THE SPATIAL INDUSTRIAL ORGANISATION OF INNOVATION

TOWARDS A MICRO-LEVEL UNDERSTANDING OF COLLECTIVE LEARNING WITHIN AND ACROSS REGIONAL INNOVATION SYSTEMS

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Introduction

1. Regional innovation systems are at the heart of the debate of both regional economic development and science and technology policies (De Bruijn and Lagendijk, 2005). At the supra-national level, both the European Commission (2001; 2007) and the OECD (2007; 2009) put high emphasis on regional dimensions of innovation as key factor in the generation of sustained competitive strength. According to the European Commission, geographical proximity is an important factor in innovation processes, through the development of research infrastructure such as science and technology parks and specialised equipment and facilities, regional networks of small and medium sized companies, clustered around universities and corporate R&D centres of (multinational) companies (European Commission, 2001). In a similar vein, according to the OECD, localised knowledge spillovers due to inter-firm linkages, a versatile labour pool and strong innovation-related infrastructures can be a tangible source of productivity gain for firms and can constitute a pervasive argument against relocation or in favour of investment (OECD, 2007). Moreover, the current economic recession has amplified the importance of innovation, and more specifically its regional dimension, in economic growth (OECD, 2009). Policy responses in industrialised economies seek to achieve a so-called double dividend by both restoring short-term growth prospects and more structural reforms in the regional business climate. At the national level, Bachtler and Yuill (2007) observe a shift from policies aimed at redistribution, often targeted at specific less-favoured regions and on conventional interpretations of investment-driven growth, to nationwide regional economic policies aimed at the structural drivers of growth in terms of regional innovation

capacities. At regional and local levels, the list of valleys, corridors and highways, all wanting to become the next top innovation hot spot, is practically infinite (Castells and Hall, 1994). Drawing on typical regional growth wonders, like Silicon Valley (Saxenian, 1994), Emilia-Romagna (Brusco, 1982) and Toyota City (Fuyita and Hill, 1993), policy officials aim at the public conditions suitable for innovative business development (Cooke, 2002). To support regional economic policy initiatives, since the 1990s, much effort has been geared towards interregional and transnational policy learning initiatives, often with a strong focus on best practices of successful high-growth innovation poles (Lagendijk and Rutten, 2003; Hospers, 2005). Learning initiatives concern experimental programmes such as regional innovation strategies (RIS) and regional innovation and technology transfer strategies (RITTS), and the establishment of communities of practice, such as the network of innovating regions in Europe (IRE) and the recently in 2009 established European Cluster Policy Group.

2. Regional innovation systems can be conceived as a branch in the so-called territorial innovation models family tree of regional economic development models which explain regional competitive advantage through collective learning processes among regionally embedded organisations (Moulaert and Sekia, 2003). Although different branches in the territorial innovation family tree place different emphases on different determinants of regional innovative strength, similarities are striking (Oinas, 1999). In all models, under conditions of intensified competition pressure and shortening product life cycles in a globalising knowledge economy, firms increasingly focus on the core business of the company and adapt to strategies of open innovation to achieve sustained competitive strength (Chesbrough, 2003). Economic interaction occurs through conventions in organised markets, embedded in social, institutional and cultural contexts (Lundvall, 1988). Due to its tacit nature, knowledge is sticky in space and enables the creation of unique collective assets for competitiveness of both firms and the regional environment in which these firms are situated (Maskell and Malmberg, 1999). Proximity serves as a catalysing factor in collective learning processes through external economies of scale and scope, institutional support to inter-firm cooperation and trust building and cultural correspondence between the actors involved.

3. In the past decennia, territorial innovation models received enormous attention both as endogenous growth models for regional development and as practical guidelines for policy intervention. Territorial innovation models provide an appealing theoretical basis for regional economic policies. Firstly, because territorial innovation models fit in well with the current preoccupation with micro-economic supply-side intervention aimed at regional competitiveness in a global economy, and especially with the policy imperatives of raising productivity and innovation (Martin and Sunley, 2003, pp. 8-9). Secondly, through concepts such as multi-level governance (Kaiser and Prange, 2004), territorial innovation models adhere strongly to modern network approaches to government interventions. Public responsibilities for regional development do not rest solely on the shoulders of governments, but is taken up jointly by governments, businesses and knowledge institutions (Etzkowitz and Leydesdorff, 2000). Thirdly, because the main guidelines for policy interventions focus on the region's soft infrastructure in terms of institutional capacity, it is possible for governments to set up cluster policies with limited financial consequences in comparison with investments in 'hard' infrastructural assets. Fourthly, localised knowledge spillovers due to inter-firm linkages, a versatile labour pool and strong innovation-related infrastructures can constitute a pervasive argument against firm relocation (Knoben and Oerlemans, 2008).

4. As territorial innovation models are at the heart of the debate on regional development and innovation studies, it is not surprising they are subject to criticism as well. Summarising the critical statements given in the literature (*e.g.* MacKinnon *et al.*, 2002; Simmie, 2005), a number of critical evaluative remarks stand out. A first observation focuses on the generalisation of observations drawn mainly from case study material. Originally, territorial innovation models predominantly adhere to economically successful regions, thereby restricting the population of regions 'to the dependent variable' (Staber, 1996). Theory needs a broader perspective, since economic success cannot be explained solely on the basis of successful regions. Although the territorial innovation model framework has been extensively

applied not only on successful cases, but also, and recently perhaps predominantly, on less-favoured regions and catch-up areas (*e.g.* Morgan and Nauwelaers, 2003; Tsipouri, 2005), models place development in unique historical cultural and institutional contexts. This research tradition, classified by Crevoisier (1999) as the particularising approach in economic geography, imposes severe limits to generalisation. The theoretical risk is that explanations are based on tautological reasoning that the environment assists innovative firms while at the same time the presence of innovative firms constitutes the environment itself (Simmie, 2005). As McCann (2007) argues, this disadvantage especially weighs heavily in the contemporary policy context in industrialised countries, where evidence-based *ex ante* policy design and *ex post* policy evaluation have increasingly become the norm. The strongly empirically oriented geography of innovation (Feldman, 1994; 1999) strand within economic geography is promising in this respect. Theoretically, it is embedded in endogenous growth models, specifically its spatial interpretations in terms of the spatial diffusion of knowledge. Studies are built on broad populations based on which, with a top-down approach, the existence of regional knowledge spillovers is tested. The central hypothesis concerns the role of distance in knowledge diffusion. Whether on the basis of micro-level citation studies (*e.g.* Jaffe *et al.*, 1993) or aggregated analyses within the knowledge production function framework at regional level (*e.g.* Anselin *et al.*, 1997), in the geography of innovation literature the actual process of interaction remains untouched, an issue that is of central importance to the second point of evaluation.

