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Spatial embeddedness and firm performance: an empirical exploration of the effects of proximity on innovative and economic performance

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Summary

Recent theoretical developments in organisation science and regional economics have emphasised the importance of networks and geographical proximity for the performance of firms. Empirical evidence on these relationships is scarce, though. In this paper, we ask to what extent firm-specific resources, embeddedness, proximity, and industry factors influence innovative and economic outcomes. We used a theoretical synthesis of regional and organisational science to build a research model that enabled us to derive several hypotheses on the influence of proximity on outcomes, taking other important predictors for performance into account. Our empirical findings confirm the importance of proximity especially for innovative outcomes. Moreover, we found that in particular network relations with buyers and suppliers are conducive for firm performance, whereas other indicators of embeddedness and of internal resources have little impact probably due to substitution effects. Finally, regional as well sectoral R&D spillovers influence outcomes in a positive way.

Introduction

In recent years, a growing body of research in regional and organisational science has focused on inter-organisational networks, innovation and proximity. In this research, several theoretical frameworks are used. Some refer to old theoretical approaches like the Marshallian industrial district and externalities (Becanttini, 1989), and some refer to more recent developments like R&D spillovers (Audretsch and Feldman, 1996), 'innovative milieux' (Maillat, 1991), 'New Industrial Spaces' (Storper, 1997), the network approach (Fisher, 1999), and the literature on national and regional systems of innovation (Lundvall, 1992; Gregersen and Johnson, 1997; Morgan, 1997).

In a discussion and evaluation of these approaches, Oerlemans et al. (2000) conclude that there is a general agreement on the importance of spatial proximity for innovation. Territorial closeness to organisations in the same and related industries affects the ability to receive and transfer knowledge and encourages risk taking and sharing. Firms' innovation processes are presumed to benefit more from local than from non-local linkages, all else equal. However, there is little consensus as to how and why this occurs (Audretsch, 1998).

Moreover, these literatures tend to theoretically underspecify what we call the proximity effect, i.e. profiting from localised networks. They do not clearly specify the theoretical mechanisms explaining the comparative advantages and outcomes of local as compared to non-local links. Empirical studies have been limited by the tendency to focus on successful networks and districts (Staber, 2001) in which proximity is a defining feature of a district or network instead of a variable of interest on its own. As a result, the empirical evidence showing that the innovative and economic performance of firms is a function of especially local links is scarce and the effects of geographical space become a black box. From a methodological point of view, empirical studies have tended to apply descriptive or discursive rather than statistical approaches (Love and Roper, 2001). Consequently, the evaluation of the relative importance of factors that differentiate successful and unsuccessful firms and regions becomes a difficult task.

Our object in this paper is therefore to penetrate the black box of geographical space and to unravel the effects of proximity in innovation networks on innovative and economic performance. An important question is how to model the proximity effect: as an one factor model in which proximity is represented as a direct distance decay function of knowledge transfer or as a model showing the proximity effect in combination with dominant predictors for innovative and economic performance with several proxies for distance (users, suppliers, regional R&D). In this paper, we followed the approach to model innovative and economic performance as a function of the firms' internal resource base, the externally acquired resources (innovative ties with a variety of actors), the regional and sectoral R&D intensity (measuring the extent in which firms can benefit from regional and/or sectoral knowledge stocks), and the geographical distance between important buyers and suppliers (which is the most direct measure of the proximity effect). Linking a resource based argument (internal and external resources) with a proximity based argument (using three distinct proxies) results in an interesting model.

This approach enables us on the one hand to contribute to an ongoing discussion in the field of inter-organisational relations. In a literature review of 158 studies on inter-organisational relations and networks, Oliver and Ebers (1998) conclude that research has centred on the driving forces behind inter-organisational networking, rather than on the possible consequences of networking. As a recommendation for future research, they state, "we need more comparative research that spells out regional or industry dimensions that could make a difference for networking and its outcomes" (Oliver and Ebers, 1998: 567). By studying the effects of (geographical) networks and sector-specific characteristics on innovative and economic outcomes, we add to this discussion.

