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ABSTRACT

Firm collaboration and modes of innovation in Norway*

This paper examines the sources of firm product and process innovation in Norway. It uses a purpose-built survey of 1604 firms in the five largest Norwegian city-regions to test, by means of a logit regression analysis, Jensen et al.'s (2007) contention that firm innovation is both the result of 'science, technology and innovation' (STI) and 'doing, using and interacting' (DUI) modes of firm learning. The paper classifies different types of firm interaction into STI-mode interaction (with consultants, universities, and research centres) and DUI-mode interaction, distinguishing between DUI interaction within the supply-chain (i.e. with suppliers and customers) or not (with competitors). It further controls for the geographical locations of partners. The analysis demonstrates that engagement with external agents is an important source of firm innovation and that both STI and DUI-modes of interaction matter. However, it also shows that DUI modes of interaction outside the supply chain tend to be irrelevant for innovation, with frequent exchanges with competitors having a detrimental effect on a firm's propensity to innovate. Collaboration with extra-regional agents is much more conducive to innovation than collaboration with local partners, especially within the DUI mode.

JEL Classification: L14, O31 and O32
Keywords: competitors, customers, dui, firms, innovation, Norway, STI, suppliers and universities

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1. Introduction

There has traditionally been a strong dividing line in the research looking at the sources of innovation. This dividing line has been fundamentally determined by the value different strands of research award to science and technology as the key element for the generation, diffusion, and assimilation of innovation. Researchers on innovation have, over the years, placed themselves on either side of the dividing line. On one side of the line, the linear model of innovation (Bush, 1945; Maclaurin, 1953), and research on knowledge spillovers (Audretsch and Feldman, 1996; Cantwell and Iammarino, 2003; Sonn and Storper, 2008) have looked at innovation from a scientific and technical perspective. This has led to the use of research and development (R&D), patenting, information and communications technology (ICT) expenditures, and the level of education and training of the labour force as the main proxies of, as well as the key factors behind, the development and assimilation of innovation. On the other side of the dividing line, researchers have tended to place the greatest emphasis on institutions, interactions, networks and informal relationships that facilitate the generation and exchange of knowledge (Lundvall, 1992). This strand has given rise to a blooming literature which, under different definitions and names – e.g. 'neo-Marshallian industrial districts' (Becattini, 1987), 'innovative milieux' (Aydalot, 1986), 'learning regions' (Morgan, 1997), or 'regional innovation systems' (Cooke et al., 1997; Cooke and Morgan, 1998) – regards innovation as a territorially embedded phenomenon, determined by the social and institutional conditions in a given territory (Iammarino, 2005).

Using Jensen et al.'s (2007) terminology, this distinction leads at the firm level to the emergence of what are known as the 'Science, Technology and Innovation' (STI) and the 'Doing, Using and Interacting' (DUI) modes of firm learning. The STI-mode of innovation refers to the use of scientific knowledge in the development of new technologies that form the basis of new products or processes within the firm. The DUI-mode refers to on-the-job problem-solving based on the exchange of experiences and know-how, through which firms find solutions to various problems that arise. These processes typically involve a large component of tacit knowledge (Jensen et al., 2007: 62-64). The STI and DUI-modes of innovation have used different approaches, techniques, and proxies to explain and measure how innovation at the level of the firm is generated. The STI-mode has generally relied on deductive approaches and quantitative techniques, employing R&D, patenting, ICT and the formal education of the workforce as the key indicators. The DUI-mode of innovation is somewhat more diverse, although inductive and qualitative approaches have tended to prevail. Quantitative methods based on survey data have played a relatively small role in DUI-mode approaches. According to proponents of the DUI-mode, "the vast majority of quantitative survey-based studies of innovation simply had little to say about the relation of DUI-mode learning to innovative performance" (Jensen et al., 2007: 681). This is partly a result of the difficulty in operationalising the complex institutional and relational factors at the base of DUI-mode approaches to innovation, but also a consequence of a general belief that processes such as learning by doing and using are best analysed through in-depth case studies.

Both approaches to innovation have tended to run in parallel, virtually ignoring each other. There have been few attempts to try to reconcile STI and DUI-modes. Some of these attempts have adopted a territorial and macro-approach, using regions and metropolitan areas as their unit of analysis (e.g. Crescenzi et al., 2007; Rodríguez-Pose and Crescenzi, 2008). The quantitative analyses combining both STI and DUI using micro-data and the firm as the unit of analysis have been extremely limited (Jensen et al., 2007; Kirner et al., 2009). Jensen et al. (2007) is the first and by far the most prominent among these. Based on data from 1643

Danish firms, the authors use latent class analysis to classify firms according to their intensity of use of STI and DUI-modes of innovation. The results show that firms which combine the two modes of innovation are more likely to introduce new products and services than those specialised in either of the modes (Jensen et al., 2007).

While making a pioneering and important contribution to our knowledge, one of the potential downsides of their analysis is that the classification of firms into three clusters according to the intensity of use of STI and DUI-modes of innovation by each firm creates a rather crude trichotomous division which represents the variables of interest in the logistic regression analysis on which the key conclusions are based. This implies a significant loss of information about STI and DUI-modes of learning at the level of each firm.

In this paper we aim to make a contribution to this debate by analysing to what extent STI and DUI-modes of innovation are conducive to the introduction of firm level innovation in Norway. We use a specifically tailor-made survey of 1604 firms with more than ten employees in the five major Norwegian city-regions. The survey measures the different types of interactions that these firms engage in. We classify the interactions with different partner types into STI-interaction types and DUI-interaction types. STI-interaction types include connections with universities, research institutes, and consultancy firms. DUI-interaction types encompass linkages with other firms in the conglomerate, suppliers, customers, and competitors. DUI-type interactions are, in turn, divided into those that fall within the regular supply-chain (interactions with suppliers and customers), and those which do not (interactions with competitors).

The main contributions of this paper lie in four areas. First of all, in the use of different measures of innovation. In contrast to previous work, which tends to differentiate between product and service innovation (Jensen et al., 2007; Kirner et al., 2009), we distinguish, on the one hand, between product and process innovation, defined as the introduction of new products or processes in the firm over the last three years, and, on the other, between incremental and radical innovation. This gives us a classification of four types of innovation which may be affected by different patterns of collaboration at the level of the firm. The fourfold classification allows for much greater nuance in the explanation of how different forms of firm partnerships may affect different types of innovation. Secondly, rather than classifying firms according to their innovation practices, we use the different interaction linkages of each firm individually as our independent variables of interest, dividing, in turn, DUI-type interactions according to whether they are conducted within the supply-chain or not. Thirdly, we pay specific attention to the often neglected topic of the geographical dimension of the different partnerships of the firm and how they influence innovation. STI and DUI-mode interaction are frequently conducted at different geographical scales and this may significantly affect the capacity of firms to produce different types of innovation. We therefore distinguish between interactions conducted in close geographical proximity, i.e. at the level of a locality or region, and those that are conducted with partners located in distant cities or abroad. Last, but not least, we apply the analysis to Norway, using a specifically tailored survey specially designed for the purpose of this research.