5. The second point of evaluation concerns the focus on regional dimensions of innovation at the neglect of determinants at the level of the individual innovating firm. There is a need to 'open the black box' of the innovation process by improving insight in the underlying processes of innovation at the level of individual and corporate agents and their interactions that supposedly promote and sustain regional development (Howells, 2002; Lundvall and Borras, 2005). The relevance of this claim is accentuated by the outcomes of the limited number of empirical studies that integrate both regional and firm-level determinants of innovation in the analyses. Sternberg and Arndt (2001), Beugelsdijk (2007) and Raspe (2010) all point to the importance of firm-level determinants of innovation, thereby putting the relevance of the regional environment into perspective. In contrast, in the majority of contributions within economic geography, the firm remains a somewhat vague entity without a clearly defined form or function (Maskell, 2001). Especially contributions which emphasise the social dimensions in territorial innovation models (Asheim, 2000; Moulaert and Nussbaumer, 2005) show a tendency to ignore the firm as loci of capitalist wealth accumulation and repositories of power (Hudson, 1999; Taylor, 2005). Although theoretical arguments at the level of the individual innovating firm are not totally absent in the literature, critical comments stem from a growing dissatisfaction with the starting point of the framework. Although firm-level arguments increasingly are taken up in regional economic development models, a micro-level based theory of spatial interaction through innovative firms is as yet far from established. To explain regional economic development, territorial innovation models traditionally start from a frame of mind that is, to a great extent, regionally confined by the concept of embeddedness. Firm level arguments are linked to the notion of embeddedness, through a variety of arguments based on interaction catalysts at the level of the region. Examples include transaction costs economics (Scott and Storper, 1987), trust and other social interaction catalysts like social capital (Putnam, 1993), tolerance (Florida, 2002), institutional thickness (Amin and Thrift, 1995) conventions (Storper and Salais, 1997) and cognitive focal points in learning processes (Lorenzen and Foss, 2003).

6. The third evaluative point concerns the notion of spatial proximity. In territorial innovation models proximity is generally put on a par with spatial proximity. Torre and Rallet (2005) bring the complexity of spatial proximity back to its essence by stating that neighbours might ignore or even hate one another and that, in a similar vein, local firms can be rivals and refuse any cooperation. Alternative conceptions of space range from economic space (Perroux, 1950), institutional space (North, 1990), cognitive space (Nooteboom, 2000), technological space (Carlsson, 1997) and social space (Granovetter, 1973) to organisational space (Hudson, 1999) and emotional space (Taylor, 2005). Geometrical distance as such is not to be seen as a necessary, nor as a sufficient condition for innovation (Boschma, 2005).

Organisational, social, institutional and geographical proximity can, most likely in combination with each other, provide effective mechanisms to coordinate complementary knowledge assets in collaborative innovation processes. Geographical forms of proximity, combined with some level of cognitive proximity, is sufficient for interactive learning to take place. However, other forms of proximity can act as a substitute for geographical proximity. Hence, regional embeddedness cannot be presupposed beforehand. These insights contrast with the traditional conception of space as employed in territorial innovation models. Territorial innovation models claim a geographical distinction in types of interaction (Lagendijk, 2002). Within the region there are processes of collective learning and the growth of associational structures on the basis of untraded interdependencies. Coordination occurs through trust, reciprocity and long-term strategic agreements, uphold by regionally embedded structures. Outside the region is the global marketplace, driven by shortening product life cycles to which regional clusters have to respond. Here, coordination is based on traditional market institutions and interaction is largely based on classical arm's length coordination. In a vast majority of accounts a particular (local, regional) or a bifurcated (global-local) geographical scale of analysis is used in ways that, in effect, preclude alternatives and that obscure the subtle variations within, and interconnections between, different scales (Dicken *et al.*, 2001).

7. This contribution focuses on an empirical assessment of spatial dimensions of innovation that aims to meet the above stated evaluative points in relation to the territorial innovation models literature. The contribution aims to assess spatial dimensions of innovation based on a broad population of individual innovating firms in a theoretical context that goes beyond the classical bifurcation of territorial space. In Section 2, a short theoretical outline is given of the theoretical framework upon which the analyses are based. Here, hypotheses are formulated to serve as guideline for the empirical analyses presented in Section 3. In Section 4, conclusions and policy implications are given.

Spatial organisation of collaborative innovation processes

8. To gain better insight in the spatial dimensions of innovation at the individual firm level, the theoretical framework of territorial innovation models needs to be matched by complementary theoretical perspectives. A potential combination concerns the theoretical framework of the spatial industrial organisation of innovation. This hybrid framework seeks to combine elements from economic geography, industrial organisation and strategic management. The framework of spatial industrial organisation is based on a spatial interpretation of both transaction cost theory and the capabilities-or competence-based approach. It distinguishes transaction cost theory considerations from competence based arguments and draws from integrative approaches in industrial organisation, notably Powell's (1990) concept of network coordination, Langlois and Robertson's (1995) dynamic theory of business institutions and Nooteboom's (2000) cycle of learning. For an extensive account on the theoretical framework and its building blocks, see De Bruijn (2010, pp. 47-80). Here, a short outline is given of the main arguments, which form the basis of the hypotheses, which are empirically assessed in Section 3.

9. The framework of spatial industrial organisation starts, firstly, from a positive relation between distance and transaction costs. Transaction costs, in this light, comprise spatial interpretations on both traditional exchange aspects (Scott and Storper, 1987) and modern interpretations focused on the costs to bridge cognitive distance in interactive learning processes (Nooteboom, 2000). The positive relation between distance and transaction costs is seen as a general feature in interactive learning processes.

10. Hypothesis 1: Transaction costs in innovative network linkages are positively connected to the distance between the partners involved.

11. However, in environments characterised by high levels of uncertainty – high-technology industries, radical forms of innovation, early phases in the product life cycle, explorative learning phases in the cycle of discovery – transaction costs weigh relatively heavily on operational management. Especially

in these contexts, from a transaction costs point of view, concentration of innovative activities and regionally embedded collective learning processes are to be expected.

12. Hypothesis 2: Compared to more stable environments, transaction costs in innovative network linkages are relatively high in environments characterised by high levels of uncertainty.

13. The positive connection between distance and transaction costs applies to different conceptions of space (geographical, cognitive, organisational, institutional and cultural forms of space). Different forms of space can act as communicating vessels in the sense that, for instance, distance in a geographical sense can be compensated by proximity in an organisational sense (Nooteboom, 2000)[1]. The connection between distance and transaction costs applies to the broad population of innovating firms. However, the impact is stronger for small and medium-sized firms than for large firms since small companies often lack resources to invest time and money in extraregional collaborations (Knight, 2001).

14. Hypothesis 3: In relation to partnership linkages in innovation trajectories, small- and medium-sized firms engage relatively often in partnerships at limited spatial distance, whereas large firms engage relatively often in partnerships at wider levels.

15. Therefore, it is not surprising that in the literature on industrial districts, small and medium-sized firms take a prominent position (*e.g.* Goodman *et al.*, 1989). Contributions emphasise external economies of scale and scope in combination with flexibility of small firms in learning processes, as opposed to risks of inertia in learning processes in large vertically integrated firms.

16. Secondly, the framework of spatial industrial organisation starts from a technologically differentiated concept of space. Due to local processes of imitation and selective adoption routines and competences between firms in a particular industry tend to converge within regions rather than between regions (Boschma, 2004). In explorative learning phases in which diversity plays an important role through differentiation and reciprocation as search strategies for new combinations, we are unlikely to find all potentially relevant divergent inputs within the boundaries of the regional environment. At the edge of the technological frontier, international (extraregional) linkages play a determining role in the competitive strength of innovating firms (Freeman and Soete, 1997). Here, explorative learning strategies distinguish themselves from more incremental forms of discovery focused on efficiency gains, refinement and implementation which often evolve in regional and national contexts.

17. Hypothesis 4: Innovative firms implementing explorative innovation strategies, collaborate at wider distance than firms engaged in exploitative innovation strategies.

18. The role of diversity of knowledge inputs in learning processes is also linked to radical innovation and the introductory and growth phases in the product life cycle (Langlois and Robertson, 1995). Because of high turnover in firms, the absence of a dominant design means that necessary information can come from many directions and, therefore, a low cost strategy that economises on information costs is not an option. A loosely, globally organised knowledge network is seen as the most appropriate coordination mode to take on learning challenges in these circumstances (Almeida, 1996).

