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by

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Abstract:

The paper assesses the role for innovation of one aspect which has been generally overlooked by evolutionary economic geography: context. It analyses how context shapes the impact of collaboration on firm-level innovation for 1604 firms located in the five largest city regions of Norway. Specifically, the analysis shows how the benefits to firms of collaborating within regional, national, and international innovation networks are affected by the knowledge endowments of the region within which the firm is located. Using a logit regression analysis, we find, first, that only national and international networking have a significant positive impact on the likelihood of innovation (the former only for process innovation), whereas the regional knowledge endowments have no direct effect. Second, regional cooperation is particularly effective in regions with high investments in R&D, whereas international cooperation is important in regions with an educated workforce – and regional and national collaboration may be ineffective in such cases. We conclude that, in the case of Norway, context is essential in determining the capacity of firms to set up networks and innovate. Regions with an educated workforce can use the resulting absorptive capacity to successfully assimilate knowledge being diffused through global pipelines from faraway places. However, this absorptive capacity is likely to be heavily filtered if regional firms mainly rely on internal connections within Norway.

Keywords: Innovation, interaction, networking, context, human capital, R&D, firms, Norway.

Introduction

In evolutionary economic geography, innovation is fundamentally the consequence of the interaction of firms with other firms in the same or in nearby locations. Context also matters, as firms are considered to be the outcome of their history, and their potential future trajectory is strongly shaped – in a path dependent manner (Martin and Sunley 2006: 399) – by past events. However, within evolutionary economic geography it is mainly firms that shape their surroundings and not vice versa. Firms have the capacity to affect and change their environment, but the mechanisms through which the geographical context in which a firm operates influences its economic trajectory tend to be weakly operationalised. This is acknowledged by Boschma and Frenken who state that "we expect the effect of (territory-specific) institutions on [firm-specific] routines to be small as firms develop routines in a path-dependent and idiosyncratic manner" (Boschma and Frenken 2009: 153).

In this paper, we tackle the issue of context head-on, by concentrating on how outcomes linked to the capacity of individual firms to learn and adapt through interaction are strongly influenced by the educational and research environment in which the firm conducts its activity. We will argue that the benefits of firm collaboration, whether conducted within the region or at a distance, may not be equally distributed across regions, but may instead be strongly affected by the conditions of the local environment in which the firm conducts its main operations. From our perspective, innovation activities are territorially embedded and fundamentally affected by the social, institutional, and political conditions in which they take place (Rodríguez-Pose 1999; Asheim and Isaksen 2002), a notion which has been developed under different theoretical guises in the form of industrial districts, learning regions, innovative milieus, and regional innovation systems (Aydalot 1986; Becattini 1987; Asheim and Isaksen 1997; Cooke et al. 1997). We will further posit that the type of collaboration firms engage in – i.e. collaborating locally versus engaging with other actors at a distance – may depend crucially on the institutional conditions and resource endowments of the region within which the firm is located (Rodríguez-Pose and Fitjar 2013).

In order to do this, we will assess how, in the case of Norway, firms' collaboration with actors at different geographical scales – regional, national, and international – is conditioned by the socioeconomic environment in which they operate and how this affects the firms' capacity to introduce innovations. In particular, we focus on the two aspects of the regional economy which have traditionally been regarded as the main motors for innovation: research and development activities (R&D) and education levels. Our aim is to analyse how these factors may act as filters of the innovative potential of firms directly, and – crucially – how they mediate the effects of collaborations established by individual firms in order to achieve greater innovation, both within the region and with actors outside the region. We will test whether this is the case using a tailor-made survey of firm-level innovation and collaboration involving 1604 firms located in the five largest city regions of Norway.

The results show that local conditions in R&D and human capital endowment strongly shape the innovative returns derived from the interaction of Norwegian firms with other stakeholders in the economy at different geographical scales. In particular, the analysis underlines how – in accordance with what has been highlighted in recent literature on other countries (e.g. de Jong and Freel, 2010) – although regional levels of R&D and education may

have a limited or no direct effect on firms' probability of innovation, they play an important role in determining not only how firms collaborate (Fitjar and Rodríguez-Pose, 2013), but also the returns to such collaboration in terms of increased innovative capacity. Our results indicate that the local social economic environment in Norway thus operates as a filter which either favours or limits the innovative capacity of firms, depending on their level of interaction both with neighbouring and distant economic actors. Specifically, regional collaboration only contributes to radical product innovation in regions with high levels of internal R&D, while it is ineffective in regions with medium or low levels of R&D. The effect of national collaboration on radical product innovation is also enhanced when regional R&D is higher. Conversely, international collaboration does not interact significantly with regional R&D, but its effect on innovation is enhanced in those regions with a good endowment of human capital. The effects of international collaboration on product innovation tend to be stronger in regions with an educated workforce, whereas regions with lower levels of education derive fewer benefits from global pipelines, due to the lower levels of absorptive capacity. In contrast, education has a negative interaction with regional and national collaboration, which are more likely to lead to innovation in regions with a less educated workforce.

The paper is structured into the following five sections: First, we elaborate on our theoretical framework and hypotheses. Second, we present the case of Norway and the data. Third, we explain how the main variables were operationalised and present some descriptive data for each region. Fourth, we introduce the results of four regression models analysing the impact of collaboration, regional knowledge endowments, and their interaction on different innovation outcomes. Finally, we conclude with some implications for the literature on innovation and regional development, as well as for regional policy in Norway and beyond.

Resource endowments, interaction and innovation

Since at least the work of Marshall (1920), cooperation between firms and external agents has been considered to be of fundamental importance for innovation (e.g. Porter 1998; Chesbrough 2003; Nooteboom 2004; Tapscott and Williams 2006). Firms which are able to draw on knowledge and new ideas generated both within and outside the firm are better placed to develop marketable new products and more efficient production processes.

In recent years, cooperation has in particular been at the heart of evolutionary economic geography. Evolutionary economic geographers have adopted firms as the main protagonists of the analysis, and the organisation and routines of individual firms, together with their capacity to learn and adapt through interaction and externalities, has been central in a large number of analyses in recent economic geography (cf. Mackinnon et al. 2009). Evolution – and therefore change and innovation – is determined by firm interaction in networks which selectively shape the environment in which economic activity takes place. Firm learning, technological change, and self-organisation shape the geographical context in which a firm operates (Mackinnon et al., 2009). This shaping of the local context and how, as a consequence, it subsequently affects the performance of firms in a path dependent manner has been increasingly analysed by evolutionary economic geographers (e.g. Boschma and Martin, 2010). However, the mechanisms through which contextual factors associated with regional overall educational, innovative or institutional endowments affect the performance of

individual firms and their capacity to learn, change and organise themselves are still poorly understood. There is no well-established two-way road. While in an evolutionary economic geography framework, firms affect and change their environment and this change, in turn, affects their performance, the mechanisms through which the geographical context – understood as the set of local or regional conditions which make territories more innovation prone or averse – in which a firm operates influences its economic trajectory have attracted much less attention in evolutionary economic geography. It is generally believed that overall local conditions would have a small or negligible effect on firm behaviour, as the specific routines of firms will be the result of path dependency (Martin and Sunley, 2006; Boschma and Frenken, 2009). The consequence is that the role of context and local conditions tend to be weakly operationalised.