On the other hand, we add to the scarce empirical evidence in the regional sciences on the effects of (spatial) embeddedness on the performance of innovative firms. Where international comparisons of (regional) innovation performance have been made, these empirical studies have tended to compare specific regions with similar industrial or structural characteristics (see for example: Hassink, 1993; Cooke and Morgan, 1994). In this paper, we focus not only on the effects of proximity on innovative performance. The fact that firms are located in different regions with differing conditions and are a part of different sectors with varying innovative traditions are also taken into account. This enables us to evaluate the relative importance of each of these factors in the explanation of innovative and economic performance.

In order to realise these goals, we address the following research question: To what extent do firm-specific resources, embeddedness, proximity, and industry factors influence innovative and economic outcomes?

Theoretical framework

Many scholars stress the importance of industrial innovation for economic performance and development. The long-term growth of organisations and thus of regions and nations depends on their ability to continually develop and produce innovative products and services (Sternberg, 2000). Moreover, this innovative activity takes place in a world that is characterised by increasing uncertainty resulting from fast-changing technologies and global competition. As a result, firms are on the one hand encouraged to concentrate on their core competences and value chains are disintegrated (Storper, 1997). On the other hand, this increasing division of labour among organisations forces them to rely more heavily on inter-organisational transactions, transfers and collaborations and to make a move from hierarchical governance structures to network governance structures that are based upon trust and reciprocity instead of threat and coercion. Especially the advocates of network approaches to innovation (Saxenian, 1990; DeBresson and Amese, 1991; Maillat, 1991; Håkkansson, 1993; Fisher, 1999) stress the benefits of collaborating and interacting with external actors for the innovative capacity of firms. The view that no firm may function efficiently as an island on itself has become somewhat axiomatic (Freel, 2001).

Elsewhere (Oerlemans et al, 1998) we have stated that the (geographical) network approach to innovation tends to overemphasise an inter-organisational approach to organisational processes like innovation. As a result, there is a propensity to undervalue the contributions made by internal resources. Yet, in most industries the greater part of innovation effort is made by firms themselves and occurs within firms themselves (Nelson, 2000). We therefore have to find a balance between an internal and external view of innovation.

Economic actors will allocate resources to the exploration and exploitation of new products and processes if they know, or believe in, the existence of some sort of scientific, technical or market opportunity that could lead to economic benefits (Dosi, 1988). The innovation process of individual firms can be conceived as an open system (Katz and Kahn, 1966) where heterogeneous (knowledge) inputs are transformed into outputs (results of innovation). As far as this process is related to external economic actors, it is useful to distinguish two categories of external knowledge inputs: unintentional and intentional (Hur and Watanabe, 2001).

With regard to the first category, we refer to the spillover literature. Because of the non-rivalness property of knowledge, knowledge producing economic actors cannot fully appropriate the results of their activities and these results spill partially over to other actors on an involuntary and unintended basis (Harabi, 1997). As a result, positive externalities will occur and this knowledge will circulate in the economy, thereby creating increasing returns relating to scale and long-term growth (Griliches, 1992). However, as will be explained below this does not imply that this type of external inputs can be acquired without any costs by an innovator firm. In this paper, two levels of unintentional external inputs to innovation will be discerned, namely sectoral (Soete and Ter Weel, 1999) and regional (Caniëls and Verspagen, 2001) that will be discussed more in more detail later.

The second category discerned are intentional external knowledge inputs, which include interactions between innovator firms and a variety of other economic actors, such as buyers, suppliers, universities or consultants. In contrast to the previous category, these transfers of knowledge and information are intended and voluntary contributions of these actors to the innovation processes of the focal firm. As such, these interactions capture the (geographical) network activity of innovator firms.

After this discussion of balancing the internal and external view of innovation, the stage is set for the development of a theoretical model that will enable us to explore empirically the relative effects of firm-specific resources, network, regional and industry factors on the innovative and economic performance.

Firm-specific resources

The central proposition of the resource-based approach is that firms select actions that best build on and maintain their unique set of resources in order to stay competitive (Combs and Ketchen, 1999). In the context of innovation, technical knowledge is the main strategic resource to be developed or acquired (Hage and Alter, 1997). In-house R&D activities are often perceived as the most effective way to accomplish this. R&D activities are very important not only for developing one's own product and process innovations but also for monitoring competitors and absorbing the latest technological trends on the market (Cohen and Levinthal, 1990; Harabi, 1997). We expect, therefore, that higher levels of in-house R&D activities enable firms to develop heterogeneous resources and learn more about technological opportunities, resulting in higher levels of innovative and economic performance.