The paper is structured into five further sections. In the theoretical section following this introduction, we look at the role of the sources of knowledge and innovation, focusing later on the geography of STI and DUI-modes of innovation. We then present the case and describe the data in section 3. The following section deals with the empirical analysis linking partner types with innovation outcomes. Section 5 examines what difference the geographical dimension of partnerships makes for innovation. The conclusions and some indications for future research are presented in section 6.

2. The role of sources of knowledge in innovation

The scholarly literature about where firms get the knowledge to generate and implement innovation has tended to be divided between two camps: a) a larger camp, which posits that firm-level innovation is the consequence of advances in science and technology (S&T), driven by investment in R&D and by human capital (the STI-mode of innovation) and b) a smaller, but growing camp putting the emphasis on learning-by-doing and using (the DUI-mode of innovation) (Jensen et al., 2007).

For those placed in the STI camp, innovation in firms is the result of investments in R&D and S&T and interaction with centres producing new knowledge – mainly research centres and universities, but also consultancies, scientific brokers and foundations for the diffusion of scientific research – which generate the codified and explicit knowledge which can be used by the firm to produce new innovations. The capacity to generate and adopt new innovations will also be largely dependent on the human capital available in the firm and on the level of training of employees. As pointed out by Jensen et al. (2007: 681), in STI-type analyses "there is a tendency to expect that the increasing reliance on science and technology in the 'knowledge-based economy' will enhance the role played by formal processes of R&D requiring personnel with formal S&T qualifications". Hence, STI-type research has, by and large, resorted to investment in R&D, level of education of the workforce, and cooperation with research centres as the key indicators behind the analysis of innovation and the economic outcomes linked to innovation (e.g. Rodríguez-Pose and Crescenzi, 2008).

The proponents of the DUI approach, by contrast, have tended to be profoundly sceptical about the relevance of the STI-mode of innovation, in general, and of R&D, in particular, as a source of firm-level innovation (Cooke, 2001). For those in this camp, innovation is not about putting resources into R&D or pumping up the formal qualifications of employees (Hansen and Winther, 2011); innovation in the firm is mostly generated by the capacity of managers and employees to find solutions to existing problems and to respond to the challenges made by suppliers, customers, and the market. Innovation is therefore about markets and organisations (Caraça et al.., 2009) and the result of a combination of learning-by-doing and using, which requires a huge amount of mainly informal interaction between people, both within and outside the firm (Lundvall, 1992; Storper and Venables, 2004; Barge-Gil et al., 2011). Constant and repeated interaction generates the tacit knowledge which facilitates the response to user demands and, ultimately, drives innovation within the firm (Jensen et al., 2007).

As indicated by Jensen et al. (2007), the STI and DUI-modes of innovation are linked to different forms of interaction both within the firm and with the environment of the firm. Using Lundvall and Johnson's (1994) classification, the STI-mode of innovation requires interaction that leads to 'know-what' and 'know-why' types of knowledge. These are types of knowledge which, despite also having an informal interaction component, tend to be associated with formal relationships. The fundamental channels of transfer of this type of knowledge are either through universally-accessible sources of knowledge, such as books, scientific articles or the internet, or by the establishment of formal relationships with the organisations which produce this knowledge, such as universities and research centres. The DUI-mode of innovation, by contrast, tends to rely on 'know-how' and 'know-who' types of knowledge. These are types of knowledge which are obtained through repeated, mainly informal, interaction. Imitation and learning by doing are the main sources of 'know-how'. Social capital and local buzz provide the main sources of 'know-who'.

Hence, different types of relationships and interactions are at the base of the STI and the DUI-modes of innovation. The 'know-what' and 'know-why' types of knowledge which fuel STI are generated through often purpose-built engagement by the firm with external agents. These external agents include universities, research centres and institutes, and consultancy firms. The 'know-how' and 'know-who' needed for a DUI-mode of innovation are obtained through different channels of interaction. These channels involve the informal and formal exchanges internal to the firm, but also with suppliers, customers and competitors. However, not all of these DUI-type of interactions lead to similar forms of 'know-how' and 'know-who'. Within the DUI-mode, a distinction can be made between two different types of partners. On the one hand, interaction with suppliers and customers implies collaboration with partners that are interrelated and have formed close complementary bonds within the supply chain. Most of these types of relationships have both a high formal and informal component and a clear purpose: to improve the delivery of products and services and to boost their competitiveness in the market. As a consequence, these relationships have innovation as one of their main purposes and essential components. On the other hand, relationships with competitors have an entirely different purpose. They tend to be informal, rather than formal, and do not have the transfer of knowledge or innovation as their fundamental purpose. Through information exchanges, knowledge leading to innovation may spill over, but this is more an unintended, albeit welcome, outcome of these exchanges, rather than the main purpose. Hence, we are talking of informal interaction with partners outside the supply-chain.

The distinction between DUI-mode relationships within and outside the supply-chain in many ways reproduces the debate about the different types of externalities that matter for innovation. Knowledge spillovers can only occur between agents that share languages and codes and face similar or related problems and can apply similar or related technologies. As a consequence, knowledge flows are likely to be higher among firms in the same or in related sectors. This type of relationship will usually be within the supply-chain. Sharing the same value chain is likely to generate common interests and to produce benefits from specialisation (Marshall-Arrow-Romer) type externalities or from related variety externalities (Frenken et al., 2007; Boschma and Iammarino, 2009; see also van der Panne, 2004). DUI-mode relationships outside the supply-chain will be more conducive to diversification, or Jacobs type, externalities, where knowledge is diffused and exchanged for the mere fact of 'being there' and interacting with other socio-economic agents in a tacit and informal way (Jacobs, 1969; Gertler, 2003). But the use of different languages and codes by agents and firms may imply that a large share of the knowledge exchanged cannot be easily transformed into innovation.

2.1. The geography of STI and DUI-modes of innovation

One aspect which has attracted very little attention in the literature about STI and DUI-modes of innovation is that the types of interactions that are linked to STI or DUI-modes of innovation, respectively, may have very different geographical dimensions. Because of the more formal nature of STI-links, geographical proximity may not necessarily be essential for the generation of this type of innovation.[1] The codified analytical and synthetic knowledge of the sort that dominates within the STI-mode is assumed to be universal and can be shared across cultural contexts and geographical distance. STI-mode innovation implies a capacity of firms to reach out to universities or research institutes, or vice versa, or for firms to hire management consultants that can serve as bridges between the firm and producers of scientific knowledge. This entails not only intent, but greater pecuniary and time costs. Because of the higher costs, firms will try to maximise their value for money and look for the best partners for the transmission of knowledge. This would generate links close to what Bathelt et al. (2004) have denominated 'global pipelines', that is, purpose-built connections between a given local firm and partners in the outside world (see also Maskell et al., 2006: 999). The building of pipelines implies some sort of cognitive (Boschma, 2005) or organised (Torre and Rallet, 2005) type of proximity. However, this will not necessarily mean geographical proximity, as the best research institutes, universities or consultancy firms with knowledge that can be readily used by the firm may not necessarily be located in the firm's immediate vicinity. As a consequence, it is likely that STI-mode innovation will rely on a strong non-local and non-regional dimension, with local components being particularly relevant only in those cases such as Oxford (Lawton-Smith, 1998), the Silicon Valley (Saxenian, 1996) or large urban agglomerations (Feldman, 1999; Glaeser and Gottlieb, 2009) where top research centres coincide with dynamic and innovative firms.

