very well be innovative but they are dependent on being a part of a larger structure providing them with a wider knowledge network. For small firms, the costs and risks associated with innovation activities can be hard to overcome and being part of a larger corporate group

bring opportunities to share costs, knowledge and risks. Moreover, when controlling for multinational firm ownership, the dummy variable for exporting firms miss significant importance, which suggest that the networks provided by multinational corporate groups give rise to similar, yet stronger effects on the probability of innovation.

Table 5 Effects of firm and regional characteristics on innovation**:** logistic regression, odds ratios (*t-statistics*) ψ

Variables	**1**	**2**	**3**	**4**	**5**
Firm characteristics					
Small firm	0.53***	0.72	0.53***	0.71	0.79
	(-2.83)	*(-1.49)*	*(-2.86)*	*(-1.52)*	*(-1.03)*
High education	1.01**	1.09**	1.01**	1.01*	1.01*
	(1.81)	*(1.78)*	*(1.83)*	*(1.80)*	*(1.82)*
Exporter	1.63**	1.42	1.61	1.40	1.35
	(1.66)	*(1.18)*	*(1.62)*	*(1.13)*	*(0.96)*
Multinational	-	13.01***	-	13.25***	12.83***
		(5.10)		*(5.05)*	*(5.17)*
Regional characteristic					
KIBS access	-	-	1.00	1.00	-
			(-0.65)	*(-0.75)*	
Collaboration					
Collaboration	-	-	-	-	3.27***
					(3.84)
Industry dummy	yes	yes	yes	yes	yes

ψ Number of observations=618
Number of poststrata= 4
Population size= 8 151
Significant at the level ***0.01, **0,05, and *0.1

A number of regional characteristics have been included among the regressors to capture effects of regional innovative milieu. Independent of variable used in this respect we find no significant influences. As shown in Table 5 accessibility to people employed in the knowledge intensive business sector is insignificant across all model specifications. This outcome is most likely a related to the specific economic structures in the Jönköping region. There are only two localities in this region with urban characteristics and KIBS employees are highly concentrated to these two locations. As a result, most respondents of the survey have about equally poor access to KIBS and find other sources of external knowledge. Nevertheless, firms in rural areas in the county of Jönköping are innovative, which may plausibly be an effect of successful collaborations. This hypothesis is tested in model specification five where accessibility to KIBS is excluded and collaboration (of any type) is included instead. As general as collaboration is identified here, it is highly significant with an odds ratio far above 1. Again, the dummy variable for small firms is insignificant and remains so even if the variables multinational and exporter are excluded (though not shown in Table 5). These findings indicate that collaboration is important for firm-level innovation as it brings additional resources into the innovation process.

Who do they collaborate with and where are they located?

The results in Table 5 tell us that collaboration matters for innovation. However, with respect to firm- and regional characteristics, only internal knowledge and being a part of a multinational concern affect the probability of the firm to be innovative. The second step of the analysis is to further explore the effects of different collaboration designs.

Collaborations have been categorized into two main types: who is the collaborator and where is this collaborator located? The responses to these two questions enables us to assess whether collaboration foremost takes place between firms close to each other or further away and whether proximity in an organizational, cognitive and spatial dimension enhances the likelihood to be innovative. Table 6 presents the estimated results from the logistic regressions when collaboration is divided with regard to type of collaborator and the location of collaborating partners.

The first categorization covers the question: who is the collaborator? A collaborator within the *same corporate group* can be close in terms of both organisational and cognitive proximity. Presumably, this would give advantages in terms of knowledge and capital but also in terms of deeper understandings of processes related to the emergence and development of innovation ideas. However, being in the same corporate family does not necessarily also imply that all entities are categorised into the same industry.[5] Instead, two firms within the *same industry* can be closer in terms of cognitive proximity. Knowledge within two such collaboration partners can be related but also complementary to each other, enhancing possibilities for innovation for both of them. Table 6 shows the outcomes of these two variables in specifications 6 and 8. In specification 6, omitting the variable *multinational*, the probability of being innovative increases if collaborating firms belong to the same industry but the effect is substantially larger when they belong to the same corporate group. Organisational proximity seems to be far more important for boosting innovation collaborations than cognitive proximity. This is further accentuated when we in specification 7 add *multinational*. About half of the effect of collaborating within the same corporate family is now captured in that we actually have a better model specification with respect to firm characteristics.