The organisation of internal R&D activities is a second firm-specific resource, which has to be taken into account. As an analogy to Cohen and Levinthal's two faces of R&D (1989), we propose the idea of the two faces of the organisation of R&D. On the one hand, the organisation of in-house R&D activities in a department indicates that the undertaking of these activities is a more routinised and continuous process and that the firm is used to change, which is an inevitable by-product of innovative activities (Meeus and Oerlemans, 2000). The presence of an R&D department is on the other hand especially of importance in research related collaborations. It gives external partners an identifiable and recognisable unit within an organisation, which facilitates the transfer of knowledge and information. This eases the production of innovations and related economic results. Therefore we propose that firm that have organised their R&D activities have higher performance levels.

A large part of the knowledge base of an organisation is embodied in its employees and in this sense the knowledge and skills of employees are a valuable asset in innovation processes. Larger firms are assumed to have a larger variety of knowledge, skills and experiences, which can be utilised in innovation. This yields the proposition that firms with larger human knowledge bases have higher performance levels.

The arguments discussed above enable us to formulate hypothesis 1:

H1: The stronger the innovator firm's internal knowledge resources (size and organisation of R&D and human resources), the higher its performance level.

Embeddedness

Embeddedness, i.e., the extent in which economic action and outcomes of firms is affected by dyadic relations and by the structure of the overall network of relations (Granovetter, 1985), performs several functions in the context of innovation (Håkansson, 1989). Firstly, these networks of relations have a function for the knowledge development process in an economy. Ideas and knowledge needed to develop innovations are often a product of the confrontation of different fields of knowledge. Especially the interactions between heterogeneous actors and resources provide a platform for this confrontation. Secondly, networks have a coordination function. The success of product and process innovations is highly dependent on the extent to which they are adapted to already existing technical systems and/or focussed on market demands. Network interaction enables actors to communicate with and monitor external parties in order to perform feasibility checks on chances and threats of technological opportunities and changing user needs (Lundvall, 1992). The mobilisation of external resources is a third function of economic networks. According to the network approach, firms rarely have all required resources internally to innovate successfully. As a result, some of these resources have to be acquired externally. Because resources are heterogeneous, i.e., their economic value depends on other resources with which they are combined, innovating firms have to be knowledgeable about their uses and performances. Learning is a way to accomplish this. As far as external resources are concerned, this type of learning is called learning by interacting: firms make actively use of the knowledge and experience of a variety of economic actors in their network (Hakansson, 1993). Therefore, hypothesis 2 reads:

H2: The more innovating firms utilise their external resources bases, the higher their performance is.

Proximity issues

In terms of the role of spatial proximity in facilitating innovation networks two bodies of literature can be discerned: regional R&D spillover literature and spatial interaction literature. The main difference between the two lies in the theoretical mechanisms explaining the relation between innovation and proximity.

As already discussed by Thompson (1962), regional R&D spillover literature argues that innovation is a cumulative activity, implying that firms located in regions that have accumulated high levels of innovative success and possess a relevant stock of knowledge will be favoured in the next rounds of innovation. Two interrelated mechanisms are put forward as explanations. Due to the partially non-rival nature of the locally accumulated knowledge on the one hand, and an assumed distance decay function of communication and knowledge transfer on the other, this knowledge spills unintentionally and in particular over to firms located in the region. Moreover, these effects are sustainable over time. Firms located in regions that first emerged as centres of innovative activity tend to sustain this advantage over time. Basically, this is a variation on Myrdal's theory of cumulative causation.

Just as in the regional spillover literature, spatial interaction literature assumes a negative elasticity with regard to the transfer of (technological) knowledge in space. The level of codification is important here since spatial proximity is assumed to be of importance especially in case tacit knowledge has to be exchanged. Moreover, in contrast to regional spillover literature it is actual and intended interaction between economic actors that is functioning as the mechanism of knowledge transfer. Although the spatial interaction literature has a heterogeneous nature because of its great variety of concepts and perspectives, the importance of inter-personal links, of a common institutional culture amongst workers, entrepreneurs and politicians, and of a positive attitude towards collaboration, all facilitated by spatial proximity, stimulate interactions between actors in general and the flow of knowledge and information in geographical space in particular. These notions can be found in industrial district theory (Asheim, 1996), the innovative milieux approach (Aydalot and Keeble, 1988), and the 'New Industrial Spaces' approach (Storper, 1997). They all assume that firms that tap into local knowledge flows will acquire necessary resources more easily, and are therefore able to perform better.