19. It is important to remark that arguments derived from a transaction cost perspective and arguments derided from competence based consideration appear to be complete contradictions at first sight. In circumstances characterised by high uncertainty, the transaction cost perspective predicts spatial concentration, whereas in the same context, competence based approaches predict interactive learning

[1] This example can be related to the strong inward foreign direct investment in high-technology regions like Silicon Valley (Teece, 1992).

communities connecting differing competences at international scale. However, these spatial mechanisms do not necessarily contradict each other. According to Barkema *et al.* (1997), engagement in international R&D partnerships is characterised by both a high risk profile in the light of communication difficulties and a high value since generally collaborating firms scanning the globe have access to a divergent set of technologically advanced competences, whereas domestically constrained firms are only able to tap from the competences within the national system of innovation. For multinational enterprises, an international research presence can be consistent with the idea of local search (Ahuja and Katila, 2004). Another interpretation stems from Manshanden (1996) who presupposes a trade-off between transaction costs associated with local interaction and transaction costs associated with extraregional (international) interaction. In this view the region serves as coordination arena for project markets which require flexible relations in ways that partners can be found and dropped according to the current market situation (Maskell and Lorenzen, 2004). Transaction synergies induced by clustering provide advantages which can be invested to overcome transaction hurdles in international interaction to gain access to strategic components which often are not available in the regional environment.

20. It must be emphasised that these theoretical propositions are to be seen as a crude generalisation of the spatially structuring processes in innovative networks as they reveal themselves in everyday reality. Caution must be preserved in interpreting the notion of space. As mentioned earlier, the positive connection between distance and transaction costs applies to different conceptions of space which may act as communicating vessels in the sense that, for instance, distance in a geographical sense can be compensated by proximity in an organisational sense. Additionally, a wide array of contingencies might prove relevant in the organisation of innovative activity (Langlois and Robertson, 1995; Nooteboom, 2000). Important contingencies concern the character and scope of the innovation, the nature of technological development, appropriability regimes, stage in the product life cycle and cycle of discovery and characteristics of the institutional and regional environment. Whereas the latter is concerned, the framework of spatial industrial organisation presupposes a structuring role of the regional environment on the economic organisation of innovative activities. Regionally embedded institutional arrangements can help to overcome problems of insufficient economies of scale and scope within small and medium-sized firms. However, as Grabher (1993) convincingly demonstrates, the same arrangements that can act as a catalysing factor, can also hamper learning through lock-in. In general however, for innovative firms the chance of finding suitable complementary competences is higher in urban agglomerations than it is in peripheral settings because of external economies of scale. Moreover, urban agglomeration offer time proximity which is facilitated by geographic proximity to hub airports (Simmie, 2002). The concept of time proximity is built on the international exchange between innovative hot spots, which serve as knowledge hubs in international knowledge exchange. Apart from the institutional environment and agglomeration economies, the distance of state-of-the-art knowledge in the regional and national system of innovation to the technological frontier plays a contingent role (Brökel, 2008). Since evolutionary perspectives emphasise the stickiness of innovative capabilities, international cooperation can provide access to country-specific advantages. In this sense, international R&D collaboration can be seen as a vehicle for tapping into state-of-the-art competences (Miotti and Sachwald, 2003). Although, given these contingencies, the resulting spatial patterns of industrial organisation are hard to predict, the underlying spatially discriminating mechanisms outlined in this section are supposed to exert a generic impact.

21. In the light of the evaluative points given in the previous section, the framework of the spatial industrial organisation of innovation offers fruitful perspectives to overcome the problematic features outlined through the evaluative points discussed in Section 1. It addresses spatial dimensions of innovation at the level of individual firms engaging in collaborative networks, it combines both regional and extra-regional linkages as integral part of theoretical arguments and, although the framework acknowledges the role of structuring contingencies, it is based on a broad population of innovative firms considered through a homogenising lens. Before empirically assessing the hypotheses outlined above, in the next section the data source on which the analyses are based is shortly introduced.

Empirical findings

22. The Community Innovation Survey. In the endeavour to gain some empirical insight in the structuring elements of the spatial industrial organisation of innovation, we draw on the second Community Innovation Survey (CIS 2.5) held in the Netherlands. The survey relates to the period from 1996 to 1998. Use of the CIS has a number of advantages. Firstly, the CIS takes into account the interactive nature of the innovation process (Kline and Rosenberg, 1986). Innovation is not solely considered to be dependent on linear determinants of learning like expenditures on in-house research and development as input for innovation processes, but results of innovation are analyzed within a micro-level framework in which throughput factors like interaction between partners in innovation trajectories and knowledge diffusion play a fundamental role. Secondly, a strong point of the CIS is that the survey explicitly distinguishes between invention and the economically relevant concept of innovation, since companies are explicitly asked about the effect of innovation trajectories on their market position. Thirdly, the CIS contains information on the distance between collaborating partners. Although more recent questionnaires are available, use is made of the CIS 2.5 because it distinguishes partnership between distance classes based on geometrical distance between the partners involved and the distinction between national and cross-border partnerships. Fourthly, the survey contains three questions on difficulties in partnership strategies which are used to measure the concept of transaction costs. Finally, the response rate to the CIS 2.5 questionnaire amounts up to 69% (Statistics Netherlands, 2000), which is an good score compared to the response rate in other countries (Evangelista *et al.*, 2001).

23. There are also disadvantages associated with the use of the CIS. Inter-country comparisons are highly influenced by cultural differences in the interpretation of what can be considered to be 'new' (Kleinknecht *et al.*, 2002). International comparability is, in the analytical framework presented here, of interest in relation to the issue of external validity. Additional issues concern the measurement of competences, the fact that transaction costs are measured in relation to partnership in general and not in reference to specific partners and the time frame under consideration. As with all secondary data the variables and framing of the questions as available are given beforehand. The CIS for instance does not provide information on competences and transaction costs are measured through the answer to the question whether respondents have experienced difficulties in their partnership agreements. In the CIS, the question on difficulties in the management of partnerships is not framed in relation to specific partners or specific categories of partners but to partnership agreements in general. In the Netherlands version of the CIS, questions on the geometrical distance between partners have only been integrated in relatively old versions of the survey, the most recent connecting to the period from 1996 to 1998. Furthermore, the Community Innovation Survey reduces innovation to technological innovations (Djellal and Gallouj, 1999, Holbrook and Hughes, 2001). Non-technological renewal, although highly relevant for competitive strength, is not fully addressed in the version covering the period from 1996 to 1998.

24. Spatial patterns of partnership linkages. Innovating firms usually innovate in partnership with several partners. To relate the distance to (different kinds of) partners to attributes of the innovating company that innovates in partnership, a cluster analysis has been performed on the basis of the number of different kinds of partners located at a distance of less than 50 kilometres from the responding company innovating in partnership, the number of different kinds of domestic partners located at a distance of minimum 50 kilometres from the innovating company and the number of international partners at a distance of minimum 50 kilometres from the company. All these numbers relate to the number of partners as a fraction in the total number of different kinds of partners[2]. Through cluster analysis, based on an

[2] Ideally, the analysis should be based on the number of different partners, not on the number of different kinds of partners. Unfortunately, on the basis of the CIS 2.5 these numbers cannot be given. Following Kleinknecht and Reijnen (1992) this number serves as a proxy of the total number of partners with which innovating companies cooperate in their innovation trajectories. Following the classification of partners in CIS 2.5 in terms of eight different partners in the national and international environment at a distance of less than 10,

iterative partitioning method with three categories, companies are categorised by the scale of innovative networks in which they predominantly participate. The three type classification is chosen for reasons of interpretability and the size of subpopulations within each cluster. Unlike the results of a categorisation in four cluster types, the three type solution is characterised by a rising scale of distance through the cluster types in both institutional (domestic versus cross-border partnership) and geometrical terms. The results are summarised in Table 1.