Collaborations can be further explored by subdividing them into collaboration with client, customer and/or competitor. From the results of specification 8 in Table 6, we distinguish that firms that collaborate with suppliers and clients have a higher probability of innovation than firms that do not have any backward or forward linkages in their networks. The effect of client collaboration (forward integration) is slightly larger than collaborating with suppliers (backward integration). This is not a surprising result, given that we know that the region of study largely is composed by sub-contracting firms. We can also see that collaboration with competitors (horizontal integration) has no significant effect on the probability to innovate. This can be due to lack of relevant competitors. It may also be a strategic choice in a cluster of similar firms, minimizing the risk to expose any innovation ideas to the firms competing in, more or less, the same markets. Whether this is a result of few opportunities or strategy (if

[5] *Same corporate group* and *same industry* are not correlated with each other why they can be controlled for simultaneously.

not a combination) may be associated with the regional structure; a rural region may hold fewer opportunities to collaborate.

Table 6 Effects of collaboration (**whom and where**) on innovation**:** logistic regression, odds ratios (*t-statistics*)ψ

	6	**7**	**8**	**9**
Firm characteristics				
Small firm	0.66***	0.82	0.75	0.78
	(-1.81)	*(-0.85)*	*(-1.20)*	*(-1.01)*
High education	1.01***	1.01	1.01	1.01
	(1.81)	*(1.62)*	*(1.76)*	*(1.60)*
Exporter	-	1.41	1.15	1.02
		(1.11)	*(0.42)*	*(0.05)*
Multinational	-	5.96***	12.30***	10.70***
		(3.38)	*(5.12)*	*(4.67)*
Industry dummy	yes	yes	yes	yes
Regional characteristic				
KIBS access	-	-	-	-
Collaboration: with whom				
Same corporate group	13.16***	6.93***	-	-
	(5.13)	*(3.52)*		
Same industry	1.90**	1.92**	-	-
	(2.34)	*(2.34)*		
Supplier	-	-	1.79*	-
			(1.91)	
Client	-	-	1.88**	-
			(2.01)	
Competitor	-	-	1.30	-
			(0.83)	
Collaboration: where				
Inter regional	-	-	-	1.55
				(1.39)
Extra regional	-	-	-	2.96***
				(2.01)
International	-	-	-	1.71
				(1.19)

ψ Number of observations=618
Number of poststrata= 4
Population size= 8 151
Significant at the level ***0.01, **0,05, and *0.1

The second categorization covers the spatial dimensions of collaboration. Only one of the geographical dimensions has a significant effect on firm probability to be innovative. Collaborating with partners outside the firm's own region enhances the probability of being innovative. Collaboration within the region has no effect. This finding indicates that external assets relevant for spurring innovations (e.g. knowledge, experiences and risk capital) that firms strive to reach through collaborations are comparably scarce within the Jönköping region. These types of resources are generally abundant in dense regions, which attract highly educated people working in knowledge intensive and creative industries. Larger cities often function as nodes for innovative activity since they have access to the relevant resources such as transportation, trade networks, and skilled labour. Being located in a rural region with low density may offer only few (if any!) opportunities for collaboration within a short geographical distance. Innovation processes often require very specific inputs: a certain type of knowledge, a specific type of business service

or a particular logistic solution. The opportunities to find this in a rural region are small, for what reason firms have to reach beyond regional borders to find relevant collaboration partners.

Conclusions

The main aim of this study is to examine how firm collaboration affects innovation. The empirical analysis is based on data from a survey on firm innovation and collaboration in the County of Jönköping. The survey data provides a rich material which gives the general picture on how firms collaborate and innovate in a rural region located at some distance from larger metropolitan cities. The material also allows us to present more detailed "brushstrokes" on how innovative firms act in this setting, and identify factors of importance for the probability that a firm is innovative. A general conclusion from this work is that collaboration enhances the probability that a firm is innovative in some respect.