It is our belief that both types of knowledge flows are important to innovation processes. Therefore we hypothesise that:

H3: The more innovating firms are able utilise intended and unintended regional knowledge flows, the higher their performance is.

Industry factors

In his seminal paper, Pavitt (1984) showed that there are important sectoral differences with regard to innovative activity. As was stated in a previous section, firms cannot prevent that parts of the results of their knowledge production efforts spills over to other firms. This is especially of importance to firms active in the same sector, since they can absorb this knowledge more easily because they built on comparable knowledge bases (Smith, 1995) and therefore are able to innovate more successfully. This results in hour fourth hypothesis:

H4: The more innovating firms are able to appropriate sectoral knowledge flows, the higher their performance is.

Research Design

Data source

This article draws on a survey on R&D, networks and innovation in the Netherlands. The survey was held in 1995 (relating to firm behaviour in the period 1989-1994) among some 5,500 manufacturing and services firms with more than five employees. The response rate was 8%, i.e. 365 firms. For details on the features of the survey, see Oerlemans (1996). Although the response rate was low, the number of cases is quite sufficient to perform a number of multivariate exploratory analyses. Capello (1999) and Dahlstrand (1999), for example, use 63 and 157 observations, respectively, in their estimations.

Measurement of variables

In this paper, the relative effects of firms' internal resources, network, regional and industry factor on firm performance are explored. However, firm performance is a multi dimensional concept and can therefore be measured in multiple ways. In a previous section, we defined the proximity effect as the comparative advantages of local ties in comparison to non-local links. As a result of the focus of this paper, these comparative advantages lie on two related fields : innovative and economic. If proximity indeed has the assumed effects, it eases the innovation process and will contribute to more positive innovative outcomes for innovator firms. From a regional economic perspective however, higher innovative outcomes do not necessarily translate into some form of regional economic development. It is therefore of interest to find out whether the proximity effect also holds for indicators related to economic performance.

Two indicators will be used for the measurement of innovative performance. First, the *percentage of new processes and products* in the time period 1989-1994. This variable describes physical outcomes of innovation processes. Firms were asked to indicate which percentage of the processes and products were new to the firm in a 5-year period. Higher scores on this variable indicate higher levels of newness. The second indicator of innovative outcomes is the *scope of innovation results*. Results of innovation are not necessarily physical in nature. Part of the innovative efforts of firms are directed at, for example, a reduction of cost prices, quality improvements, or the speeding up of internal processes. In other words, this variable captures the more qualitative dimensions of innovation outcomes. Moreover, if firms are able to realise a wider variety of results as outputs of their innovation processes, this is evaluated as a higher level of performance. To measure the scope of innovation results, we asked firms to indicate to what extent process and/or product innovations resulted in (a) reductions of cost prices; (b) quality improvements of processes and/or products; (c) increases of production capacity; (d) improvements in delivery time; (e) increases in sale, and (f) increases in profits[1]. A compound variable was calculated as the average sum score of the items mentioned above. Higher scores indicate a wider scope of innovation results.

The second group of indicators describe economic outcomes. After all, at some point in time the produced innovations should create economic value for the firm and in a wider context for a regional of a national economy. We discern two types of economic outcomes. On the one hand, the average annual growth percentage of sales in 1989-1994, and on the

[1] Answers: (1) Very little; (2) little; (3) not little/not much; (4) much; (5) very much.

other the average growth percentage of employment in the same time period[2]. Higher scores indicate higher growth percentages of sales and employment respectively.

In line with our theoretical model, four groups of independent variables are distinguished. *Firm specific resources* are described using three variables. First, R&D effort measured as the percentage of the total workforce devoted to R&D activities. Second, R&D department, which is a dummy coded variable. The value 1 is assigned in case an innovating firm has such as department and 0 in all other cases. The third variable used is the number of employees. It is assumed that a larger number of employees stands for a wider variety of human knowledge resources that could be beneficial to innovation.