Table 1. Cluster analysis on spatial scope of partnership, 1996 to 1998

	Cluster 1: Regional	Cluster 2: National	Cluster 3: International
National partnership			
within 50 kilometres	76.6	9.6	9.7
outside 50 kilometres	17.3	79.8	16.5
International partnership			
within 50 kilometres	4.1	7.0	19.9
outside 50 kilometres	2.0	3.6	53.9
N (n)	2123	1389	1241

Source: Ministry of Economic Affairs, on the basis of Statistics Netherlands, CIS 2.5

25. Over 2 100 companies in the first cluster innovate predominantly in partnership with domestic partners that are located within 50 kilometres from the company. The second cluster consists of companies which innovate predominantly with domestically based partners located at further distance from the responding innovating company. Nearly 1 400 companies are, based on the spatial scope of their network linkages in terms of partnership in innovation processes, primarily embedded in the national system of innovation in the Netherlands. Companies primarily embedded in international networks are classified in the third cluster. With a number of about 1 250 companies, companies which engage in international networks of innovation make up a quarter of all companies innovating in partnership.

26. Table 2 makes a distinction between industry, firm size and character of the innovation. According to the figures in Table 2, innovative networks of companies in high-technology sectors are highly international in their nature. Whereas for the total population of innovating firms engaging in partnership, just over a quarter innovates predominantly with international partners, for firms in high-technology sectors this figure amounts to 40%, a difference which is statistically significant at the 1% level. The relation between firm size and the spatial scope of innovative networking is striking. Small companies predominantly innovate with partners located in the regional production environment, whereas large companies innovate predominantly with partners outside the regional environment. Whereas for small companies innovating in partnership, one out of two firms engages in partnership predominantly with regionally based partners, medium- and large-sized companies are less confined to the regional environment. Concerning medium-sized firms, 33% of all firms innovating in partnership innovate predominantly with domestic partners located at a distance of more than 50 kilometres from the responding company, whereas 31% innovates predominantly with international partners. For large firms these figures amount to 37% and 34% respectively, whereas these figures for the total population of firms in the CIS 2.5 amounts to 29% and 26%. Collaborating firms producing innovations new to the market generally engage in wider spatial networks than firms producing incrementally new product innovations new to the firm. Whereas in the first category, the share of firms predominantly innovating in cross-border partnerships amounts to 38%, the same share for firms active in incremental innovation processes is significantly lower at 19%.

10 to 50 and more than fifty kilometres, the average company innovating in partnership cooperates with 3.7 different kinds of partners out of a maximum of 48 possible combinations.

Table 2. Spatial scope of partnership by sector, firm size and character of innovation, 1996 to 1998

	Regional	National	International
Total population	44.7 (2123)	29.2 (1389)	26.1 (1241)
High-technology activities			
High-technology sectors	31.7** (272)	28.9 (248)	39.5** (339)
Other	47.5** (1851)	29.3 (1141)	23.2** (902)
Firm size			
small	50.5** (1575)	26.6** (829)	22.9** (716)
medium	36.1** (384)	33.1** (352)	30.9** (329)
large	29.0** (165)	36.6** (208)	34.4** (196)
Character of innovation			
Product innovation new to the market	30.3** (273)	31.4 (283)	38.2** (344)
Product innovation new to the firm	50.6 (645)	30.5 (389)	18.8 (240)

Source: Ministry of Economic Affairs, on the basis of Statistics Netherlands, CIS 2.5

* indicates significance at the 5 percent level; ** at the 1 percent level (significance is based on the difference between the shares of companies innovating at a particular predominant scale in the various subpopulations compared to the same figure for the total population, which is assessed through binomial test procedures)

27. *Spatial industrial organisation of partnership linkages*. Table 3 places transaction costs into spatial perspective. Although transaction costs, in terms of the costs of contact, contract and control are not explicitly incorporated in the CIS 2.5, the respondents are asked to give an indication of difficulties with respect to the management of partnership in innovation trajectories. This aspect can be seen as the central element transaction costs play in territorial innovation models. In dynamic approaches which place elements of learning and technological development central in the analysis (Langlois, 1988; Nooteboom, 1992), transaction costs are defined differently. According to Langlois and Robertson (1995, p. 35) "dynamic transaction costs are the costs of persuading, negotiating, coordinating and teaching potential partners in innovation trajectories". Another way to look at these costs is the costs not having the right capabilities in-house or at the market when you need them. These costs are measured here by means of the answer to the question whether respondents experienced problems in the cooperation with partners in pending innovation processes. Although trouble-free partnerships are not freely available, the assumption that problems in the cooperation with partners stand in positive connection to dynamic transaction costs can be conceived realistic.

Table 3. Difficulties in partnerships by origin of partners and sector, firm size and character of innovation, 1996 to 1998

	Regional	National	International	Total
Total population	5.4** (115)	7.1 (99)	10.6** (132)	7.3 (346)
High-technology activities				
High-technology sectors	3.5** (9)	8.1 (20)	12.4** (42)	8.3 (72)
Other	5.7** (105)	6.9 (79)	10.0** (90)	7.0 (274)
Firm size				
small	4.6** (72)	5.0** (41)	12.0** (86)	6.4 (199)
medium	6.4 (24)	8.5 (30)	8.0 (26)	7.6 (81)
large	11.0 (18)	13.5 (28)	10.2 (20)	11.6 (66)
Character of innovation				
Products new to the market	7.4* (20)	9.2 (26)	13.8* (48)	10.4 (94)
Products new to the firm	7.2 (46)	7.0 (27)	12.2** (29)	8.1 (102)

Source: Ministry of Economic Affairs, on the basis of Statistics Netherlands, CIS 2.5

* indicates significance at the 5 percent level; ** at the 1 percent level

Significance is based on the difference between the shares of companies innovating at a particular predominant scale in the various subpopulations compared to the same figure for the total population, which is assessed through a binomial test procedure.

28. Almost 350 companies which innovate in partnership experience difficulties with partners during the innovation process. This means that over 7% of all companies innovating in partnership experiences difficulties in collaborative agreements. For companies innovating predominantly with partners in the regional environment, this share amounts to 5.4%, which is significantly lower than the share for all companies innovating in partnership. Similarly, the share of companies experiencing difficulties in partnership is significantly higher for companies innovating predominantly with international partners at more than 10%. These figures point to a positive relation between distance and transaction costs. Of all firms predominantly innovating in partnership with partners located abroad, quite a lot experience difficulties with network partners. Of all firms predominantly innovating in partnership with partners located within a circle of 50 kilometres, relatively few experience difficulties in their collaborative agreements. It is worth noting that, based on the figures in Table 3 on difficulties in partnership, distance is relevant both in terms of geometrical distance (partners located within and beyond a circle of 50 kilometres from the innovating company) and institutional distance (domestic partners versus partners located abroad). This pattern equally holds when different subcategories, based on firm size, sector and character of the innovation, are considered. Companies engaging in more radical forms of innovation experience more difficulties in partnership, than other firms innovating in partnership. The share of manufacturing firms developing innovations new to the market that experience partnership difficulties, which amounts 10.4%, is significantly higher than the same figure for manufacturing firms which develop incrementally new innovations new to the firm.