While this focus by evolutionary economic geographers on the internal institutional factors which shape the innovative and economic trajectory of a firm is welcome, it tends to neglect that firms are embedded in geography and local institutions which they may not always be able to influence (Amin and Thrift 1995; Morgan 1997; Martin and Sunley 2006). A thorough understanding of context in particular geographical spaces is needed in order to grasp firm trajectories. Context and geography create the territorial conditions and social relationships which shape the potential of firms to emerge, network, learn, and thrive (and/or die) in different environments (Rodríguez-Pose, 2013). This indifference of context and of how interactions are constructed, evolve, and/or endure over time thus represents a significant barrier for fully comprehending where and how economic activity takes place. It also ignores a large body of literature in economic geography assessing how local conditions shape the learning and innovative capacity of the economic agents acting in a particular territory. These conditions generate learning regions (Morgan 1997), creating environments that are more or less conducive or hostile to frequent formal and informal interaction among individuals, firms and other institutions and, consequently, to innovation and growth (Leydesdorff 2000; Storper and Venables 2004; Cooke et al. 2005). Likewise, local conditions may affect the capacity of firms to first engage and then successfully establish pipelines that allow them to tap into and exploit knowledge produced elsewhere (Bathelt et al. 2004; Fitjar and Rodríguez-Pose 2011; Morrison et al. 2013). As argued by Cohen and Levinthal (1990), a firms' ability to discover and exploit external knowledge – its absorptive capacity – depends crucially on the endowments of the area in which it operates. Building on this work, successive studies have discussed the importance of regional or cluster-level conditions (e.g. Giuliani 2005; Azagra-Caro et al. 2006), such as R&D availability or the presence of skilled labour in the region, as factors on which firms are capable of building their absorptive capacity (Florida 2002; Moretti 2004; Rodríguez-Pose and Vilalta-Bufí 2005).

This paper adopts the perspective that local conditions affect the capacity of firms to network and to reap the rewards derived from such networking. As a consequence, we seek to examine the combined impact of interaction with external agents and regional knowledge endowments on the innovative potential of the firm. In view of the discussion above, we hypothesise that both interaction and local context are important for a firm's ability to innovate, but also that they complement each other and that their effects are interlinked. Firms that operate in more favourable environments for innovation – i.e. areas with a better endowment of human capital and with more investment in R&D – will have significant advantages in accessing new knowledge relative to firms located in more innovation averse areas. The quality of the

knowledge and new ideas will depend on the resources that are available in the local context. However, the benefits of operating in a better environment for innovation will only materialise through frequent interaction with other socioeconomic stakeholders. Consequently, firms that interact frequently in favourable environments will be able to access knowledge from a larger variety of sources and will be exposed to a larger number of fresh ideas. This will increase their potential for discovering new combinations of knowledge that can be put to productive use relative to firms that rely only on knowledge internal to the firm. Conversely, firms in regions with inferior knowledge resources will be – all other things being equal – less likely to innovate. The potential disadvantages related to the environment in which a firm is located can be, however, overcome by reaching out beyond the immediate geographical neighbourhood to socioeconomic actors located elsewhere in the country or abroad. Firms with many connections to distant actors will therefore be better placed to tap into the knowledge being produced outside the firm and to reduce any weaknesses related to the location where they are based.

Interaction for innovation

The role of collaboration, interaction and networks with knowledge-producing or idea-generating agents outside the firm has been highlighted as crucial for innovation by researchers across a variety of scientific disciplines (e.g. Powell et al. 1996; Cooke and Morgan 1998; Chesbrough 2003). Firms that develop trusting relations and open channels of communication with their suppliers and customers, as well as with scientific and other knowledge-producing communities (Fabrizio, 2009; Spithoven et al., 2011), are able to utilise not only knowledge internal to the firm, but can also enhance their absorptive capacity and thus benefit from knowledge spillovers from these external agents. The result is a higher potential for developing new products or production processes through the combination of knowledge from both internal and external sources.

While these assertions are widely accepted, the spatiality of such interactive learning has been a more controversial issue. Most of the attention has until recently been devoted to local interaction within cities or regions, on the rationale that face-to-face contact is essential for the development of trust and for the transmission of tacit knowledge that drives the processes of interactive learning (e.g. Saxenian 1996; Storper and Venables 2004; Sonn and Storper 2008; de Jong and Freel, 2010). Regions that are able to sustain such buzz environments of frequent interaction between innovative agents across a number of industries and functions provide environments that promote the circulation of knowledge, benefiting all firms that are able to tap into the network. However, the tendency to put the stress on local interaction has come under fire from scholars that emphasize instead the capacity of firms and regions to tap into knowledge produced elsewhere in order to avoid lock-in and myopic knowledge sourcing (e.g. Amin and Cohendet 1999; Bathelt et al. 2004; Moodysson 2008). Firms that only interact locally run the risk of shutting themselves off from external knowledge emanating from outside the region, which can be particularly problematic in small or peripheral regions (Rodríguez-Pose and Fitjar 2013). Meanwhile, the lack of geographic proximity can be offset by temporary proximity (Grabher 2002; Torre 2008) or closer relational proximity, which is arguably more important (Amin and Cohendet 1999).

On the basis of this literature, we may postulate the following:

H_1: Firms that interact with a variety of regional partners will be more likely to innovate.

H_2: Firms that interact with a variety of non-regional (national and/or foreign) partners will be more likely to innovate.

Regional resource endowments

The notion that firms are strongly influenced by the environment in which they are located is also central to the literature on regional development (e.g. Storper 1997; Cooke and Morgan 1998). Regions provide resources such as labour, specialised suppliers or research institutions that affect the profitability and innovative potential of firms. This is partly related to the ability of firms to obtain external economies of scale when locating close to other firms in the same, in related, or in other industries (agglomeration economies) and partly to their ability to access common resources that are available to all firms in a particular space, but inaccessible at a distance (localisation economies).

These common resources may arise as externalities derived from the activity of other actors. For instance, R&D investments have powerful externalities that may outweigh the private benefits of research (Griliches 1958; Jaffe 1986). Universities and other public research institutions may actively seek to generate such externalities. However, since knowledge is often a non-excludable good (Grossman and Helpman 1991), even the R&D activities of firms and private research institutions create externalities that may be obtained by rivals through monitoring, imitation, staff mobility or other strategies. Firms may therefore benefit not only from the R&D activities taking place within the firm itself, but also from investments in R&D in the region more generally. It may be, however, far more difficult to tap into this knowledge from a distance, both due to the challenges of monitoring knowledge production in remote locations, the reduced ability to recruit staff, and the challenges of accessing informal information flows and more tacit knowledge. Several studies have therefore concluded that R&D externalities tend to be limited in their geographical reach (Audretsch and Feldman 1996; Anselin et al. 1997; Moreno et al. 2005; Rodríguez-Pose and Crescenzi 2008).