Network activity of innovating firms is measured with two types of variables, R&D cooperation on the one hand and external contributions to the innovation process on the other. The main difference between the two is related to the distinction between availability and utilisation. The variable R&D cooperation is a count of the number of research collaborations of the innovating firm with a variety of external actors[3]. In many studies (e.g. Brouwer and Kleinknecht, 1996), R&D cooperation is viewed as direct input for the innovation process. We take a different position. Having collaborative arrangements with external parties does not necessarily imply that actual transfer of knowledge is realised. In our view, these collaborations are a necessary precondition that enable firms to interact and indicate whether appropriate channels for communication are available. The actual interaction and utilisation is measured with a second variable 'external contributions to the innovation process'. In our survey, we asked innovating firms how often in the last five years external organisations thought up ideas for, or made important contributions to, the realisation of innovations[4].

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[2] Both variables are calculated as: [[[sales (employment) 1994 – sales (employment) 1989] / sales (employment) 1989] * 100] / 5.

[3] External actors involved are: suppliers, buyers; competitors; educational institutions, R&D labs, and engineering companies.

[4] External organisations included were: Trade associations; National Centres for Applied Research (TNO); private consultants; buyers, suppliers; competitors; chambers of commerce; regional innovation centres;

These 12 items were entered in a factor analysis (results not presented here) that resulted in a solution with six factors: external contribution to innovations by (1) trade associations; (2) universities; (3) institutions of professional and vocational training; (4) business partners in value chain; (5) private knowledge infrastructure; (6) business partners outside value chain[5]. Firms that have more R&D relationships and are able to interact more intensively with external organisations, have more access to and utilise external knowledge bases more intensively, which enables them to achieve higher performance levels.

The variables that will be used to measure the influence of *proximity* on performance belong to one of two groups. The first group (one variable) measures local R&D spillovers. The Netherlands is split into 4 regions[6] and for every region the average regional R&D effort is calculated as a proxy for regional R&D spillovers. Depending on its location, this regional R&D effort is assigned to a specific firm. Higher values of this variable indicate higher levels of regional R&D spillovers. The second group of proximity variables contains two variables. Both variables describe geographical distance of relationships but with different actors. Firms were asked to indicate the geographical location of the buyer or supplier most important to their innovation processes. These variables are dummy coded, with a value 1 in case this buyer or supplier is located in the same region and 0 in all other cases. It is assumed that local ties facilitates the (intended) transfer of knowledge between users and producers, which enables the receiving firm to innovate with more success.

The last independent variable in our model is an indicator for sectoral R&D spilovers. Firms were grouped in six sectors: traditional industry, metal industry, IT sector, business

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technical universities; other universities; colleges for professional and vocational education. A 5-point Likert scale was used to measure the frequency of interaction: (1) never; (2) sometimes; (3) regularly; (4) often; (5) always.

[5] A varimax rotated principal component analysis resulted in 6 factors. Kaiser-Meyer-Oklin = 0.654; Bartlett's Test of Sphericity = 301.229 with a level of significance = 0.0000; cumulative percentage of variance explained = 70.48%.

[6] Region West containing the provinces Utrecht, North and South Holland, Flevoland; Region North = provinces Groningen, Friesland and Drenthe; Region East = provinces Gelderland and Overijssel; Region South = provinces Zeeland, North Brabant and Limburg.

sector, chemicals and plastics, and construction (materials)[7]. For each of the six sectors, the average R&D effort was calculated. This figure was assigned to an innovating firm according to its sectoral code. Higher values of this variable indicate higher levels of sectoral R&D spillovers.

Model estimation issues

In order to test the relative importance of firm-specific resources, network, proximity, and sectoral factors on different dimensions of firm performance, four models (one for every performance indicator) were estimated using stepwise OLS regression analysis with pairwise deletion. The models were estimated without an intercept. The argument for this decision is rather straightforward. Including an intercept in the models would imply that firms could have a certain level of (innovative) outcomes independent from the fact whether they perform innovation related activities. In the context of this paper, that would be improbable.

An econometric concern in estimating the models is the existence of multicollinearity among the independent variables. To check for multicollinearity, we used the so-called variance inflation factor (VIF), which is the reciprocal of the tolerance. As the VIF increases, so does the variance of the regression coefficient, making it an unstable estimate. Large VIF values are an indicator of multicollinearity (Tacq, 1997). The variance inflation factors found in our estimates ranged from 1.03 to 1.32, expressing the fact that no multicollineatiy problems occurred.