Table 4. R&D-companies by origin of partners and sector, firm size and region, 1996 to 1998

	Regional	National	International	Total
Total population	14.2** (302)	28.4** (394)	35.0** (435)	23.8 (1131)
High-technology activities				
High-technology sectors	50.0 (136)	51.7 (128)	60.7* (206)	54.7 (470)
Other	9.0** (166)	23.3** (266)	25.4** (229)	17.0 (661)
Firm size				
Small	8.8** (138)	14.9 (124)	24.5** (175)	14.0 (437)
Medium	24.4** (94)	42.6** (150)	38.4* (126)	34.7 (370)
Large	42.4** (70)	58.0 (120)	68.0** (133)	56.9 (324)
Character of innovation				
Products new to the market	65.2 (178)	73.6 (209)	71.0 (244)	70.1 (631)
Products new to the firm	2.7** (17)	12.4* (48)	20.2** (48)	9.0 (114)

Source: Ministry of Economic Affairs, on the basis of Statistics Netherlands, CIS 2.5

* indicates significance at the 5 percent level; ** at the 1 percent level

Significance is based on the difference between the shares of companies innovating at a particular predominant scale in the various subpopulations compared to the same figure for the total population, which is assessed through binomial test procedures.

29. Table 4 focuses on the share of R&D-companies in the total population of firms innovating in partnership. In comparison with other innovative companies, R&D companies explicitly focus on explorative search strategies as a core business of the firm, measured on the basis of R&D-employment (see Statistics Netherlands, 2000, pp. 263-265 for full details). Explorative search strategies demand a high diversity in knowledge inputs and, due to local processes of imitation and selective adoption, the global landscape of technological competences differentiates across space. Therefore, it is to be expected that R&D-companies distinguish themselves from other innovative firms through a relatively wide spatial scope of partnership agreements. Of all companies innovating with predominantly international partners, 35% can be designated as R&D-company. For companies predominantly innovating in partnership with domestic partners located outside the regional environment, this figure amounts to 28%. Both shares distinguish themselves statistically from the average share of R&D-companies in the total population of companies innovating in partnership. The same connection between the scope of partnership in innovation

trajectories and share of R&D-companies also holds for a specific subpopulation based on high-technology activities (although differences are not statistically significant at the 1% level due to limited size of the subpopulation), firm size and character of the innovation. Where the character of innovation is concerned, the differences in the share of R&D-companies across the categorisation based on the spatial scope of partnership for companies engaging in product innovation new to the market are not statistically significant. This is mainly due to the fact that the question whether innovating firms have developed product innovation new to the market during the period from 1996 to 1998 serves as an important criterion in the determination of the status of R&D-company.

30. *Synergies in partnership.* Issues of competitive strength are integrated in the CIS 2.5 through the question whether the respondents estimate the effect of technological innovations on market share as insignificant, significant or strong. Variables on competitive strength are therefore based on self-classification. Although in general more objective measures of competitive strength are to be preferred over self-classification, these measures suffer from the important disadvantage that on the basis of one stream of the CIS time frames between input, throughput and output cannot be taken in consideration. In general, it can take several years from initial investment to economic impact of the results of the innovation process (Ravenscraft and Scherer, 1982).

31. In Table 5 the results of a logistic regression with the impact of innovation on competitive position, as estimated by respondents to the CIS, is reported. In logistic regression the chance of an event occurring is being modelled against a set of explaining variables. Two models are reported, one that models the chance of the event that respondents estimate the impact of innovation on competitive position as significant, and one that models the chance of the event that respondents estimate the impact of innovation on competitive position as considerable. The following independents are taken up in the model (see Annex 1 for more detailed overview of the variables). Innovation expenditures (IE) are the (logarithmic transformation of the) total costs of innovation. Expenditures in R&D only comprise a part of total innovation expenditures. Government subsidies (GS) is a dummy variable indicating whether the innovating company benefited from government subsidies (at regional, national or European level) or not. Clearly, innovation is not a matter of financial inputs alone. Information sources (IS) is a variable that describes the importance that respondents attach to information sources in the innovation process, which can be interpreted as the inspiration needed to innovate. Information sources range from internal sources (in-house sources, new personnel and, if applicable, the mother company), network partners (customers, suppliers, competitors and public and private knowledge organisations) to codified and tacit sources such as patents, software, literature, trade fairs and conferences. Following the theoretical arguments earlier the dummy variables on the status of R&D-company and difficulties in partnership have been integrated in the model through interaction terms with the spatial scope of network embeddedness, the latter through dummy variables based on the cluster analysis reported in Table 1. The dummy variable of R&D-company (RDC) is integrated in the model through interaction variables with the scope of partnership (RNE/NNE/INE for regional, national and international embeddedness respectively) relating to hypotheses based on concepts of clustering and agglomeration. The interaction between the dummy variable difficulties in partnership (DP) and spatial scope of partnership reflects the hypothesis of transaction costs in territorial innovation models that, when difficulties between partners occur, they are easier to manage when companies are co-located or are part of the same cluster. The dummy variable other difficulties (DO) is expected to have a negative impact on competitive strength. Other difficulties comprise a range of difficulties from financial hurdles, through insufficient qualities of the organisation to market acceptation. Non-technological innovation (NTI) is represented by a dummy variable which indicates whether the technological innovation is coincided by non-technological innovation like improvements in strategy, operational management, design and marketing. Protection through licensing (PL) is a dummy variable indicating whether the responding company is active in licensing or not. Protection of intellectual property is considered to positively impact the effects of innovation on competitive strength. Finally, apart from a range of sector dummies based on the standard sector classification in the Knowledge and Economy

publication series by Statistics Netherlands (Statistics Netherlands, 2000) The sector dummies are included because of market conditions which strongly affect competitive dynamics in industries (Eisenhardt and Martin, 2000).

32. 33. The model fit of the model with significant impact as dependent variable is higher than the model fit of the model with considerable impact as dependent variable. Intuitively, it is easier to model significant performance than outstanding performance. Based on the value of log likelihood and on Nagelkerke's pseudo R-squared the model with significant impact fits better on the data. However, both models perform significantly better than the base model with only the constant as independent[3].

Table 5 Logistic regression with the impact of innovation on competitive position as dependent, 1996 to 1998, summary of results[i]

Independents[ii]	Significant impact	Considerable impact
Constant	0.10 (30.8)**	0.31 (8.1)**
IE1	4.47 (88.8)**	1.70 (9.1)**
IE2	1.34 (8.1)**	1.90 (46.2)**
GS	1.69 (20.7)**	1.39 (9.8)**
IS	1.60 (15.9)**	1.34 (7.3)**
LIC	0.98 (0.1)	0.87 (2.3)
DP*RNE	0.18 (33.3)**	0.23 (14.4)**
DP*NNE	0.30 (18.2)**	0.18 (16.4)**
DP*INE	0.86 (0.3)	0.75 (1.2)
DO	0.82 (0.5)	0.93 (0.6)
RDC*RNE	1.45 (3.4)	2.25 (24.1)**
RDC*NNE	1.25 (1.8)	0.77 (2.7)
RDC*INE	0.91 (0.3)	1.47 (5.8)*
NTI	1.78 (21.6)**	1.08 (0.4)
N	3252	3252
-2LL	3334	3744
R^2_N	26.1	18.0
H-L	77.5**	17.0*
Percentage correct	75.2 (69.5)	68.4 (65.3)

Source: Ministry of Economic Affairs, on the basis of Statistics Netherlands, CIS 2.5

* indicates significance at the 5 percent level; ** at the 1 percent level

[i] Figures relate to the log odds ratio associated with a one-unit change in the independent variable in terms of the dependent variable (the chance of a significant, respectively considerable impact of innovation on competitive position), a value higher than 1 indicates the odds will increase, whereas a value lower than one indicates decreasing odds. The Wald coefficient, reported between brackets, equals the coefficient divided by its standard error, is an indication of the strength of the association and follows a Chi-square distribution.