Another crucial regional resource is the availability of skilled labour. This is conventionally seen as part of the agglomeration economies of locating close to other firms in the same industry (Marshall 1920), which offers opportunities of recruiting workers with specialised skills more easily from other firms. Workers are also more likely to locate in such regions, as they will have a larger number of possible employers to choose from. More recently, and more controversially, the localisation economies of skilled labour has also been given ample attention in the literature on "creative cities" (Landry 2000; Florida 2002), which argues that firms locate in regions where they have access to the best talent, thus breaking with the mainstream view that workers follow jobs. More recently, education and creativity have been brought together by Marrocu and Paci (2012), who underline that the combination of both elements leads to the formation of more innovative and productive environments. As a consequence, the presence of skilled and creative labour in a region is expected to have an effect on the innovative potential of its firms.

Thus, we may posit that:

H_3: Firms located in regions with higher investments in R&D will be more likely to innovate.

H_4: Firms located in regions with a higher share of educated workers will be more likely to innovate.

Interaction in which regions?

While both interaction and the regional environment are expected to affect innovation, their effects are not just additive, but also multiplicative. Interaction is bound to be more effective if there are more knowledge resources available in the environment. Similarly, the effect of R&D investments in the environment is bound to be higher for firms with multiple formal and informal connections to other actors in the region. This point is elaborated in a variety of theories of innovation: the literature on regional innovation systems examines both the quality of the innovation support infrastructure and the linkages between firms and knowledge producers which help promote interactive learning (Cooke et al. 1997; Asheim and Isaksen 1997). The triple helix approach explores the same issues from an evolutionary perspective (Etzkowitz and Leydesdorff 2000; Leydesdorff 2000). From a slightly different angle, the central propositions of the learning region approach are that innovation is an interactive process and that it is shaped by social institutions (Morgan 1997). This has important implications for innovation policy, which might succeed by encouraging regional collaboration in well-endowed regions, whereas policy in regions with less internal R&D will do better by promoting extra-regional linkages (Fornahl et al. 2011; Broekel 2013).

One feature that all of these theories have in common is their emphasis on local interaction. However, as mentioned above, the literature on interactive learning has increasingly gone beyond the study of localised interaction within clusters to also consider the role of collaboration with distant partners. With some exceptions, this literature has a lot less to say about how the regional environment affects the ability of firms to link up successfully to partners in remote locations. In order to probe this relationship, we borrow the notion of absorptive capacity developed in the innovation studies literature (Cohen and Levinthal 1990). The absorptive capacity of a firm is its ability to find, assimilate and exploit external knowledge, which depends crucially on the knowledge resources available within the firm. This approach has been applied at the level of the region or the cluster in a few studies (Giuliani 2005; Azagra-Caro et al. 2006): regions must possess sufficient knowledge resources to discover and utilise knowledge from external partners in order for global pipelines to serve a purpose. These knowledge resources are linked to basic endowments in education and knowledge. More educated populations living in environments which are more open to innovation – proxied by R&D – tend to be not only more open-minded and receptive to trends coming from outside the region, but also usually have the experience and wherewithal to reach out to economic and social actors in more distant locations (Tjosvold and Poon, 1998; Noorderhaven and Harzing, 2009). Conversely, in regions with insufficient knowledge resources, firms often find themselves in environments which are innovation averse (Rodríguez-Pose, 1999) and where the stimuli to reach out to the outside world are limited. Hence, the few internationally connected firms in these contexts may isolate themselves from other regional actors, acting as gatekeepers, further restraining the knowledge flows into the region (Giuliani and Bell 2005; Morrison 2008; Morrison and Rabellotti 2009). The human capital stock of the region thus serves to promote its ability to absorb knowledge through international connections.

H_5: The effects of regional collaboration will be higher in regions with higher investments in R&D.

H_6: The effects of international collaboration will be higher in regions with a higher share of educated workers.

Case description and method

In order to examine the theoretical propositions put forward in the preceding section, we conducted a survey of firms in the five largest city regions of Norway: Oslo, Bergen, Stavanger, Trondheim and Kristiansand.[1] In total, these five regions make up around half of the population of Norway – Oslo being the largest with around 1.4 million inhabitants, and the population of the other four ranging from 150,000 in Kristiansand to 375,000 in Bergen.

Norway represents an interesting case because it has pursued policies aimed at increasing innovation by both improving regional endowments in education and R&D, as well as facilitating the establishment of linkages both within clusters in Norway as well as between Norwegian firms and socioeconomic agents located elsewhere (Rodríguez-Pose and Fitjar 2013).

From a purely territorial dimension, innovation policy in Norway has tended to rely more on educating its workforce than on investments in R&D. In 2010, R&D expenditures made up 1.76 percent of GDP, well below the OECD average of 2.33 percent. This put Norwegian R&D expenditures on a par with China's and around half the level of its nearest neighbours, Finland, Sweden and Denmark[2]. Private sector R&D investments are particularly low, making up less than half of total R&D expenditure in Norway. This is partly explained by the industrial structure, consisting predominantly of industries with low R&D intensity. In contrast, Norway has a well-educated workforce. In 2009, 46.8 percent of 25-34-year-olds held a tertiary education degree, compared to an OECD average of 37.1 percent. In Western Europe, only Ireland had a higher proportion of educated people in this age range. Among 55-64-year-olds, 27.2 percent of Norwegians held a tertiary degree, which again compares favourably with the OECD average of 22.4 percent.

In terms of linkages, Norwegian firms – encouraged by favourable policies – have traditionally relied heavily on collaborative innovation strategies in order to compensate for their small size and low R&D intensity. As a result, they have made more frequent use of external partners than firms in many other European countries (Fagerberg et al. 2009). This includes both inter-firm collaboration and collaboration with research partners, notably with public research institutes, which have served as a bridge between university research and innovation activities in industry. Furthermore, recent innovation policy has tended to emphasize regional networks and the development of clusters. This is a feature both of central

1 A city region is defined here in terms of having a common labour market. Following the definition of the Norwegian government in its *Greater Cities Report* (2003), we include all municipalities around the city itself in which 10 percent or more of the population commute into the urban core for work. Commuting data was updated for 2009 and based on data presented in Leknes (2010).

2 This is in part due to Norway's high GDP per capita. Norwegian R&D expenditures are above the OECD average in per capita terms, although still well below its Nordic neighbours.

government programmes, such as Arena, Norwegian Centres of Expertise, VRI (Programme for Regional R&D and Innovation), and the regional research funds that were established in 2010 (Finsrud 2009; Hanssen et al. 2011; Jakobsen et al. 2012), as well as of local government policies being pursued through the establishment of regional development agencies in many regions (Farsund and Leknes 2010).

This study examines how these attributes of the Norwegian economy and society – low R&D intensity, high levels of education, and frequent interaction between firms and external partners – affect the ability of Norwegian firms to innovate. Data was collected through a survey conducted in the spring of 2010 of 1604 firms with more than 10 employees in the five largest Norwegian city regions – 400 in each of Oslo, Bergen and Stavanger, 300 firms in Trondheim, and 100 firms in Kristiansand. The professional market research firm Synovate (now Ipsos MMI) was responsible for sampling firms from the Norwegian Register of Business Enterprises – where all firms are required by law to register – and for telephone interviewing the chief executives of each firm. Synovate approached 5887 firms in total, with a response rate of 27.2 percent.