[7] Traditional industry = food & beverages, paper and printing, textiles, clothing and leather industry (n = 39); Metal industry = machines and tools, metal products, transport equipment (n = 91); IT sector = IT related industries and electronics (n = 27); Business services = R&D organisations, business services (n = 32); Chemicals/plastics = manufacture of chemical, rubber and plastics products (n = 26); Construction (materials) = construction sector and manufacture of materials for the construction sector (n = 148).

Empirical results

Table 1 shows the results of the stepwise OLS regression for the four different outcome variables we distinguished. Notable features of the estimates are firstly the finding that firm-specific resources turn out to be of little importance for outcomes, since only in two equations significant coefficients can be noted. Firms with a R&D department have a broader scope of innovation results, probably indicating that realising a broader, more qualitative set of innovation results asks for a well-organised and more or less continuous R&D process.

Table 1: OLS stepwise regressions

Independent Variables	Outcomes: dependent variables			
	Percentage changed processes and products 1989-1994	Scope of innovation outcomes	Average annual growth % of employment in 1989-1994	Average annual growth % of sales in 1989-1994
R&D effort	+0.003 (0.915)	-0.027 (0.371)	+0.037 (0.586)	**+0.174 (0.009)**
R&D department	-0.030 (0.347)	**+0.105 (0.008)**	-0.052 (0.483)	+0.014 (0.858)
Number of employees	-0.003 (0.892)	+0.030 (0.278)	-0.014 (0.806)	-0.052 (0.353)
Number of employees sq.	+0.011 (0.620)	+0.020 (0.451)	-0.004 (0.940)	-0.048 (0.391)
R&D cooperation	+0.023 (0.467)	**+0.104 (0.008)**	-0.042 (0.604)	-0.128 (0.104)
F1: business agents	+0.031 (0.169)	-0.019 (0.476)	-0.080 (0.148)	-0.084 (0.136)
F2: universities	+0.003 (0.886)	-0.035 (0.206)	**+0.345 (0.000)**	-0.009 (0.875)
F3: prof.voc. training	+0.012 (0.585)	+0.000 (0.991)	**-0.145 (0.009)**	**-0.136 (0.015)**
F4: value chain	**+0.079 (0.000)**	**+0.066 (0.016)**	**+0.233 (0.000)**	**+0.133 (0.018)**
F5: priv. tech. infra.	+0.022 (0.313)	+0.030 (0.271)	**+0.147 (0.008)**	-0.013 (0.819)
F6: horiz. partners	+0.005 (0.810)	+0.024 (0.369)	-0.072 (0.187)	-0.027 (0.630)
Proximity users	**+0.090 (0.065)**	+0.058 (0.335)	+0.090 (0.367)	**0.237 (0.002)**
Proximity suppliers	**+0.112 (0.004)**	**+0.095 (0.041)**	**+0.174 (0.014)**	-0.016 (0.855)
Regional R&D spillovers	**+0.668 (0.000)**	**+0.680 (0.000)**	+0.055 (0.643)	+0.001 (0.996)
Sectoral R&D spillovers	**+0.129 (0.000)**	+0.009 (0.826)	**+0.189 (0.008)**	**+0.246 (0.004)**
F-value	384.995	238.949	19.460	22.554
Significance	0.000	0.000	0.000	0.000
N	224	224	224	224

Moreover, it turns out that higher levels of R&D effort are associated with higher growth levels of sales. A comparable result was found by Brouwer and Kleinknecht (1996) and Love and Roper (2001). Nevertheless, the overall results with regard to the association between internal resources and performance levels show that there is little evidence in support of hypothesis 1.

In hypothesis 2, we stated that higher levels of embeddedness were positively associated with the performance of innovating firms. Regardless of the output indicator used, this is confirmed in the case of the contributions to the innovation process by important users and suppliers. Besides this overall result, we find varying patterns for the different dimensions of performance. In case the scope of innovation outcomes is the dependent variable, the number of R&D relationships has a positive and significant coefficient. In tandem with the already described positive influence of the presence of a R&D department, this result stresses the importance of a well organised R&D process for the realisation of a broader scope of, more qualitative, innovation outcomes. The estimate with growth of employment as the dependent variable shows a somewhat puzzling result. In comparison to the other estimated models, a broader range of the variables describing embeddedness play an important role in this model. Besides the already noted influence of the value chain, also the contributions to the innovation process by universities and the private knowledge infrastructure are positively associated with growth of employment. Conversely, an unexpected negative coefficient is found for the contributions to the innovation process by institutes for professional and vocational training. A comparable result for this variable was found when growth of sales was the dependent variable. In general, these findings lead to the conclusion that higher levels of embeddedness are associated with higher growth levels of employment, but interestingly enough this is not applicable to the models in which innovation outcomes are the dependent variables.