DUI-modes of innovation, by contrast, require cooperation with partners that share the same practical problems and experiences. This means that the knowledge that is transferred in the DUI-mode of innovation tends, as a general rule, to be more tacit, and maybe more frequent in industries with synthetic or symbolic knowledge bases, which rely on local understandings and cultural context (Asheim and Gertler, 2005; Moodysson et al., 2008). But even within the DUI-mode of innovation there are significant differences between relationships within and outside the supply-chain. In the former, depending on the location of the suppliers and customers, these relationships can be of two kinds: a) interaction at a distance, when customers and suppliers are not located nearby, which means a lack of geographical proximity, but strong cognitive, organisational and, most likely, social and institutional proximity (Boschma, 2005); and b) interaction at close quarters, when different agents in the production chain share the same location, adding geographical proximity to all the other types of proximity.

DUI-mode relationships with competitors will, in all likelihood, be much more constrained geographically. The ad hoc and informal nature of the interaction, the feeling that 'something is in the air' (Gertler, 2003), means that firms, in order to benefit from the tacit knowledge linked to DUI-mode relationships outside the supply-chain, have to 'be there' (Gertler, 1995). This necessarily represents face-to-face contacts and geographical proximity to be able to reap the spillovers and the tacit knowledge generated from local buzz (Storper and Venables, 2004).

In brief, partnerships within the STI-mode of innovation are likely to be based on more universal knowledge that can be transferred across large geographical distances, meaning there is less value-added in cooperating with locally based scientific partners. Thus, there may

1 Although existing theoretical literature has tended to emphasise the importance of geographical proximity in the establishment of firm-university linkages, empirical evidence suggests that this type of proximity in reality plays a limited role in setting them up (Lawton Smith, 2007).

be more to be gained from sourcing science-based knowledge from global nodes of excellence, rather than restricting oneself to local partners. In contrast, DUI-mode of innovation relationships – particularly outside the supply-chain – can be expected to rely more on geographical proximity, as local partners will be more accessible than faraway ones for this type of learning.

In order to capture these different relationships and interactions, we distinguish between regional and non-regional cooperation across the three categories considered in this paper: STI-mode relationships, and DUI-mode relationships within the supply-chain and outside the supply-chain, respectively. In the three types of relationships cognitive or organised proximity plays a crucial role. However, we will argue that cognitive proximity at geographical distance is preferable to cognitive or organised proximity at close geographical quarters. Cognitive proximity at a distance may maximise the returns of specialisation and related-variety spillovers, without falling into the trap of excessive repeated interaction. By contrast, excessive cognitive proximity in limited geographical spaces may lead to repeated interaction in which no new information and knowledge is exchanged and can therefore be detrimental for innovation (Torre and Rallet, 2005; Asheim et al., 2007; Fitjar and Rodríguez-Pose, 2011). The detrimental effects for innovation of excessive cognitive proximity are likely to be stronger for firms located in smaller and more isolated geographical areas.

We also expect different types of externalities to be linked to different types of innovation. Specialisation and related-variety externalities, where agents and firms share the same language and codes, will be more prone to the generation of incremental product and process innovation, whereas Jacobs-type externalities, by creating new combinations of knowledge and technologies stemming from different sectors, will lead to more radical product and process innovation (Frenken et al., 2007; Fitjar and Rodríguez-Pose, 2011).

3. Case description and data

In order to answer the questions of whether and in which way different types of STI and DUI-partnerships and their geographical dimensions affect different types of innovations, we conducted a survey in the spring of 2010 of 1604 firms located in the five largest urban agglomerations of Norway. The survey was based on a questionnaire incorporating questions from the Community Innovation Surveys (CIS), which were modified to include data on the location of partners (inside or outside the region).[2] Data collection was administered by Synovate, a survey firm specialised in innovation management, and took the form of telephone interviews with the chief executives of the firms. Synovate also randomly sampled from the Norwegian Register of Business Enterprise, which by law lists all firms in Norway, firms with 10 or more employees located in municipalities where 10 percent or more of the population commute into one of the five major Norwegian city-regions: Oslo, Bergen,

2 The CIS itself only asks whether partners are located within the same country or abroad, making it impossible to distinguish between interaction within functional regions, where face-to-face contact and random encounters are much more likely, and interaction that may be at a geographical distance even though both partners are located in the same country. As much of the literature on the DUI-mode of innovation has focused specifically on the regional scale, it is important that we make this distinction.

Stavanger/Sandnes, Trondheim and Kristiansand.[3] In total, we approached 5887 firms, with a response rate of 27.2 percent. Table 1 shows the descriptive data for the firms in the sample, including sector, size, ownership and location. The choice of Norwegian firms was driven by the fact that Norway is a coordinated market economy in which collaboration between firms frequently takes place through non-market relationships and where inter-firm coordination is a key element in competence building (Hall and Soskice, 2001).

Table 1: Descriptive data on the firms included in the sample

Sector	**N**	**% of sample**	**No. of employees**	**N**	**% of sample**
Mining / quarrying	31	1.9	0 – 19	663	41.3
Manufacturing	296	18.5	20 – 49	523	32.6
Elect./gas/water supply	12	0.8	50 – 99	205	12.8
Construction	258	16.1	100 – 999	200	12.5
Wholesale/retail trade	276	17.2	1000 or more	13	0.8
Hotels and restaurants	129	8.1			
Transport/communic.	124	7.7			
Financial services	45	2.8			
Other services	432	27.0			
Ownership	**N**	**% of sample**	**City region**	**N**	**% of sample**
Fully foreign owned	174	10.9	Oslo	403	25.1
Partly foreign owned	69	4.3	Bergen	401	25.0
Fully Norwegian owned	1361	84.9	Stavanger	400	24.9
Fully regionally owned	1140	71.1	Trondheim	300	18.7
Partly regionally owned	178	11.1	Kristiansand	100	6.2

As a way to test the hypotheses that different modes of learning and interaction result in different kinds of innovation, we distinguish between product and process innovation, and also between radical and incremental innovation. We expect the STI-mode to be more conducive to radical innovation and to product innovation, whereas the DUI-mode, in particular when it comes to cooperation outside the supply-chain, is more likely to be linked to incremental product innovation and to process innovation. For total product innovation, respondents were asked whether their firms had introduced any new and/or significantly improved products during the last three years. They were also asked if these product innovations were new to the market, in which case they were classified as radical product innovations, or only new to the firm (incremental product innovations). Similarly, the measure of total process innovation was based on a question about whether the firm had introduced any new and/or significantly improved methods or processes for production or delivery of products during the last three years. If these new processes were new to the industry, they were classified as radical process innovations, otherwise as incremental ones. Table 2 shows the share of firms surveyed which reported innovation within each of the categories.