Variables, descriptive data and model

Variables and data

The indicators of innovation used in the survey were identical to those used in the Community Innovation Survey series. Managers were first asked whether their firm had introduced any new or significantly improved goods or services into the market during the last three years (*Product innovation*). If they had, a follow-up question asked whether these product innovations were new to the market (*Radical product innovation*), or only new to the firm. Similarly, managers were asked whether the firm had introduced any new or significantly improved methods or processes for production or delivery of products during the last three years (*Process innovation*), and if so, whether these were new to the industry (*Radical process innovation*), or only new to the firm. The reason for distinguishing between product and process innovation is that these two types of innovation are often associated with very different procedures and types of interaction. While product innovation – especially in the cases of radical product innovation – tends to be connected to invention and hence is likely to benefit more from in-house research, as well as from contacts with research centres and universities, process innovations are more often connected to requests by customers and suppliers. Table 1 shows the share of innovative firms within each category, both in total and by city-region. Oslo has the highest share of innovative firms for all four types of innovation, while Bergen has the lowest share in each case. However, the difference between Oslo and Bergen is only statistically significant at the 90 percent level for product innovation and radical product innovation. Stavanger, Trondheim and Kristiansand occupy an intermediate position, with the order of these three cities varying by type of innovation. The differences between them are never statistically significant.

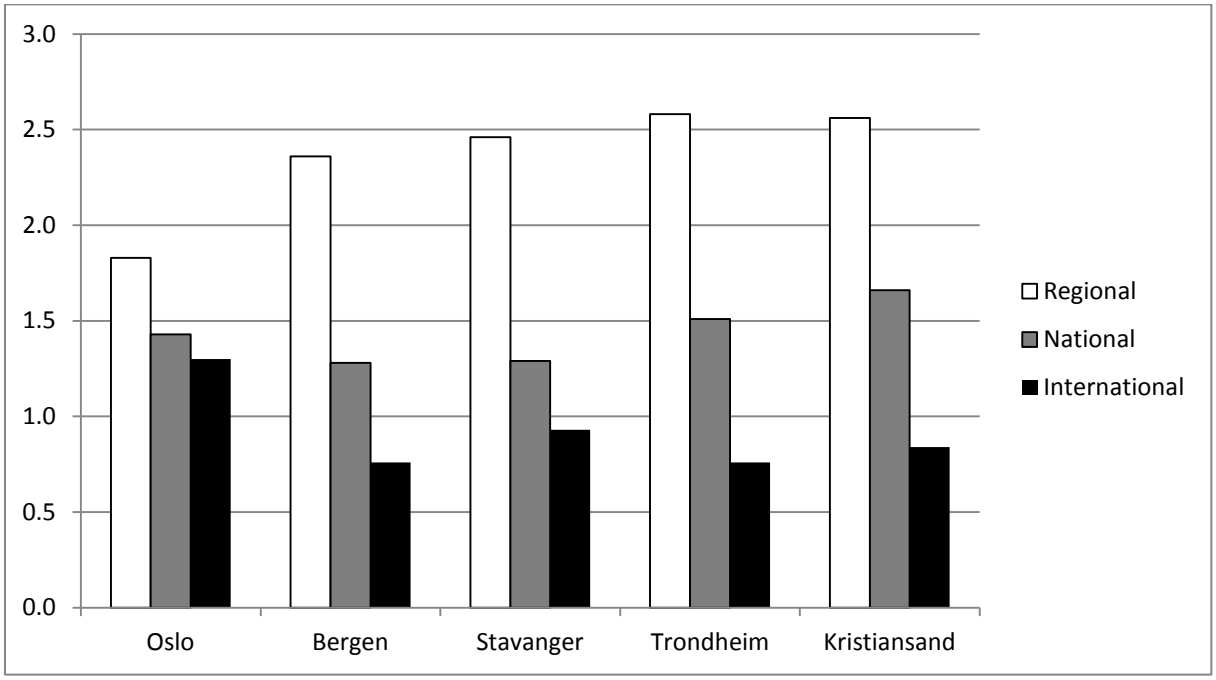
Table 1: Innovation in Norwegian city regions, % innovative companies

	Oslo	Bergen	Stavanger	Trondheim	Kristiansand	Total
Product innovation	59.6 (2.4)	46.4 (2.5)	54.0 (2.5)	52.3 (2.9)	58.0 (4.9)	53.4 (1.2)
Radical prod. Innovation	34.0 (2.4)	25.2 (2.2)	33.8 (2.4)	29.0 (2.6)	30.0 (4.6)	30.6 (1.2)
Process innovation	50.4 (2.5)	42.4 (2.5)	46.8 (2.5)	48.7 (2.9)	47.0 (5.0)	47.0 (1.2)
Radical proc. innovation	20.4 (2.0)	16.5 (1.9)	18.8 (2.0)	19.7 (2.3)	20.0 (4.0)	18.8 (1.0)
N	403	401	400	300	100	1604

The top number in each cell denotes the percentage share, with the standard error listed below in parentheses.

Examining with whom the companies cooperated, all managers were presented with a list of seven different types of partners (other firms within the conglomerate, suppliers, customers, competitors, consultancies, universities, and research institutes) and asked to state which (if any) types they had used as partners, also during the last three years. For each type used, managers were also asked whether their partners were located within the region, elsewhere in Norway, and/or abroad. By adding up the number of different types of partners used at each level of geographical distance, we construct an index of the importance of regional, national and international cooperation for the companies surveyed. The average numbers for each city region, shown in Figure 1, provide an equivalent measure for the regional innovation system as a whole. In all the regions, regional partners are most frequently used, while international partners are the least used. However, firms in Oslo use fewer regional partner types than the other four city-regions, with an average of 1.8 regional partner types compared to a combined average of 2.5 partner types in the other city-regions. Conversely, Oslo-based firms use more international partner types than any other region – 1.3 on average, compared to 0.8 in the other city-regions combined. There are minor differences in the number of national partner types used, with the firms in the western city-regions of Bergen and Stavanger using the fewest (1.3) and those in Kristiansand using the most (1.7).

Figure 1. Average number of partner types used at different scales by city region



While innovation outcomes are fairly similar across city regions, the patterns of collaboration used by firms in pursuit of these outcomes are more diverse. In particular, firms in Oslo tend to rely to a greater extent on global pipelines, whereas firms in the peripheral city-regions depend more on local interaction. The question of interest is whether the effectiveness of the different types of interaction is filtered or conditioned by the regional environment. As mentioned earlier, we consider two aspects of the regional environment that may affect the ability of regional, national and international interaction to promote innovation in firms: the level of investment in R&D in the region and the education level of the regional workforce. Data on R&D investments were drawn from the Nordic Institute for Studies in Innovation, Research and Education's (NIFU) indicator report (Røsdal, 2010), and measure total per capita R&D expenditure in 2008 in the county in which the city region is located.[3] Data on education levels were drawn from Statistics Norway's online database (Statistics Norway, 2010). They measure the number of people with tertiary education as a percentage share of the region's adult population (aged 16 or older) in 2009. The year of measurement for both regional variables takes place during the three-year-period in which cooperation and innovation are measured (2007-2010), which is appropriate given that we will examine the interaction between these variables and cooperation, suggesting simultaneity of the effects.