The proximity effect turns out to be relatively influential. In all estimates at least one significant effect in the expected direction can be noted. Especially when indicators of innovation outcomes are the dependent variables, proximity seems to matter. Innovating firms with local innovative ties with buyers or suppliers and which are able to benefit from regional stocks of knowledge, have higher innovation performance levels. The importance of proximity for innovation stressed in theoretical literature, is confirmed in our study. To a lesser extent, proximity indicators have a positive and significant coefficient when economic outcomes are considered, but only direct distance measures of proximity are of importance. Overall it can be concluded that hypothesis 3 is confirmed.

The effects of sectoral R&D spillovers prove to be significant and have the expected sign. With the exception of the model in which scope of innovation outcomes is the dependent variable, it can be concluded that higher sectoral R&D spillovers are associated with higher performance levels, confirming hypothesis 4. This result is found more often in empirical studies on this type of R&D spillovers (see for example: Caniëls, 2001; Love and Roper, 2001).

Discussion and conclusion

The main aim of this paper was an empirical exploration of the relative importance of firm-specific resources, embeddedness, proximity, and sectoral factors for firm performance. The paper used a theoretical synthesis of organisational science (resource based theory, network theory) and regional science (district theory, systems of innovation) accounting for innovative and economic outcomes. The resulting research model enabled us to derive several hypotheses on the influence of proximity on outcomes, taking other important predictors for performance of firms also into account.

Proximity matters, especially for innovative performance. This is one of the most important findings of our analyses. Local innovative links with buyers and suppliers, as well as benefiting from local knowledge stocks, turned out to have positive impacts on innovative and economic performance, even if other predictors are taken into account. These results confirm the assumption found in regional science on the facilitating role of local linkages for the transfer of innovation related knowledge. Also sectoral R&D spillovers impacted on outcomes in the expected way. Sectoral knowledge stocks are important sources for innovative and economic performance.

The results for the embeddedness variables give rise to some discussion. On the one hand, we found a general effect of the contributions of important buyers and suppliers to the innovation process. The production and product related technological knowledge embodied in these actors turned out to be of value for the innovative and economic performance of firms in our survey. On the other hand, only in the model with growth of employment as the dependent variable a broad variety of external contributions seems to matter, although we expected this would also be the case for innovative outcomes. One interpretation of these results is consistent with findings by Baum and Oliver (1992). Their results suggest that embeddedness in the institutional environment underlies amongst others, the improved survival capabilities of a population of organisations. As far as growth of employment can be regarded as an indicator related to firm survival, our findings point in the same direction. Another interpretation could be that the effects of embeddedness are substituted by the indicators for proximity and sectoral R&D spillovers. A similar substitution effect is observed by Love and Roper (2001) in their study on location and network effects on innovation success in the UK, Germany and Ireland. This would imply that if firms have the choice, they prefer direct local ties and the use of regional knowledge sources above a variety of actors in their institutional environment.

This substitution effect could also be an interpretation of our finding that on average internal resource bases do not add much to the explanation of firm performance. As argued by Teece (1988), (geographical) networking may be undertaken by innovators in response to internal resource constraints. In a recent paper, Oerlemans, Meeus and Boekema (2001) found evidence pointing in the same direction, i.e., under the condition that innovation processes were highly problematic and thus caused resource deficits, firms were inclined to show more network activity.

Moreover, our study shows that including both indicators for actual interaction and knowledge spillovers has explanatory value for firm performance. As indicators of intended and unintended knowledge flows in an economy, they point to the fact that researchers should take a balanced approach when dealing with these matters.

Finally, we are conscience of the fact that our analyses could be extended with tests of simultaneity and interaction effects. We excluded these, because the paper would get to crowded. Moreover, in assessing the contribution of our study some caution is needed. Our sample is relatively small, causing the possibility of sample bias and, therefore, putting some stress on the generalisation of our claims. Also caution should be exercised, because other regional economic variables, like e.g. sectoral differences or regional growth levels, were not included here..

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