3 Based on 2009 data from Statistics Norway, presented in Leknes (2010). The 10 percent commuting criterion was based on the Norwegian government's definition of city-regions in its *Greater Cities Report* (Ministry of Local Government and Regional Development, 2003)

Table 2: Innovations developed in the last 3 years, % of surveyed companies

	Product innovation	Process innovation
Type of innovation: (% of all companies)		
Total innovation	53.4	47.0
	(1.2)	(1.2)
Radical innovation only	30.6	18.8
	(1.2)	(1.0)
N	1604	1604
Innovations were developed… (% of innovative companies)		
mainly by our company	47.3	36.0
	(1.7)	(1.8)
in cooperation with other companies or organisations	36.5 (1.6)	40.4 (1.8)
mainly by other companies or organisations	14.8 (1.2)	22.7 (1.5)
Don't know	1.4	0.9
	(0.4)	(0.0)
N	857	753

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

The innovative firms were also asked about the origins of their innovations: were they developed (a) mainly by the company itself, (b) in cooperation with other companies or organisations, or (c) mainly by other companies or organisations? Table 2 also lists the responses to these questions in the context of product and process innovations, respectively. The results show that collaboration is important for the development of new products and processes in Norway. 37 percent of innovative firms reported having collaborated with others in the development of new products, and 40 percent in the development of new processes. An additional 15 percent had introduced new products developed mainly by others, with the equivalent figure for process innovation being 23 percent.

In order to examine who these other companies or organisations are, managers were also asked which, if any, of seven different types of partners (other firms within the conglomerate, suppliers, customers, competitors, consultancies, universities, and research institutes) their firm had cooperated with during the past three years. Table 3 shows the share of firms that reported cooperating with partners of each type. Suppliers and customers are the most commonly used partners, with three in four firms collaborating with suppliers and almost as many with customers. More than one in three firms also collaborates with competitors, making up a sizeable number of firms. In terms of scientific partners, consultancies are the favoured type, with nearly half of firms collaborating with consultancies. Almost one in four collaborate with universities, and slightly fewer with research institutes.

Table 3: Number and share of firms collaborating with different types of partners

Partner type	Number of firms	% of firms	S.E.
Other firms within the conglomerate	830	51.7	1.2
Suppliers	1214	75.7	1.1
Customers	1150	71.7	1.1
Competitors	606	37.8	1.2
Consultancies	774	48.3	1.2
Universities	399	24.9	1.1
Research institutes	346	21.6	1.0

4. Partner types and innovation outcomes

The first research question we examine is whether collaboration with these partner types improves the likelihood of developing innovations, and furthermore, whether different types of partners are conducive to different types of innovations. In addressing this question, we fit logistic regression models for each of the four types of innovation outcomes presented in the top half of Table 2, using dummy variables for each type of partner as independent variables.

The basic regression model takes on the following form:

$$\text{logit}(\pi_i) = \alpha + \beta_1 \text{ Partners}_i + \gamma_2 \text{ Controls}_i + \delta_3 \text{ Region}_i + \varepsilon_i \quad (1)$$

where π refers to the probability of firm *i* introducing an innovation, with four different regressions being run – one for each of the innovation outcomes (total product innovation, radical product innovation, total process innovation, and radical process innovation). The independent variables of interest are seven dummy variables for the different types of partners (other firms within the conglomerate, suppliers, customers, competitors, consultancies, universities, and research institutes). These variables take the value 1 if the firm has collaborated with this type of partner within the last three years, and 0 otherwise.

As usual in firm-level analyses, the model controls for a set of factors that are related both to innovation and to the use of partners. These include the size (log no. of employees),[4] industry (a set of dummy variables referring to one-digit NACE codes)[5] and ownership (share held by foreign owners) of the firm, as well as the less frequently controlled for characteristics of the chief executive: level of education (no. of years beyond compulsory lower-level schooling), age, and directorships held in other companies (logged for the reasons stated in footnote 4). We expect firm size to be positively related to innovation due to the larger pool of resources held by larger firms, and we also expect foreign-owned firms to be more technologically advanced and, therefore, more innovative. In terms of the characteristics of the manager, education and personal networks are likely to have, as stated by the STI and the DUI-modes

4 We use the log number of employees for two reasons: One, the effect of further employees is expected to decline with increasing company size, and two, the distribution of the company size variable is highly skewed (median = 22, mean = 70, skewness = 10).

5 The categories used are (1) mining and quarrying, (2) manufacturing, (3) electricity, gas and water supply, (4) construction, (5) wholesale and retail trade, (6) accommodation and food service activities, (7) transporting, storage, information and communication, (8) financial and insurance activities, and (9) other services. The categorisation is based on the company’s listing in the Norwegian Register of Business Enterprises.

of innovation respectively, a positive impact on innovation, while age is expected to be negatively associated with innovation due to the lower level of risk aversion among young managers. We also include fixed effects for the five city regions in order to examine whether there are any residual differences between the regions after controlling for other factors. ε depicts the error term.

Table 4 shows the results of the logistic regression analyses for each of the four innovation outcomes. All models have been tested for multicollinearity, non-linearity of the linear predictor, and significant outliers. No significant violation of assumptions was found.

Table 4: Logit regression estimation of the empirical model. Innovativeness

	Product innovation	**Radical product innovation**	**Process innovation**	**Radical process innovation**
Partner types				
Within the	0.39***	0.20	-0.02	0.10
conglomerate	(0.12)	(0.13)	(0.12)	(0.15)
Suppliers	0.39**	0.33*	0.76***	0.38*
	(0.14)	(0.16)	(0.14)	(0.19)
Customers	0.36**	0.54***	0.03	-0.03
	(0.13)	(0.15)	(0.13)	(0.17)
Competitors	-0.39***	-0.55***	-0.14	-0.09
	(0.12)	(0.13)	(0.12)	(0.15)
Consultancies	0.15	0.18	0.16	0.03
	(0.12)	(0.13)	(0.12)	(0.15)
Universities	0.30*	0.53***	0.21	0.13
	(0.16)	(0.15)	(0.15)	(0.18)
Research institutes	0.26	0.20	0.26	0.79***
	(0.16)	(0.16)	(0.16)	(0.18)
Control variables				
Manager's	-0.01	0.01	-0.00	0.03
education level	(0.02)	(0.03)	(0.02)	(0.03)
Manager's age	-0.01	-0.00	-0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Manager's log no.	0.18*	0.11	0.08	0.04
company dir.ships	(0.08)	(0.08)	(0.08)	(0.10)
Log no. of	0.19**	0.12*	0.24***	0.16*
employees	(0.06)	(0.06)	(0.06)	(0.07)
Share held by	0.48*	0.55**	0.35	0.14
foreign owners	(0.02)	(0.19)	(0.19)	(0.22)
Industry	Controlled***	Controlled***	Controlled***	Controlled***
Region	Controlled	Controlled	Controlled	Controlled
Constant	-0.57	-2.07***	-1.10*	-2.75***
	(0.46)	(0.50)	(0.45)	(0.58)
N	1602	1602	1602	1602
Pseudo R^2	0.11	0.11	0.09	0.09

Note: * = P < 0.05 ** = P < 0.01 *** = P < 0.001
The top number in each cell denotes the coefficient, with the standard error listed below in parentheses.