Table 2 shows descriptive data on the regional environment in the five city regions in terms of the levels of R&D investments and university education. The variation is highest for R&D

3 Unfortunately, no statistics exist at the level of city regions, forcing us to resort to county-level data. For Oslo, we use the combined data for the capital region, i.e. Oslo and Akershus counties. For Kristiansand, we use the combined data for the Agder region, i.e. Vest-Agder and Aust-Agder counties. The data include both public and private R&D expenditure. Overall, 47.9 percent of Norwegian R&D was conducted by the public sector in 2008. The share of private R&D varies from 30.9 percent in Hordaland (Bergen) and 32.4 percent in Sør-Trøndelag (Trondheim) to 67.7 percent in Rogaland (Stavanger) and 73.8 percent in Agder.

investments, which are five times higher in Trondheim than in Kristiansand. Stavanger and Kristiansand have the lowest levels of both R&D expenditures and educational attainment, whereas Oslo and Trondheim have the highest levels in both categories.

Table 2: R&D investments and education levels in Norwegian city regions

	Oslo	**Bergen**	**Stavanger**	**Trondheim**	**Kristiansand**
R&D expenditure, NOK 1000 per capita	17.438	10.683	4.769	23.292	4.630
% university educated adults	32.2	28.8	26.5	30.3	25.1

Model

In order to examine the relationship between the connectivity of firms at different geographical scales and the conditions of the place where a firm is located, on the one hand, and innovation, on the other, we conduct a set of logistic regression analyses using the four outcomes presented in Table 1 (*product innovation*, *radical product innovation*, *process innovation* and *radical process innovation*) as the dependent variables. In each analysis, we use two types of predictors. First, the number of partner types used within the region (*regional partners*), elsewhere in the country (*national partners*), and abroad (*international partners*). Second, the characteristics of the region in which the firm is located: R&D expenditure (*regional R&D*) and education levels (*regional education*). The models control for a number of factors expected to affect both collaboration and the likelihood of innovation, including the manager's age, education level, and (log) board memberships, as well as the (log) size of the firm, its foreign ownership share, and a set of dummy variables representing different industries.

We fit two different types of regression models. The first model examines separately the impact of inter-firm collaboration and the regional environment, testing hypotheses 1 to 4. The second model examines the interaction between inter-firm collaboration and the regional environment as a test of hypotheses 5 and 6. The models are specified as follows:

$$\text{logit}(\pi_{ij}) = \alpha + \beta_1 \text{Partners}_{ij} + \beta_2 \text{Environment}_j + \gamma_3 \text{Controls}_{ij} + \varepsilon_{ij} \quad (1)$$

$$\text{logit}(\pi_{ij}) = \alpha + \beta_1 \text{Partners}_{ij} + \beta_2 \text{Environment}_j + \beta_3 \text{Partners}_{ij}*\text{Environment}_j + \gamma_4 \text{Controls}_{ij} + \varepsilon_{ij} \quad (2)$$

where π refers to the probability of company *i* located in region *j* introducing an innovation of the relevant type in the three years preceding the data collection. *Partners* refer to the three variables measuring regional, national, and international collaboration, respectively. *Environment* refers to the two variables measuring the characteristics of the region *j* in which company *i* is located: Regional R&D and education. *Controls* refer to the control variables outlined above. ε represents the error term.

Results

Table 3 shows the results of the regression analyses for the models using the two forms of product innovation as the dependent variable. The models have been tested for multicollinearity, non-linearity of the linear predictor, and significant outliers, with no problems having been detected. The multicollinearity diagnostics are shown in the appendix.

Table 3: Logit regression estimation for product innovation

	Product innovation		Radical product innovation	
	Model 1	**Model 2**	**Model 1**	**Model 2**
Regional partners	0.05	0.05	0.05	0.05
	(0.03)	(0.03)	(0.04)	(0.04)
National partners	0.05	0.06	0.03	0.03
	(0.04)	(0.04)	(0.04)	(0.04)
Internat'l partners	0.20***	0.19***	0.23***	0.22***
	(0.05)	(0.05)	(0.05)	(0.05)
Regional R&D	0.00	-0.00	0.00	-0.01
	(0.01)	(0.01)	(0.02)	(0.02)
Regional education	-0.01	0.01	-0.01	-0.01
	(0.04)	(0.04)	(0.05)	(0.05)
Regional partners		0.02*		0.01*
** Regional R&D*		(0.01)		(0.01)
National partners		0.02*		0.02*
** Regional R&D*		(0.01)		(0.01)
International partn		-0.02		-0.00
** Regional R&D*		(0.01)		(0.01)
Regional partners		-0.02		-0.05*
** Regional educ*		(0.03)		(0.03)
National partners		-0.07**		-0.07**
** Regional educ*		(0.03)		(0.03)
International partn		0.07*		0.05
** Regional educ*		(0.04)		(0.03)
Manager's	-0.01	-0.01	0.02	0.02
education level	(0.02)	(0.02)	(0.03)	(0.03)
Manager's age	-0.02**	-0.02***	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Manager's log no.	0.22***	0.22***	0.16*	0.16*
company dir.ships	(0.08)	(0.08)	(0.08)	(0.08)
Log no. of	0.22***	0.23***	0.15**	0.16***
employees	(0.06)	(0.06)	(0.06)	(0.06)
Share held by	0.54***	0.52**	0.46**	0.45**
foreign owners	(0.21)	(0.21)	(0.19)	(0.19)
Industry	Controlled***	Controlled***	Controlled***	Controlled***
Constant	0.10	0.12	-1.24***	-1.28***
	(0.37)	(0.37)	(0.40)	(0.40)
N	1602	1602	1602	1602
Pseudo R^2	0.09	0.10	0.09	0.10

Note: * = P < 0.10 ** = P < 0.05 *** = P < 0.01

The top number in each cell denotes the coefficient, with the standard error listed below in parentheses.

The first four hypotheses are tested in Model 1. H_1 held that interaction with a wide range of regional partners would be associated with a higher likelihood of innovation. This hypothesis is not supported by the findings. The analysis shows that collaborating with a wide range of regional partners is not in itself associated with significantly higher probabilities of product innovation (see also de Jong and Freel, 2010). H_2 suggested that collaboration with non-regional partners would be linked to innovation. This is supported, but only for collaboration with international partners and not for national ones. Collaborating with partners abroad has a significant positive relationship with both product innovation and, even more so, radical product innovation. H_3 and H_4 proposed that firm innovation would be associated with regional factors, specifically with regional R&D investments and regional education levels, respectively. Neither of these hypotheses are supported by the results. Neither regional R&D investments nor regional education levels contribute in and of themselves to improving the capacity of regional firms to innovate (model 1).