[ii] Sector dummies are not reported.

34. Considering the impact of individual independents, the similarities between both models, with dependent significant respectively considerable effects of innovation on competitive position, as estimated by managers of responding firms, are striking. Only the impact of non-technological innovation (NTI) varies considerable between both models. It is highly significant for the output of innovation in terms of the effect of innovation on competitive position estimated by managers as significant, whereas the coefficient is not statistically significant for innovation output in terms of the effect of innovation on competitive position estimated by managers as considerable. In the remainder of this section the dependents of both models are simply referred to as innovation output. Innovation expenditures (IE) have a large positive impact on innovation output. Similarly, additional government subsidies (GS) impact

[3] For an extensive elaboration of model specifications, see De Bruijn (2010, pp. 204-210).

positively on innovation output. However, the output of innovation processes does not solely depend on financial inputs. Use of information sources (IS) is an important source of inspiration given its statistically significant positive impact on the output of innovation. A somewhat remarkable outcome is that protection through licensing does not exert a statistically significant positive effect on the output of the innovation process, an outcome that might be related to the observation that patents are, in general, not the most efficient way to capture the profits of innovation.

35. Difficulties in partnership exert a negative influence on innovation output. To test the impact of difficulties in partnership by scale, interaction terms are taken up in the model between the (dummy) variables difficulties in partnership and cluster membership based on the scope of partnership in innovative networks in which responding firms predominantly participate. Especially in regional and national innovation networks, difficulties are of relevance, given the negative statistically significant coefficients of the interaction terms of difficulties in partnership (DP) and regional network embeddedness (RNE) and national network embeddedness (NNE) respectively. Given the theoretical expectation that difficulties are easier manageable in clusters this outcome is a somewhat surprising result. Proximity serves as a catalyzing factor for innovation, because in proximate relationships chances of difficulties are less than in more distant network links. However, when difficulties do occur, these difficulties are not easier manageable in regional network links than in more distant network variants, a finding that might be related to reputation effects in cluster surroundings. The status of R&D-company (RDC), corrected for innovation expenditures, exerts a positive impact on innovation output, but only in interaction with regional network embeddedness (RNE). As is already elaborated earlier, the status of R&D-company connects to the availability complementary competences. In general, R&D-companies need to search further for complementary competences than companies which innovate in a more incremental setting. However, in the situation in which scarcely available competences are available round the corner, companies located in such an environment derive advantage out of that environment. Hence, cluster embeddedness can be seen as an exception to the general rule that companies active at the technological frontier need to scan at relatively wide spatial levels to find state-of-the-art complementary competences in the external network environment.

Conclusions and policy implications

36. Through the measurement of dynamic transaction costs as difficulties in the management of partnership, the California school line of reasoning is empirically confirmed on the basis of the second Community Innovation Survey, held in the Netherlands. Companies which predominantly innovate in partnership with partners located within the regional environment experience fewer difficulties in the management of their partnerships than firms engaged in collaborative innovation processes with partners located outside the regional environment. Similarly, companies engaged predominantly in cross-border partnerships in their innovation trajectories experience more difficulties in the management of partnerships than companies predominantly engaged in domestic partnerships. Hence, proximity serves as a catalyzing factor for innovation, because in proximate relationships chances of difficulties are less than in more distant network links. In this sense, transaction costs connect positively with distance (Hypothesis 1). On the basis of case study research, this relation has been confirmed numerous times (for some classical examples see Aydalot and Keeble, 1988, Scott, 1988; Braczyk *et al.*, 1998). With the results in this study empirical proof is provided on the basis of a broader sample of firms representing the whole population of firms in the Netherlands with 10 employees or more.

37. Companies engaging in more radical forms of innovation experience more difficulties in partnership than other firms innovating in partnership (Hypothesis 2). This relation applies to firms engaged in innovation new to the sector, as opposed to firms engaged in innovations new to the firm, firms active in high-technology sectors, as opposed to firms active in other sectors and firms engaged in both product and processes innovation simultaneously, as opposed to firms active in product or process

innovations. The connection between the scope of network linkages and difficulties in the management of partnerships is especially strong for innovative firms active in high-technology sectors. However, despite this highly geographically dependent cost structure, firms active in high-technology fields innovate to a relatively high extent with foreign partners outside the regional environment. On the other hand, small firms engage relatively often in partnerships within the scope of the regional environment (Hypothesis 3). The connection between distance and transaction costs is especially strong for small companies with less than 50 employees.

38. Compared to cross-border partnerships, in partnerships with domestic partners fewer difficulties in the management of partnerships are experienced. However, when difficulties do occur in domestic partnerships, the effect on the outcome of the innovation process in terms of market position is negative. Given the theoretical expectation that difficulties are easier to manage in regionally embedded innovation networks, this is a somewhat surprising result. A possible explanation might lie in reputation effects in regionally embedded networks through negative feedback loops in local buzz processes (Maskell and Lorenzen, 2004). On the basis of the analyses reported this possibility could, however, not be tested.

39. Within the population of firms engaged in collaborative innovation processes, firms that focus on R&D as core business, firms active in high-technology fields and firms engaged in radical innovations new to the sector, generally innovate at a wider spatial scope than other innovative firms innovating in partnership (Hypothesis 4). Since the above listed firms share as their common feature that innovation processes are more strongly focused on exploration than learning processes in other innovative companies, the conclusion is that exploration connects positively with the scope of partnership linkages in innovation networks. This finding connects with advances in international business management, which interpret geographic reach as a central element in the divergent learning processes in explorative innovation stages (Sidhu *et al.*, 2007). Firms that undertake greater geographic search have access to a more varied set of knowledge elements for recombination, because, through global pipelines, they can link in to multiple selection environments and gain information not available locally (Ahuja and Katila, 2004). Moreover, the empirical outcomes are in line with Solvell and Bresman (1997) who associate radical forms of innovation with distant network links, as opposed to incremental forms of innovation, which are associated with geographically proximate linkages. The status of R&D-company only exerts a positive impact on a firms market position in interaction with regional network embeddedness. In interaction with national and international network embeddedness, the status of R&D-company does not exert a significant effect on the outcome of the innovation processes of firms engaged in collaborative innovation trajectories. Hence, in the situation in which scarcely available competences are available around the corner, companies located in such an environment gain competitive advantage from the regional production environment. This finding is in line with Gertler's (1995) remark that, although firms in search of access to complementary competences indicate they would 'go anywhere' to obtain it, the question arising from this strategy, because of the increasing chance of experiencing difficulties due to the influence of distance, is at what cost such a strategy is pursued.

40. A number of caveats have to be taken into consideration in the interpretation of the outcomes summarised above. An important remark is that the empirical analyses reported in Section 4 exclusively focus on network linkages. Other (spatially discriminating) channels of knowledge dissemination are not taken into consideration. Additionally, this study is based on the spatial industrial organisation of firms engaged in collaborative partnership. Firms that do not engage in partnership in their innovation processes, and firms which do not engage in innovation at all, are excluded from the analyses reported. This focus neglects the impeding role of transaction costs to engage in collaborative innovation processes. Moreover, transaction costs can act as an obstruction, in the sense that companies fail to begin the implementation of innovation projects from the very start. On the contrary, in this study dynamic transaction costs are measured through difficulties in partnership in the context of innovation trajectories that have started already. This raises the question whether ex ante transaction costs in terms of the cost of contact have been

sufficiently included in the analyses. Additionally, in the interpretation of the outcomes, it must be kept in mind that in the analyses reported, the regional environment is confined to a 50 kilometre range from the responding company. This definition of the regional environment adheres to the level of the functional economic region of the city district, generally conceived as an appropriate level at which regional innovation systems manifest themselves.