The results presented in Table 4 show that different types of partnerships influence different types of innovation in different ways, but not always necessarily in the direction predicted by theory. If we take the partnerships that are traditionally linked to the STI-mode of innovation, scientific collaboration has, as expected, a relatively strong association with product innovation. Nevertheless, this association only seems to work for partnerships with universities and not for those with research institutes and consultancies (Table 4). Collaboration with universities has a strong impact on the likelihood of radical product innovation, and a weaker, but still significant, impact on total product innovation, whereas it does not seem to affect the likelihood of process innovation. The likelihood of radical product innovation is exp(0.53) = 53 percent higher, and of total product innovation exp(0.30) = 35 percent higher, for Norwegian firms that cooperate with universities. In contrast, collaboration with other types of scientific partners generally has a negligible impact on their likelihood to innovate, with the exception of a large positive effect of collaboration with research institutes for radical process innovation.

DUI-cooperation with suppliers and customers is key for the innovative capacity of firms. Collaboration with suppliers is important for all types of innovation, with the strongest effect on process innovation: the likelihood of total process innovation more than doubles for firms that cooperate with suppliers (exp(0.76) = 113 percent), whereas the likelihood of other forms of innovation increases by between 38 and 47 percent (corresponding to exp(0.33) and exp(0.39), respectively) (Table 4). Collaboration with customers is conducive to product innovation, but does not significantly impact process innovation (Table 4). Contrary to expectations, collaboration with customers also does not seem to be restricted to incremental product innovation, but is actually even more important for radical product innovation. The likelihood of radical product innovation is exp(0.54) = 71 percent higher for firms that cooperate with customers, whereas the likelihood of total product innovation increases by exp(0.36) = 43 percent.

Finally, the other form of DUI-type interactions – outside the supply-chain – has a radically different effect on innovation. Firms that cooperate with competitors in Norway tend to see their capacity to introduce product innovation significantly reduced. This effect is particularly strong for radical product innovation, but still significant for product innovation (Table 4). The likelihood of developing new products is exp(-0.39) = 32 percent lower for firms that collaborate with their competitors, and the likelihood of radical product innovation is exp(-0.55) = 42 percent lower. Cooperation within the conglomerate mostly does not have a significant effect on the likelihood of innovation, with the exception of total product innovation, where the likelihood increases by exp(0.39) = 48 percent if the firm collaborates with other firms in the conglomerate.

Table 5 shows the fitted probability of innovation for cooperation with different types of partners compared with no external cooperation by the firm at all. The results highlight that interaction with partners is, in general, an important source of innovation. In virtually all cases, cooperation with partners leads to higher levels of product and process innovation, both incremental and radical, relative to having no external interaction and conducting all innovation within the firm (Table 5). The main exception is interaction with competitors which is, in contrast with what is frequently stressed in the literature about clusters and industrial districts (Marshall, 1890; dei Ottati, 1994; Cooke, 1998, 2002; Newlands, 2003), detrimental for innovation. However, not all types of partnership have the same effect over different types of innovation. On the whole, STI and DUI-supply-chain partnerships promote innovation. DUI partnerships within the supply-chain have the greatest effect, with interaction with suppliers making an important difference for both types of process innovation and for incremental product innovation. Cooperation with customers is essential to increasing the probability of product innovation, but plays a much smaller role for process innovation in Norwegian firms (Table 5). Among the STI-mode partnerships, cooperation with universities is particularly productive in terms of both types of product innovation, while that with research institutes leads to a significant increase in the probabilities of radical process innovation. Partnerships with consultancies have the least positive effect (Table 5). DUI interactions outside the supply-chain are, taken as a whole, virtually irrelevant in terms of increasing the probabilities of innovation. Whereas, as already mentioned, interaction with competitors has a strong detrimental effect, interaction within the conglomerate only significantly increases the probabilities of innovating in Norwegian firms in the case of incremental product innovation.

Table 5: Fitted probabilities of innovation

	Product innovation	**Radical product innovation**	**Process innovation**	**Radical process innovation**
No partners	0.34	0.15	0.30	0.10
In conglomerate	0.43	0.17	0.30	0.11
Suppliers	0.43	0.19	0.48	0.14
Customers	0.43	0.23	0.31	0.10
Competitors	0.26	0.09	0.27	0.10
Consultancies	0.38	0.17	0.34	0.11
Universities	0.41	0.23	0.35	0.12
Research institutes	0.40	0.17	0.36	0.20

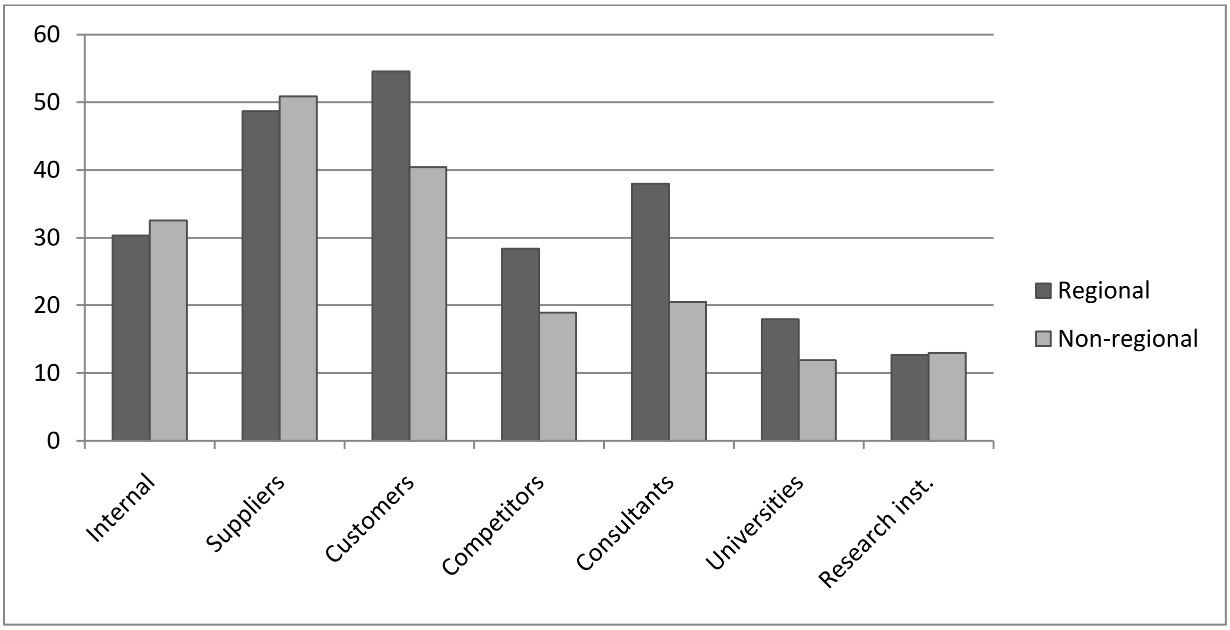
Note: Predicted probability of innovation for a firm with average values on all control variables that cooperates only with the partner type listed in the first column.