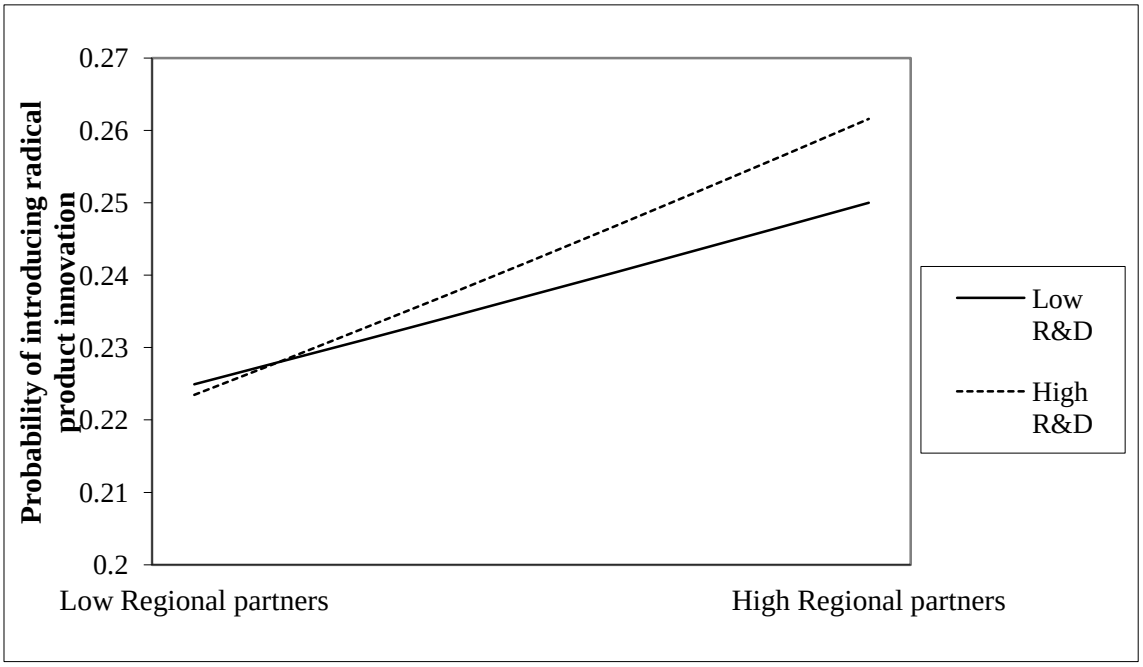
Table 4: Average marginal effects of collaboration in different environments

	Product innovation		**Radical product innovation**	
R&D expenditure:	**Min**	**Max**	**Min**	**Max**
Regional partners	-0.02	0.04**	-0.01	0.04**
	(0.02)	(0.02)	(0.02)	(0.02)
National partners	-0.02	0.05**	-0.02	0.04**
	(0.02)	(0.02)	(0.02)	(0.02)
Internat'l partners	0.07***	0.00	0.05***	0.03
	(0.02)	(0.03)	(0.02)	(0.02)
Education:	**Min**	**Max**	**Min**	**Max**
Regional partners	0.03	-0.00	0.04**	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)
National partners	0.07***	-0.03	0.05***	-0.03*
	(0.02)	(0.02)	(0.02)	(0.02)
Internat'l partners	-0.02	0.08***	0.01	0.06***
	(0.03)	(0.02)	(0.03)	(0.02)

The final two hypotheses, H_5 and H_6, are tested in Model 2 of Table 3. For regional R&D expenditure, the interaction terms including regional partners have positive and statistically significant coefficients, supporting H_5. In order to interpret these interaction terms more easily, Table 4 shows the average marginal effects of the three collaboration variables in regions with the lowest and highest levels of R&D expenditure and education, respectively. The marginal effects show that regional collaboration is connected with a significantly higher likelihood of both product innovation and radical product innovation in regions with high levels of R&D expenditure, whereas there is no significant relationship in regions with low R&D expenditure. Hence, in regions with high levels of R&D expenditure, collaborating with nearby partners go systematically together with a higher likelihood of radical innovation, whereas this is not true in regions where R&D expenditure is lower. Increasing regional cooperation from one standard deviation below the mean to one standard deviation above the mean is associated with an increase in the probability of an average firm introducing a radical

product innovation of 15.5% (from 22% to 26%) in regions with a higher expenditure in R&D. The equivalent increase is only 11% in regions with a lower level of expenditure in R&D (Figure 2). Collaboration with national partners also interacts with regional R&D expenditures in a similar way. Conversely, the interaction terms involving international partners are small and not statistically significant, and so the effects of collaboration with partners outside the region are not sensitive to local R&D investments. Examining the marginal effects reveals that international collaboration is significantly connected to innovation in regions with low levels of R&D expenditure, whereas the association is not significant in regions with higher R&D expenditure.

Figure 2. Probability of introducing radical product innovation through cooperation with regional partners in regions with a high and low endowment of R&D.



H_6 postulated that regional education levels would interact with collaboration in a different way, pertaining mainly to the association between international collaboration and innovation. This is supported for product innovation, where the interaction between international collaboration and regional education is significant and positive. In the model with radical product innovation as the dependent variable, the coefficient is not significant and H_0 cannot be rejected. An average firm in Norwegian city-regions with a good educational endowment has a 37% probability of introducing product innovations if it interacts to a little extent with international partners, compared to a 56% probability if it interacts to a large extent with international partners– an increase of more than 50%. An average firm in city regions with a lower educated workforce also seems to benefit from greater interaction with international partners, although the change in the probability of introducing product innovation is only around 18% (Figure 4), which is not statistically significant.

Furthermore, although this was not addressed in any of the hypotheses, the analysis finds that the interaction terms including regional and national partners are always negative, i.e. associated with a reduction of the association between collaboration and radical product innovation – for national partners this also holds for product innovation in general. This means that a greater interaction with national partners might benefit firms in those regions with a lower level of education, which see their propensity of introducing product innovations increase from levels of 39.5% to almost 50% for an average firm that adds an additional national partner to its contacts. Bringing an additional national partner on board in regions with a highly educated workforce is, by contrast, slightly detrimental for a firm's capacity to introduce product innovations (Figure 3) – significantly so for radical product innovation. Whereas going from low to high levels of national collaboration is linked to an increase in the average firm's chances to innovate by more than 25% in regions with a low level of education, it is connected to a reduction in the probability to innovate of close to 2.5% in regions with a better educational endowment.

While the contrasting signs of the interaction terms for partners at different scales might seem puzzling, the results are consistent with the following pattern: Regions with an educated workforce can use the resulting absorptive capacity to successfully assimilate knowledge being diffused through global pipelines from faraway places to a much greater extent than those firms located in areas of the country with a weaker level of human capital. However, this absorptive capacity is likely to go to waste, and may even obstruct innovation, if regional firms rely mainly on internal connections within Norway.

Figure 3. Probability of introducing product innovation through cooperation with national partners in regions with a high and low endowment of human capital.