First of all, considering firm characteristics we find that variables reflecting a state where the firms is part of a larger international network (being an exporter or incorporated in a multinational firm), positively affects the probability to be innovative. Being a small firm is per se negative for the probability to be innovative, but when controlling for multinational firm ownership, the negative effect of being a small firm disappears. This finding is even more accentuated when variables reflecting collaboration is included in the model. Innovation is often associated with high costs and combinations of different types of resources. Small firms have limited internal resources to use in innovation processes, which impede their innovation performance. The results of this analysis show that once they get access to a wider network and collaboration partners, small firms can be as innovative as their larger counterparts.

Another interesting result is found in the positive effect of collaboration. Our study provides evidence that collaborations characterized by organisational and cognitive proximity has a positive effect on innovation. Interestingly, collaboration with partners within the own corporate group appear to have a far stronger positive impact on the probability of being innovative than collaborations with firms in the same industry. A part of this effect is probably induced by the predominance of multinational firms in private R&D activities and follows prior expectations. Still, this finding can also indicate that organizational proximity outperforms cognitive proximity. With such interpretation, this finding supports arguments in previous literature that too much cognitive proximity hampers the innovative outcomes of collaborations simply because the collaborating partners are very likeminded (Boschma and Frenken, 2009). Rather, new ideas are stimulated by interaction of persons with different perspectives, which explains why diversity seem to be a key factor for innovation and renewal (Jacobs, 1969)

Furthermore, our study disentangles collaboration in relation to backward, forward and horizontal linkages. The latter of these three has no significant effect, but collaboration with suppliers or customers appear to have a positive effect on firm innovation. Interestingly, the odds-ratio for forward linkages are slightly higher than backward linkages, which supports ideas about how the demand-side may stimulate product development and the role of competent customers in innovation networks (Eliasson et al. 2003).

Considering the spatial dimensions of collaboration, we find that neither local nor international collaboration stimulates firm innovation. Instead, inter-regional collaborations have a positive effect on the probability that a firm is innovative. In terms of collaborations of relevance for firms' innovation output, firms in the Jönköping region mostly find their collaborating partners in other regions in Sweden. The lack of impact from local collaborators may also be a result of the regional structure, whereas the influence of international knowledge flows are partly captured by the firm-level variables reflecting export market participation and multinational firm ownership.

A number of questions remain unanswered in this paper. First, innovation activities in small firms need to be further explored and the importance of different types of collaborations for firms in different size classes is an issue that requires further investigation. Could it be that small firms have to rely more on collaboration with others? Or do larger firms per se have larger network capacity why they also collaborate more? A second relevant topic for future research, which cannot be answered by the present survey data, is the one associated with geographical structures. To what extent is the effect of collaboration related to regional structure; do firms in dense regions collaborate more since they have access to a larger variety of collaboration partners in the local economy or are collaborations more important for firms in rural areas with limited variety in local economies? These are important questions for further research and for innovation policy design.

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Appendix

A 1 Full sampling process

#		N
1	Number of firms in Jönköping county	38 714
2	Firms with at least 1 employee	8 151
3	Stratified sample (w.r.t firm size) from firms with at least 1 employee	**3 313**
4	Where never contacted by us (se row above)	1 117
5	Did not answer before the end of round of interviews	882
6	Invalid/missing phone number	198
7	Not in target group (i.e. public sector or non-profit associations)	69
8	Duplicates	27
9	Did no longer exist	21
10	Missing a relevant person to interview	14
	Sum	**2 328**
	By random sampling and due to #4 to #10 *985 firms where contacted. Respondents and non-respondents of these are presented in #11 to #14*	
11	Responded to survey	636
12	Refused to participate	237
13	Lack of time	98
14	Switchboard not allowed to give out name and number	14
	Sum	**985**

A 2 Correlation matrix

	Small firm	High edu.	Export	Multi-national	Same concern	Same indu.	Supplier	Client	Compet-itor
Small firm	1								
High edu	0.12	1							
Exporter	-0.28	0.04	1						
Multi-national	-0.37	-0.00	0.37	1					
Same concern	-0.32	-0.00	0.22	0.59	1				
Same industry	-0.05	0.03	0.03	0.06	0.20	1			
Supplier	-0.10	0.01	0.22	0.18	0.29	0.44	1		
Client	-0.20	0.01	0.22	0.15	0.29	0.46	0.54	1	
Compet-itor	-0.01	0.03	-0.05	-0.06	0.06	0.49	0.23	0.27	1