5. What difference does geographical proximity make?

The second set of research questions relates to the impact of geographical distance on the propensity to collaborate with industrial and scientific partners, as well as to the effectiveness of such cooperation. In this analysis, we focus on collaboration with partners outside the conglomerate, as the geographical reach of collaboration within conglomerates will fundamentally be shaped by whether the conglomerate itself is a regional, national or multi-national enterprise, rather than by the nature of the knowledge flows. As stated in the theoretical section, DUI-type collaborations are expected to involve more transmission of tacit knowledge and practical know-how, which is less easily transferred across geographical distance. Conversely, STI-type collaboration is primarily based on codified and universal knowledge that should, in theory, be less affected by efficiency-loss across geographical distance. Therefore, it could be envisaged that DUI-type partnerships – in particular outside the supply-chain – will more often than not take place in close geographical proximity, while extra-regional networks will be more common for STI-mode collaboration. Additionally, geographical proximity will be an asset in DUI-type partnerships, making industrial cooperation within the region more efficient than industrial cooperation with partners outside the region. This relationship is not expected to hold for STI-mode cooperation, which will possibly be even more effective in global networks due to the ability to link up to nodes of excellence.

Starting with the question of firms' propensity to collaborate, we asked for each partner type identified whether the partner was located inside or outside the region. Figure 1 shows the share of firms that cooperated with different types of partners inside and outside the region, respectively. Cooperation with partners inside the region is slightly more common than cooperation out of the region, although some categories of partners (other firms in the conglomerate, suppliers, and research institutes) are slightly more frequently located outside the region than inside it. However, there is no clear difference between DUI-mode and STI-mode partners when it comes to the frequency of collaboration inside versus outside the region. The biggest difference in regional vs. extra-regional cooperation is for consultancies: 38 percent of firms collaborate with consultancies in the region and 21 percent with non-regional consultancies. Even for universities, regional cooperation is most common: 18 percent of firms cooperate with regional universities, and 12 percent with universities outside the region.

Figure 1: Percentage share of firms which have cooperated with partner type



The next question is what difference this makes for firms' ability to innovate. Even if there does not seem to be a systematic pattern of DUI-mode collaboration taking place within clusters or city-regions and STI-mode collaboration in global networks to coincide with the theoretical expectations, it could still be the case that regional DUI-mode networks are more effective than non-regional ones in producing innovation, whereas the opposite is true for collaboration with STI-mode partners. We group the different types of partners into the three categories which we have been using in the paper: STI-mode (cooperation with universities, research institutes, and consultancies), DUI-mode within the supply-chain (cooperation with suppliers and customers), and DUI-mode outside the supply-chain (collaboration with competitors). Within each of these categories, we make a distinction between collaboration with partners located inside and outside the region, respectively. Table 6 shows, for each category, the share of firms that have collaborated with at least one partner in the category, by the partner's location.

Table 6: Share of firms collaborating with partners within and outside the region

Partner type	Regional	Non-regional
DUI non-supply-chain	28.4	19.0
	(1.1)	(1.0)
DUI supply-chain	67.0	61.5
	(1.2)	(1.2)
STI	48.0	29.1
	(1.2)	(1.1)
N	1604	1604

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

In order to analyse whether these patterns of collaboration affect a firm's ability to deliver innovation, we estimate, once again, logistic regression models for each of the four measures of innovation (total and radical, product and process innovation). The regression model takes on exactly the same form as model (1) above, but partners are now operationalised differently: Instead of referring to individual partner types, it now refers to the three broad categories of partners and includes separate variables for partners located inside and outside the region, respectively.

Table 7 shows the results of the regression analysis. The models have been subjected to the same diagnostics tests as outlined for Table 4, with no significant problems detected.

Table 7: Logit regression estimation of the empirical model. Cooperation by proximity

	Product innovation	**Radical product innovation**	**Process innovation**	**Radical process innovation**
Partner types				
DUI non-supply-chain, regional	-0.20 (0.13)	-0.51*** (0.15)	-0.13 (0.13)	-0.08 (0.17)
DUI non-supply-chain, non-regional	-0.30* (0.15)	-0.13 (0.16)	-0.07 (0.15)	-0.01 (0.18)
DUI supply-chain, regional	0.12 (0.12)	0.17 (0.13)	0.13 (0.12)	-0.03 (0.15)
DUI supply-chain, non-regional	0.73*** (0.12)	0.72*** (0.14)	0.50*** (0.12)	0.42** (0.16)
STI, regional	0.23* (0.12)	0.40** (0.13)	0.20 (0.12)	0.14 (0.15)
STI, non-regional	0.37** (0.14)	0.33* (0.14)	0.33* (0.13)	0.35* (0.16)
Control variables				
Manager's education level	-0.01 (0.02)	0.01 (0.03)	-0.00 (0.02)	0.04 (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. company dir.ships	0.21** (0.08)	0.13 (0.08)	0.07 (0.08)	0.07 (0.09)
Log no. of employees	0.20*** (0.06)	0.13* (0.06)	0.24*** (0.06)	0.19** (0.07)
Share held by foreign owners	0.59** (0.20)	0.60*** (0.18)	0.28 (0.19)	0.19 (0.21)
Industry	Controlled***	Controlled***	Controlled***	Controlled***
Region	Controlled	Controlled	Controlled	Controlled
Constant	-0.29 (0.45)	-1.89*** (0.49)	-0.82 (0.44)	-2.83*** (0.57)
N	1602	1602	1602	1602
Pseudo R^2	0.11	0.11	0.08	0.08

Note: * = P < 0.05 ** = P < 0.01 *** = P < 0.001
The top number in each cell denotes the coefficient, with the standard error listed below in parentheses

Reproducing the results of the sources of innovation analysis in the previous section, the results in Table 7 show that DUI collaboration outside the supply-chain tends to reduce the likelihood of innovation. This could be taken as an indication that local tacit knowledge is not conducive to firm innovation in Norway, at least not through the interaction between competing firms. The relationship is statistically significant for product innovation only. Collaboration with competitors outside the region reduces the likelihood of total product innovation by exp(-0.30) = 26 percent, while collaboration with competitors within the region reduces the likelihood of radical product innovation by exp(-0.51) = 40 percent. However, the coefficients for collaboration with competitors, both within and outside the region, are consistently negative for all four innovation outcomes.

In contrast, DUI collaboration within the supply-chain is positively related to innovation, but there is a great difference between collaborating with regional and non-regional partners. This relationship, however, does not go in the direction predicted by the literature. Rather than being more effective in regional networks, interaction with local suppliers and customers does not significantly affect the likelihood of innovation at all. Instead, collaboration with non-regional suppliers and customers has a strong and significant effect on all innovation outcomes (Table 7). Extra-regional collaboration increases the likelihood of product innovation by exp(0.73) = 108 percent and of radical product innovation by exp(0.72) = 106 percent, i.e. more than doubling the likelihood of innovation. For process innovation, the likelihood rises by exp(0.50) = 65 percent for total innovation and by exp(0.42) = 53 percent for radical innovation only.