41. With the above caveats in mind, the added value of the research summarised in this section can be formulated in relation to theoretical and empirical advances in territorial innovation models, the geography of innovation and industrial organisation. The added value of the theoretical perspective of spatial industrial organisation in relation to particularising approaches within the school of territorial innovation models is that it provides a broader perspective on generic spatially structuring mechanisms of knowledge and innovation. In relation to more homogenising approaches such as, for instance, the geography of innovation school and the literature on localised knowledge spillovers within the regional science tradition, the added value of research is that it addresses spatially discriminating mechanisms in industrial organisation more specifically than the claim that knowledge spillovers are regionally confined. On the question why regional spillovers are regionally confined, territorial innovation models bring up the institutional characteristics of specific localities. In this study a complementary perspective is taken in search of more generic claims that go beyond the particularising claim that the institutional environment matters albeit in different contexts in different ways. Important contingencies within the framework of the spatial industrial organisation of innovation concern the character of the innovation, the phase in the product life cycle, firm size and location. The added value of the theoretical propositions is especially relevant in relation to external linkages. As Humphrey and Schmitz (2002) argue, although the cluster literature frequently acknowledges the importance of links with the world outside the cluster, the theoretical basis behind these linkages is weak. The spatially discriminating claims introduced in this study can be seen as a theory at the micro level of the firm engaged in cooperative innovation processes, that is in line with recent theoretical advances on the aggregated level of the region. Of particular interest here is the buzz-and-pipeline model of cluster competitiveness (Bathelt *et al.*, 2004) which goes beyond the traditional global-local dichotomy in territorial innovation models. Here, the competitiveness of clusters is related to both local buzz (information and communication ecology created by face-to-face contacts and co-presence of firms in related activities within the same place or region) and global pipelines (deliberately engaged, more structural relationships at wider levels as information channels for decisive non-incremental knowledge flows). The advantage of local buzz is that each piece of information (information on technological possibilities, market opportunities or information on reliability of cluster members) has been tested for relevance and customised to the receiver. Hence, the result that companies, which predominantly engage in regional network relationships, run into few difficulties with partners does not come as a big surprise. However, when difficulties with respect to the management of partnerships do occur, the effect on market position is negative, a finding which might be related to negative feedback loops (reputation effect) through the local buzz ecology. The finding that R&D-companies, performing activities close to the technological frontier, often engage in cross-border partnerships is closely linked to the pipeline perspective, in which pipelines are conceived as information channels, providing input for radical forms of innovation. Although intuitively the outcomes of this study are in line with the buzz-and-pipeline model, we have to emphasise that in this study only deliberately engaged partnerships are at the basis of the analyses. More or less spontaneous information exchange in the form of what Bathelt *et al.* (2004) term 'local broadcasting' is not included in the analyses.

42. A promising line of future research concerns the role of business location, as an important contingency in the spatial industrial organisation of innovation. In urban conurbations such as industrial districts or clusters, more regional collaborative agreements in innovation trajectories are expected to be found than in peripheral environments. On the one hand, transaction costs in these urban environments are relatively low. On the other hand, successful urban agglomerations, based on a position as knowledge hubs in globally organised innovation networks, provide the best access to complementary technologically state-

of-the-art competences not available locally. Hence, urban agglomeration is expected to act as an important contingency in the generic spatially structuring claims in industrial organisation. Since, on the basis the CIS, a distinction in terms of location of responding companies cannot (yet) be made, it is not possible to empirically assess the theoretically predicted contingent role of the regional environment. Still, some pointers can be given on the role of complementarities in spatial clustering. As outlined earlier, the status of R&D-company only exerts a positive impact on a firms market position in interaction with regional network embeddedness. Hence, although in general R&D-companies have to scan relatively wide scales in their search of complementary state-of-the-art competences, in the situation in which scarcely available competences are available around the corner, firms derive competitive advantage out of the regional environment. More research on this topic is needed. A recently conducted feasibility study by Statistics Netherlands (De Jong and Sluiter, 2009) provides promising results to arrive at a dataset that provides opportunities to distinguish business location in the survey results. The theoretical relevance of a research framework that distinguishes business location lies in the possibilities to integrate indirect effects of network linkages, which are of primary importance in Bathelt *et al.*'s (2004) buzz-and-pipeline model of cluster competitiveness, in the analyses. A multilevel framework of analysis at both the firm and regional level, as suggested by Beugelsdijk (2007), has the advantage of distinguishing between local buzz and global pipelines which directly affect the competitive position of innovative firms on the one hand, and, on the other hand, global pipelines which touch on other firms situated in the region and indirectly impact on the competitive position of the innovating firm through interaction with local buzz mechanisms. The few examples in the literature that carry out empirical analysis in a multilevel setting (see, for instance, Raspe, 2010) provide promising results. However, none of the multilevel analyses carried out so far explicitly address the spatial scope of network linkages in a multilevel setting, in which firm characteristics and characteristics of the regional environment are combined.

43. The different spatially structuring mechanisms in the industrial organisation of innovation could provide a new opening in the dilemma that in quantitatively designed surveys the role of the regional environment is not demonstrated convincingly. Quantitatively designed studies on the role of the regional environment in innovation processes show mixed results (*e.g.* Markusen, 1998). Apart from methodological explanations in terms of level of analysis, spatial regimes representing the concept of urban agglomeration and the administrative level on which the analyses are based, one can also suspect an explanation relating to the absence of the above described spatially discriminating mechanisms of spatial industrial organisation. The central determinants in spatial industrial organisation, transaction cost arguments on the one hand and competence-based arguments on the other hand, relate to the spatial scope of innovative network linkages in opposite way. Hence, an analysis of spatial dimensions of innovation that fails to distinguish both processes, could underestimate the relevance of spatial determinants in the innovation process.

44. In this contribution, intensive use has been made of advances in strategic management and organisation science. Although some references in industrial organisation note spatial aspects through the connection between disintegration, industrial network approaches and spatial concepts such as industrial districts (*e.g.* Robertson *et al.*, 2008), a clear coherent view on spatial aspects in these contributions is missing. The theoretical, on the basis of the CIS 2.5 empirically validated, claims in this study can be seen as a first attempt to arrive at such a theory. Here, both regional and extra-regional connections are at the heart of the analyses. The spatial interpretation of competence-based approaches introduced in this study accentuates different aspects than other interpretations found in the literature at the aggregated level of networks (Foss, 1999), regions (Lawson (1999) and clusters (Lorenzen, 2004), which both focus on collective aspects of competencies and learning trajectories. In this study a complementary interpretation is included at the level of the individual innovating firm, with a central focus on the spatial scope of network linkages in innovation processes.

Policy implications

45. This study empirically confirms the regional dimension as far as networks of cooperating innovative companies are concerned. Firstly, as summarised in the previous section, the regional dimension is related to low transaction costs in collaborative linkages between innovative companies. Secondly, spatial clustering of scarcely available competences close to the technological frontier might be an exception to the general pattern, that scarcely available complementary competences are not available around the corner. Firms engaged in explorative learning strategies that can find complementary competences within the regional environment, indeed seem to derive a competitive advantage from their favourable business location. In this sense, the results of this study can be seen as an empirical confirmation of the strategic philosophy behind regional innovation policies, namely that regional dimensions matter in the innovation process. However, three important remarks need to be made.