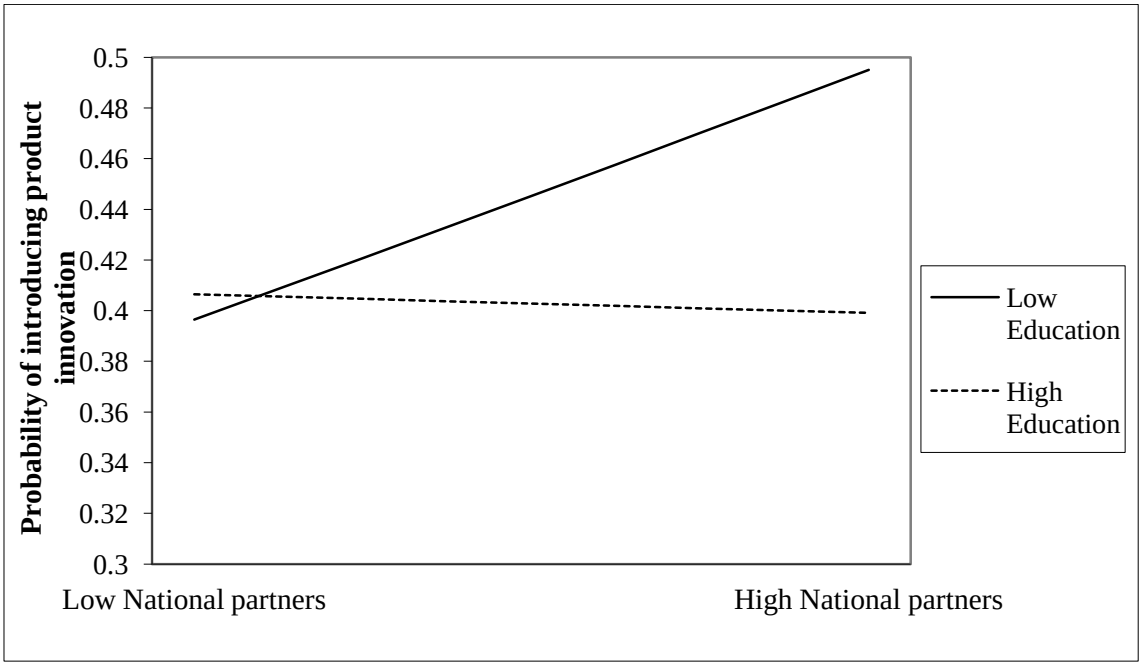
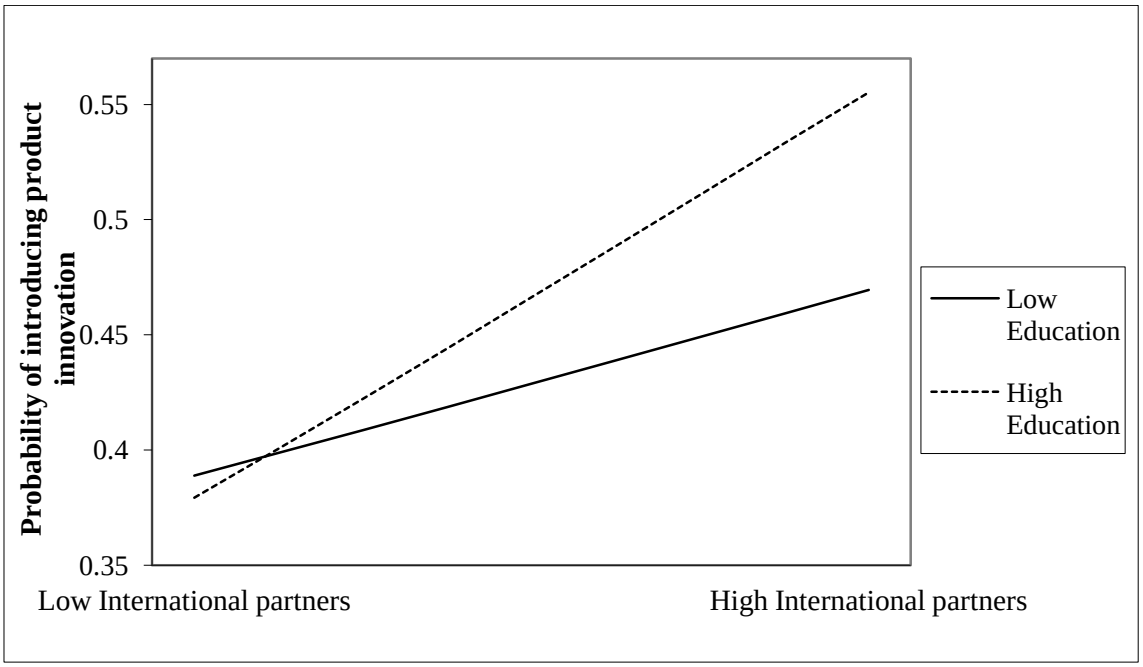


Figure 4. Probability of introducing product innovation through cooperation with international partners in regions with a high and low endowment of human capital.



As for the control variables, we note that the manager's level of education does not significantly affect firm innovation, but younger managers seem to be somewhat more successful in promoting product innovation. Well-connected managers – those holding many director positions in other firms – significantly improve their firms' ability to innovate. To the extent that these other firms are located in the same region, this could provide partial support for H_1. Larger firms are also significantly more likely to innovate, as are foreign owned ones. Furthermore, innovation levels vary significantly across industries even after all the factors in our model are accounted for.

Table 5 shows the results of the analyses using the two forms of process innovation as the dependent variables. Starting again with the association between firm collaboration and innovation, the results once more provide support for H_2, but not for H_1. Firms that collaborate with international partners are significantly more likely to introduce both process innovations and radical process innovations, supporting H_2, although the association is somewhat weaker than that observed for product innovations. Furthermore, collaborating with national partners is also significantly and positively connected with the likelihood of process innovation and of radical process innovation, also supporting H_2. However, collaborating with regional partners is not significantly associated with any form of process innovation. H_1 can thus not be supported.

Table 5: Logit regression estimation for process innovation

	Process innovation		Radical process innovation	
	Model 1	**Model 2**	**Model 1**	**Model 2**
Regional partners	0.03	0.03	0.01	0.00
	(0.03)	(0.03)	(0.04)	(0.04)
National partners	0.08**	0.08**	0.08*	0.09*
	(0.04)	(0.04)	(0.05)	(0.05)
Internat'l partners	0.09*	0.08*	0.13***	0.13**
	(0.05)	(0.05)	(0.05)	(0.05)
Regional R&D	0.00	0.00	0.00	0.00
	(0.01)	(0.01)	(0.02)	(0.02)
Regional education	0.02	0.03	0.02	0.01
	(0.04)	(0.04)	(0.05)	(0.06)
Regional partners		-0.00		0.01
** Regional R&D*		(0.01)		(0.01)
National partners		0.00		-0.02*
** Regional R&D*		(0.01)		(0.01)
International partn		-0.00		-0.00
** Regional R&D*		(0.01)		(0.01)
Regional partners		0.01		-0.02
** Regional educ*		(0.02)		(0.03)
National partners		-0.04		-0.00
** Regional educ*		(0.03)		(0.03)
International partn		0.03		0.03
** Regional educ*		(0.03)		(0.04)
Manager's	0.00	0.00	0.04	0.05
education level	(0.02)	(0.02)	(0.03)	(0.03)
Manager's age	-0.01	-0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Manager's log no.	0.08	0.09	0.08	0.12
company dir.ships	(0.08)	(0.08)	(0.09)	(0.10)
Log no. of	0.25***	0.25***	0.18***	0.18***
employees	(0.06)	(0.06)	(0.07)	(0.07)
Share held by	0.31	0.30	0.15	0.15
foreign owners	(0.19)	(0.19)	(0.22)	(0.22)
Industry	Controlled***	Controlled***	Controlled***	Controlled***
Constant	-0.36	-0.34	-2.56***	-2.49***
	(0.37)	(0.37)	(0.47)	(0.48)
N	1602	1602	1602	1602
Pseudo R^2	0.07	0.07	0.07	0.08

Note: * = P < 0.10 ** = P < 0.05 *** = P < 0.01

The top number in each cell denotes the coefficient, with the standard error listed below in parentheses.