STI collaboration with non-regional partners also has, as predicted, significant positive implications for the likelihood of innovation. Its effect is somewhat weaker than non-regional DUI collaboration within the supply-chain, even for the more radical forms of innovation. Collaboration with non-regional STI partners increases the likelihood of innovation by between exp(0.33) = 39 and exp(0.37) = 45 percent for the four types of innovation. Furthermore, STI collaboration with regional partners also has a significant positive effect on overall and, particularly, on radical product innovation (where the likelihood increases by exp(0.40) = 50 percent, an effect that is even stronger than collaboration with non-regional STI partners). For process innovation, regional STI partners do not significantly increase the likelihood of innovation, but the effects are consistently positive and larger than for any form of regional industrial collaboration (and, for total process innovation, statistically significant at the 90%-level). One potential explanation of this phenomenon is that collaboration between firms and scientific institutions within the region involves a reasonable amount of cognitive distance between both partners, whereas the cognitive distance between regional DUI-mode partners is likely to remain small and not conducive to the generation and circulation of new knowledge.

Table 8 shows the fitted probabilities of innovation for firms collaborating with different types of partners compared with no cooperation at all. Two key features can be extracted from this analysis. First that, all other things being equal, partnerships with agents outside the region tend to be more conducive to innovation than local partnerships. This applies to both STI and DUI relationships, implying that establishment of purpose-built, often formal, relationships or pipelines with the outside world is much more conducive to innovation in Norwegian firms than spillovers of tacit knowledge linked to local interaction. The second key result is that the biggest increases in the probability of a firm innovating are related to the establishment of STI types of partnerships, both at the regional and the non-regional level, and, especially, with DUI-mode collaboration with suppliers and customers outside the immediate geographical vicinity. Interactions with local suppliers and customers have only a marginal and not statistically significant positive effect on the probability of a firm innovating (and no effect at all in the case of radical process innovation) (Table 7), while co-operating with DUI partners outside the supply-chain, both at the regional and non-regional level, tends to be more often than not detrimental for the probabilities of conducting innovation.

Table 8: Fitted probabilities of innovation

	Product innovation	Radical product innovation	Process innovation	Radical process innovation
No partners	0.40	0.15	0.34	0.09
DUI non-supply-chain, regional	0.33	0.09	0.30	0.09
DUI non-supply-chain, non-regional	0.30	0.13	0.32	0.09
DUI supply-chain, regional	0.45	0.18	0.39	0.09
DUI supply-chain, non-regional	0.83	0.32	0.57	0.14
STI, regional	0.51	0.23	0.42	0.11
STI, non-regional	0.58	0.21	0.48	0.13

Note: Predicted probability of innovation for a firm with average values on all control variables that cooperates only with the partner type listed in the first column.

6. Conclusion

In this paper we have put Jensen et al.'s (2007) idea that both DUI industrial type and STI scientific type relationships are basic sources for the innovative capacity of firms to the test. We have examined this theory using a sample of 1604 Norwegian firms with more than 10 employees. We consider four different categories of innovation and distinguish between DUI generally formal types of interaction within the supply-chain and those outside the supply-chain, usually of a more informal nature. We have also paid special attention to the geographical dimension of the interactions, differentiating between interactions conducted locally and those at a distance.

The results of the analysis confirm that, in the case of Norway, engagement with external agents is an important source of firm innovation. Firms which engage in collaboration with external agents tend to be more innovative than firms that rely on their own resources for innovation. The analysis also validates the hypothesis that both STI and DUI-modes of interaction matter for innovation. However, not all DUI-modes of interaction matter in the same way. Whereas interaction with suppliers tends to promote greater levels of product and process innovation, both of the incremental and radical type, and interaction with customers is particularly beneficial for product innovation, collaboration with competitors has a detrimental effect on the propensity of firms to innovate and partnerships within the same conglomerate only matter for incremental product innovation.

The introduction of the geographical component also yields interesting results. Interaction with local agents, by and large, tends to have very little impact on raising a firm's innovation potential. The main exception is STI-type interaction with local universities. Interacting at a distance, however, makes a significant difference for the innovation potential of Norwegian firms. Firms which have established links with extra-regional universities, research centres and consultancies and, in particular, with suppliers and customers outside the region have seen their innovation potential increase radically in virtually all types of innovation.

The results for Norwegian firms challenge some long held beliefs about where firms get their innovative capacity. Although it is true that both STI and DUI-modes of interaction matter, it seems that it is the collaboration of a more formal type that makes all the difference. In our survey we have found significant evidence of interaction of the informal type, such as interaction with competitors and with customers within the region. Interaction which, according to the literature, simply happens because 'something is in the air' (Marshall, 1911) or as a result of 'being there', of sharing the same geographical location (Gertler, 1995). However, there is little indication in the results that this form of interaction and the tacit knowledge it generates leads to substantially higher innovation by Norwegian firms. Excessive cognitive or organised proximity among Norwegian agents in what are relatively small and self-contained city-regions may be detrimental to innovation, with repeated exchanges not leading to the generation of knowledge which can be used and transformed into innovation by local firms. Too much interaction with local competitors may even be detrimental for innovation, in clear contrast with one of the key ideas on which the literature on industrial districts was based. The heterogeneity among agents is what matters for innovation and such heterogeneity is more common at a distance than in close geographical proximity (Srholec and Verspagen, 2008).

More formal, purpose-built, pipeline-type interactions (Bathelt et al., 2004) are, according to our results, the key source of innovation in Norwegian firms. Firms are more likely to innovate when they purposely look for partners which may provide knowledge that can then be easily transformed into new ideas. And this is regardless of whether the partners are STI-type partners (mainly universities) or DUI partners within the supply-chain. The most important factor is that these partners have to be able to offer the new knowledge that the firms need and this is achieved, in opposition with the theories of agglomeration, regional innovation systems, and local buzz, by searching for specific partners which may not only be at a considerable cognitive distance from the firms involved, but at a considerable geographical distance, as well.

Overall, this research provides a few answers but raises a whole raft of new questions regarding the role of clusters, tacit knowledge and policy in Norway. It also calls for more in-depth analyses of how collaborations by what are generally relatively small firms emerge with distant partners. Looking into these questions will give us a clearer understanding of what seems a more complex panorama about the sources of firm innovation in Norway than the existing literature would have led us to believe.

References

Asheim, B., Gertler, M.S., 2005. The geography of innovation: Regional innovation systems, in: Fagerberg, J., Mowery, D., Nelson, R.R. (Eds), *Oxford Handbook of Innovation*. Oxford University Press, Oxford.

Asheim, B.T., Coenen, L., Vang, J., 2007. Face-to-face, buzz, and knowledge bases: Sociospatial implications for learning, innovation, and innovation policy. *Environment and Planning C: Government and Policy* 250, 655–70.

Audretsch, D.B., Feldman M.P., 1996. R&D spillovers and the geography of innovation and production. *American Economic Review* 86, 630–40.