- - The first remark relates to the nature of knowledge spillovers. Both the theoretical accounts from the viewpoint of the spatial industrial organisation of innovation and the empirical analyses aim at collaborative partnerships in innovation processes. Other studies emphasise the relevance of regional knowledge spillovers through informal contacts, job hopping and spin off dynamics. Regional innovation policy does not necessarily have to be restricted to partnership linkages between innovative firms.

- - The second remark relates to the focus of public investment, which nowadays is increasingly important in regional innovation policies, through the focus on internationally competitive (world-class) clusters. The analyses reported in this study within the framework of the spatial industrial organisation of innovation relate to a broadly delineated population of innovating firms engaging in collaborative innovation. Therefore, conclusions drawn on the basis of that population do not necessarily reflect the mechanisms and determinants of the spatial industrial organisation in specific clusters targeted by governmental efforts.

- - The third remark relates to the limits of this study. Although the outcomes of this study are in line with the general philosophy behind regional innovation policy, in the sense that regional dimensions matter for innovative capabilities and competitive strength, this study cannot be seen as scientific foundation of regional innovation programmes as carried out in practice. The importance of the regional dimension in innovation processes does not necessarily imply that all regional innovation policy initiatives are by definition successful. Another relevant aspect that has to be integrated in policy evaluations are the opportunities and bottlenecks addressed by public involvement in relation to market and system imperfections, which have to be evaluated in relation to public governance failures (Klein Woolthuis *et al.*, 2005). Additionally, the effectiveness of and synergies between generic measures, thematic and territorial approaches have to be taken into consideration, an issue strongly related to the question whether the innovation system under consideration is primarily, national, regional or sectoral in nature (Rondé and Hussler, 2005). Whereas targeted approaches have the advantage of a focused investment of scarcely available public means, a strong focus also implies a danger that new and unforeseen opportunities could be left out of public innovation policies (Nooteboom and Stam, 2008). In general, literature does not provide a clear-cut solution to this issue, although contributions all emphasise the need to differentiate cluster policies, in the sense that policy makers are strongly advised not to target the same breakthrough technologies as windows of opportunity through copy-cat innovation strategies (Hospers, 2005; Tödtling and Trippl, 2005; Visser and Atzema, 2008). A final example of issues not included in this study is the aspect of governance, dealing with the question on what administrative level opportunities and bottlenecks can best be addressed and how to ensure synergy in the activities taken up at different scales (Fromhold-Eisebith, 2007).

46. In relation to external linkages, spatial economic policies need to focus on regional economic development from an open perspective. This implies, for instance, that cluster policies need to be set up in interaction with acquisition targets of foreign business investments, focus areas of national science and technology policies and target countries in export assistance through public involvement in trade delegations. Additionally, spatial economic policies need to take indirect interactions with the global knowledge economy in account. In this light, linkages between regionally embedded small and medium-sized business enterprises and global knowledge communities is a point of particular interest. Multinational corporations and universities act as important gatekeepers in international knowledge hubs, which can be defined as clusters that are both externally well connected through global pipelines and internally connected through local buzz infrastructure. Through linkages with multinational enterprises and universities small and medium-sized companies are indirectly able to profit from global pipelines. Both Huijts (2003), in relation to multinational enterprises and more specifically the case of Philips in Southeast Brabant, and Benneworth and Hospers (2007), in relation to university spin offs in the Twente region in the Eastern part of the Netherlands, emphasise the role of science parks and campuses as arenas for open innovation to link local buzz to global pipelines.

47. In summary, this study confirms the philosophy behind regional innovation policy, in the sense that regional dimensions matter in collaborative partnerships in innovation trajectories. However, the effectiveness and efficiency of regional innovation policies carried out in practice have to be evaluated on a broader basis than can be provided in this study.

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ANNEX 1 VARIABLES INCORPORATED IN THE MODEL ON PARTNERSHIP SYNERGIES

Variable	Label	Definition
Dependents		
CP1	Significant impact of innovation on competitive position	The innovation had a significant effect on the enterprise's competitive position during the period 1996-1998
CP2	Considerable impact of innovation on competitive position	The innovation had a considerable effect on the enterprise's competitive position during the period 1996-1998
Independents		
IE1	Innovation expenditures	Estimated costs of innovation activities[i] in 1998 as a fraction in total firm revenues (dummy, 0 = 0; 1 > 0)
IE2	Innovation expenditures above the median	Estimated costs of innovation activities[i] in 1998 as a fraction in total firm revenues (dummy, 0 < 0.02; 1 ≥ 0.02)
GS	Government subsidies	Did the enterprise receive public financial support for innovation activities during the period 1996-1998? (dummy, 0 = no; 1 = yes)
RDC	R&D-company	R&D-company[ii] (dummy, 0 = no; 1 = yes)
NTI	Non-technological innovation	Apart from technological new or improved products, services and/or processes, did the enterprise engage in creative improvements[iii] during the period 1996-1998? (dummy, 0 = no; 1 = yes)
IS	Information sources	Importance attached to information sources[iv]
LIC	Licensing	Purchase of rights to use patents and non-patented inventions, licenses, know-how, trademarks, software and other types of knowledge from others during the period 1996-1998 (dummy, 0 = no; 1 = yes)
RNE	Regional network embeddedness	Enterprise innovates predominantly with domestic partners located within a range of 50 kilometres from the enterprise[v] (dummy, 0 = no; 1 = yes)
NNE	National network embeddedness	Enterprise innovates predominantly with domestic partners located outside a range of 50 kilometres from the enterprise[v] (dummy, 0 = no; 1 = yes)
INE	International network embeddedness	Enterprise innovates predominantly with international partners[v] (dummy, 0 = no; 1 = yes)
DP	Partnership difficulties	Did the enterprise experience hampering factors related to the management of partnerships during the period 1996-1998? (dummy, 0 = no; 1 = yes)
DO	Other difficulties	Did the enterprise experience other hampering factors[vi] during the period 1996-1998? (dummy, 0 = no; 1 = yes)

Source: Statistics Netherlands (2000)

[i] Apart from in-house R&D expenditures, expenditures concern extramural R&D, acquisition of licenses and other external knowledge sources, acquisition of advanced machinery and equipment (excluding depreciation), training, design and marketing. All innovation expenditures are directly related to the introduction of technologically new or improved products and processes.

[ii] See Statistics Netherlands (2000, pp. 263-265) for a detailed account on the definition of R&D-company.

[iii] Creative improvements concern new or significantly improved corporate strategies, management techniques, organisational structures and marketing concepts or strategies.

[iv] With regard to a wide array of information sources respondents are asked to estimate the use and importance of each information source in the innovation process during the period 1996-1998 use the following scale: 0 = source was not used; 1 = source was used and the use is evaluated as slightly important; 2 = source was used and the use is evaluated as important; 3 = source was used and the use is evaluated as highly important. Information sources concern internal sources within the enterprise or the enterprise group, recently hired (within the period 1996-1998) personnel and external sources (suppliers, clients and competitors, consultants, universities and other research institutions, innovation centres (publicly funded broker institutions), business organisations, and a range of other sources (patents, software and conferences). The arithmetic mean of individual scores on information sources is taken as a general measure for the importance attached to information sources.

[v] See Table 1

[vi] Hampering factors, apart from partnership difficulties, concern financial risks, high costs, lack of financial resources, unqualified personnel, lack of technological knowledge resources, inflexible organisation structure, inadequate responsiveness to external developments, market uncertainties and government legislation.