However, environmental factors make much less of a difference for process innovation than for product innovation, both in terms of the direct associations (H_3 and H_4) and the interaction with collaboration (H_5 and H_6). None of the main effects of regional-level variables are significantly associated with any form of process innovation. Nor do any of the interaction terms have a significant coefficient, with the exception of the interaction between national partners and regional R&D expenditure, which is negatively related to radical process innovation. But even in this case, the impact is much more muted. Firms in regions with lower levels of investment in R&D benefit from reaching out to additional national partners relative to firms in areas with a higher R&D intensity. Hence, H_3 through H_6 tend not to be supported when it comes to process innovation.

Among the control variables, company size has a significant positive effect on both process innovation and radical process innovation. In addition, industry has a significant effect on both forms of process innovation. None of the other control variables significantly impact process innovation. In sum, the drivers of process innovation appear to be much harder to pin down than those of product innovation.

The overall story emerging from this analysis is consistent with the expectation that regional environments in R&D and the educational attainment of the workforce condition the returns of interaction with partners. The propensity of firms to introduce innovation by linking with partners at different geographical scales varies depending on the characteristics of the region where the firm is located. In general, local and national linkages tend to be more closely related with innovation for firms located in areas where there is more investment in R&D. This could be because the new products derived from the greater investment in science and technology create externalities which can be reaped by firms when they branch out to other local or national firms, consultancies, and especially to research centres and/or universities (see also Fabrizio, 2009). Geographical proximity is essential for these relationships (Bishop et al., 2009). These mechanisms work to a much lesser extent in those areas lagging in R&D.

In the case of the education environment, the panorama is different. National connections are more closely linked to innovation for firms in regions with a lower educational endowment, whereas international ones are more strongly related to the introduction of product and radical product innovations in areas with a more educated workforce. This could imply that a well prepared workforce might enhance the absorptive capacity for innovations channelled through global pipelines. An educated workforce gives firms an enhanced absorptive capacity which allows for more efficient management of external knowledge flows and for the transformation of these flows into innovative outcomes (Escribano et al. 2009). By contrast, national contacts – possibly contributing to further diffusing innovations already adopted elsewhere in Norway – are important for the introduction of new products in parts of the country with a weaker human capital. However, the analysis can only show associations between the variables, while the causal interpretation of the results remains a matter for theoretical debate, as there are potentially also other causal mechanisms that can account for the patterns emerging in the data.

Finally, the analysis also shows that the above seems to be the case for product, more than for process innovation. Local conditions seem to make little difference for the introduction of new process innovations stemming from firm interaction at different geographical scales.

Conclusion

This paper has explored the combined impact of interaction and of regional knowledge resources on the innovative potential of firms. The results are consistent with the expectation that firms benefit from interacting with a wide range of non-regional (national and, particularly, international) partners, both in terms of their potential for product and process innovation, and both for incremental and radical innovation. However, interaction with other regional actors does not have a significant effect on innovation. While other studies have made similar findings, an important novel insight in this paper is that these benefits are not the same across different regional contexts. In fact, the transformation of connections and networks into innovation seem to vary depending on characteristics of the region in which a firm is located. While the level of R&D investments or education in the region in which the firm is located does not have any direct effect on its potential for innovation taken on their own, both factors condition the returns to both regional and non-regional collaboration, albeit in different ways. Specifically, regional R&D investments are associated with stronger effects of regional and national collaboration in terms of its impact on radical product innovation. Conversely, regional education levels tend to be connected with lower effects of regional and national collaboration on product innovation, but with higher effects of international collaboration.

This suggests that economic geography – and, especially, evolutionary economic geography – literature should consider regional context as a fundamental factor in shaping the innovative performance of firms. As the results of the analysis suggest, firms are embedded in geography and a thorough understanding of the context in which firms operate is needed in order to grasp firm trajectories. While firm conditions and firm networking remain crucial for firm innovation, operating in contexts where the R&D effort and the educational attainment of the population vary tend also to be significantly associated with the returns to specific forms of networking. In this respect, context and geography generate the conditions, networks, and policy opportunities which influence a firm's capacity to innovate. This means that the role of context has to be brought to the fore in the analysis of firm behaviour. However, and with a few exceptions (Giuliani and Bell 2005; Morrison et al. 2013), this has been an unexplored topic in evolutionary economic geography, albeit one which could become more important with the increasing emphasis on long-distance interaction and relational proximity in the economic geography literature on innovation.

The importance of local context in shaping the interactions behind firm level innovation also opens a series of new strands for research. First, it highlights the need to enhance the analysis of the role of local conditions and institutions in firm performance. Local norms and habits, as well as the quality of local government and other institutions are factors that might favour or limit the emergence of moral hazards, impacted information or insider-outsider problems which may condition a firm's performance. Second, the analysis has brought to the fore the need for taking into account the mix of socioeconomic conditions or the contextual endowments and factors that may facilitate or hinder economic activity and/or the networking of firms. Third, it has also drawn attention to the need to focus on specific policies and how those policies shape the behaviour of firms. If context in these three dimensions is properly brought into the picture, the very interesting and innovative theoretical framework proposed by evolutionary economic geographers could be significantly expanded, pushing the

boundaries of our understanding of how local institutions and local context shape the innovative and economic performance of firms and, collectively, the resilience of regions.

Finally, and specifically for the case of Norway, the paper calls into question recent developments in Norwegian innovation policy that emphasize regional collaboration and the promotion of clusters and local networks in pursuit of economic development (Hanssen et al. 2011; Jakobsen et al. 2012). Overall, the Norwegian economy is characterised by relatively low R&D intensity and high absorptive capacity as measured by levels of higher education. In such a context, policies that promote regional collaboration are likely to be counter-productive. While regional collaboration may be a viable strategy in certain R&D intensive regions, notably Trondheim, most other Norwegian regions would probably be better off putting their absorptive capacity to use in developing global pipelines through which they could assimilate ideas from the main global nodes of knowledge.

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Appendix Table: Multicollinearity diagnostics

	Model 1	Model 2
Regional partners	1.13	1.15
National partners	1.28	1.30
Internat'l partners	1.48	1.51
Regional R&D	3.47	3.61
Regional education	3.62	3.74
*Regional partners * Regional R&D*		3.55
*National partners * Regional R&D*		3.92
*International partn * Regional R&D*		4.06
*Regional partners * Regional educ*		3.59
*National partners * Regional educ*		3.84
*International partn * Regional educ*		3.95
Manager's education level	1.24	1.24
Manager's age	1.10	1.10
Manager's log no. company dir.ships	1.09	1.10
Log no. of employees	1.27	1.28
Share held by foreign owners	1.36	1.36
Industry: Mining	1.13	1.16
Industry: Manufacturing	1.45	1.46
Industry: El., gas, water supply	1.04	1.05
Industry: Construction	1.53	1.54
Industry: Trade	1.43	1.45
Industry: Hotels/restaurants	1.32	1.33
Industry: Transport and communications	1.26	1.26
Industry: Financial services	1.08	1.09

The table shows variance inflation factors.