Aydalot, P., 1986. *Milieux innovateurs en Europe*. GREMI, Paris.

Barge-Gil, A., Jesús Nieto, M., Santamaría, L., 2011. Hidden innovators: The role of non-R&D activities. *Technology Analysis & Strategic Management* 23, 415-32.

Becattini, G., 1987. *Mercato e forze locali. Il distretto industriale*. Il Mulino, Bologna.

Boschma, R., 2005. Proximity and innovation: A critical assessment. *Regional Studies* 39, 61-74.

Boschma, R., Iammarino, S., 2009. Related variety, trade linkages, and regional growth in Italy. *Economic Geography* 85, 289-311.

Bush V., 1945. *Science: The Endless Frontier*. Ayer, North Stanford.

Cantwell, J., Iammarino, S., 1998. MNCs, technological innovation and regional systems in the EU: Some evidence in the Italian case. *International Journal of the Economics of Business* 5, 383–408.

Caraça, J., Lundvall, B.-Å., Mendonça, S., 2009. The changing role of science in the innovation process: From Queen to Cinderella? *Technological Forecasting and Social Change* 76, 861-67.

Crescenzi, R., Rodríguez-Pose, A., Storper, M., 2007. The territorial dynamics of innovation: A Europe-United States comparative analysis. *Journal of Economic Geography* 7:673-709.

Cooke, P., 1998. Introduction: origins of the concept, in: Braczyk, H.-J., Cooke, P. and Heidenreich, M. (Eds), *Regional Innovation Systems: The Role of Governance in a Globalised World*. UCL Press, London, pp. 2-27.

Cooke, P., 2001. Regional innovation systems, clusters, and the knowledge economy. *Industrial and Corporate Change* 10, 945-74.

Cooke, P., 2002. *Knowledge Economies: Clusters, learning and cooperative advantage*. Routledge, London.

Cooke, P., Gómez Uranga, M., Etxeberria, G., 1997. Regional innovation systems: Institutional and organizational dimensions. *Research Policy* 26, 475-91.

Cooke, P., Morgan, K., 1998. *The Associational Economy: Firms, Regions, and Innovation*. Oxford University Press, Oxford.

Feldman, M.P., 1999. The new economics of innovation spillovers and agglomeration: A review of empirical studies, *Economics of Innovation and New Technology* 8, 5–26.

Fitjar, R.D., Rodríguez-Pose, A., 2011. When local interaction does not suffice: Sources of firm innovation in Norway. *Environment and Planning A*, forthcoming.

Frenken, K., van Oort, F., Verburg T., 2007. Related variety, unrelated variety and regional economic growth. *Regional Studies* 41, 685-97.

Gertler M.S., 1995. 'Being there': Proximity, organization, and culture in the development and adoption of advanced manufacturing technologies. *Economic Geography* 71, 1-26.

Gertler M.S., 2003. Tacit knowledge and the economic geography of context, or, the undefinable tacitness of being (there). *Journal of Economic Geography* 3, 75–99.

Glaeser, E.L., Gottlieb, J.D., 2009. The wealth of cities: Agglomeration economies and spatial equilibrium in the United States. *Journal of Economic Literature* 47: 983–1028.

Hall, P.A., Soskice, D., 2001. An introduction to varieties of capitalism, in: Hall P.A., Soskice, D. (Eds), *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*. Oxford University Press, Oxford, pp. 1-70.

Hansen, T., Winther, L., 2011. Innovation, regional development and relations between high- and low-tech industries. *European Urban and Regional Studies*, forthcoming, doi:10.1177/0969776411403990

Iammarino, S., 2005. An evolutionary integrated view of regional systems of innovation: Concepts, measures and historical perspectives. *European Planning Studies* 13, 497-519.

Jacobs, J., 1969. *The Economy of Cities*. Vintage, New York.

Jensen, M.B., Johnson, B., Lorenz, E., Lundvall, B.-Å., 2007. Forms of knowledge and modes of innovation. *Research Policy* 36, 680–93.

Kirner, E., Kinkel, S., Jaeger, A., 2009. Innovation paths and the innovation performance of low-technology firms--An empirical analysis of German industry. *Research Policy* 38, 447-58.

Lawton Smith, H., 1998. Barriers to technology transfer: Local impediments in Oxfordshire. *Environment and Planning C: Government and Policy* 16, 433–48.

Lawton Smith, H., 2007. Universities, innovation, and territorial development: A review of the evidence. *Environment and Planning C: Government and Policy* 25, 98 – 114.

Leknes E., 2010. Fremveksten av byregioner i Norge, in: Farsund, A.A., Leknes, E. (Eds), *Norske byregioner: Utviklingstrekk og styringsutfordringer*. Høyskoleforlaget, Kristiansand.

Lundvall, B.-Å. (Ed.), 1992. *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. Pinter Publishers, London.

Lundvall, B.-Å., Johnson, B., 1994. The learning economy. *Journal of Industry Studies* 1, 23-42.

Maclaurin, W.R., 1953. The sequence from invention to innovation and its relation to economic growth. *Quarterly Journal of Economics* 67, 97–111.

Marshall, A., 1890. *Principles of Economics*. Macmillan and Co, London.

Maskell P., Bathelt H., Malmberg A., 2006. Building global knowledge pipelines: The role of temporary clusters. *European Planning Studies* 14, 997-1013.

Moodysson, J., Coenen, L., Asheim, B.T., 2008. Explaining spatial patterns of innovation: Analytical and synthetic modes of knowledge creation in the Medicon Valley life-science cluster. *Environment and Planning A* 40, 1040-56.

Morgan, K., 1997. The learning region: Institutions, innovation and regional renewal. *Regional Studies* 31, 491-503.

Ministry of Local Government and Regional Development, 2003. Greater cities report: On the development of greater city policies. Norwegian Government White Paper no. 31, 2002-2003.

Newlands, D., 2003. Competition and co-operation in industrial clusters: The implications for public policy. European Planning Studies 11, 521-32.

Ottati, G. dei, 1994. Cooperation and competition in the industrial district as an organisation model. *European Planning Studies* 2, 463-83.

Rodríguez-Pose, A., Crescenzi, R., 2008. R&D, spillovers, innovation systems and the genesis of regional growth in Europe. *Regional Studies* 41, 51-67.

Saxenian, A.L., 1996. *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Harvard University Press, Cambridge, MA.

Sonn, J.W., Storper M., 2008. The increasing importance of geographical proximity in technological innovation: An analysis of U.S. patent citations, 1975-1997. *Environment and Planning A* 40, 1020-39.

Srholec, M., Verspagen, B., 2008. The voyage of the beagle in innovation systems land: Explorations on sectors, innovation, heterogeneity and selection. UNU-MERIT Working Paper No. 8/2008.

Storper M., Venables A.J., 2004. Buzz: Face-to-face contact and the urban economy. *Journal of Economic Geography* 4, 351-70.

Torre, A., Rallet, A., 2005. Proximity and localization. *Regional Studies* 39, 47-59.

van der Panne, G., 2004. Agglomeration externalities: Marshall versus Jacobs. *Journal of Evolutionary Economics* 14, 593-604.