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THE ODD ROLE OF PROXIMITY IN KNOWLEDGE RELATIONS: HIGH-TECH IN THE NETHERLANDS

GERBEN VAN DER PANNE* & WILFRED DOLFSMA**

**Delft University of Technology, Economics of Innovation, Jaffalaan 5, 2628 BX Delft, The Netherlands, g.vanderpanne@tbm.tudelft.nl*
***Erasmus University Rotterdam & University of Maastricht. Erasmus University Rotterdam, FBK, PO Box 1738, 3000 DR Rotterdam, the Netherlands, w.dolfsma@fbk.eur.nl*

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ABSTRACT
In contrast to findings in other countries, and surprisingly in view of the literature, high-tech economic activity in the Netherlands is not spread geographically according to either relevant labour market characteristics or to localised agglomeration economies. Instead, statistical analysis shows that the Netherlands is an urban field, and that the knowledge infrastructure is the only variable that can offer an explanation of the high-tech presence throughout the country. By analysing similar relationships for younger firms, we are able to make quite a strong case about causation.

Key words: Location factors, high-tech, the Netherlands, knowledge infrastructure, knowledge spillover

INTRODUCTION

Due to their continuous R&D efforts, high-tech firms are allegedly highly competitive and fast growing in terms of employment and output (Geroski *et al.* 1993). Their R&D efforts and rate of growth constitute a comparative advantage for their countries of location and thus boost national economic growth. Some regions accommodate more high-tech firms than do others. Despite regional efforts to attract high-tech firms, the success stories are few in number. Regional characteristics are apparently important and cannot easily be modified. An important strand of research in the field of economic geography analyses regionalised economic activity. The regional accumulation of knowledge and locally occurring knowledge spillovers are major topics of such research (cf. Krugman 1995; Martin 1999). Three such knowledge-related elements, originating in the industrial district argument first developed by Alfred Marshall, are emphasised in the literature: the eminence of the regional labour market, agglomeration externalities, and characteristics of the regional knowledge infrastructure.

In this pape the extent to which these three elements explain the spread of firms in high-tech industries throughout the Netherlands is assessed. Some studies show that, in a technical sense, clusters of high-tech firms do not exist in the Netherlands (Swann 1999; Wever & Stam 1999; Hoen 2001). We study the *tendency* to cluster: although there are no clusters, high-tech firms tend to concentrate in particular regions (see Figure 1).

The Dutch case differs from other cases described in the literature. To anticipate the results to some extent, the Dutch case shows that, where physical distance is deemed less important in location choices, *cognitive* distance becomes of greater significance (cf. Nooteboom 2000). This element, thought to be of increasing importance, is included in the study by examining the effects of the knowledge infrastructure on the geography of high-tech economic

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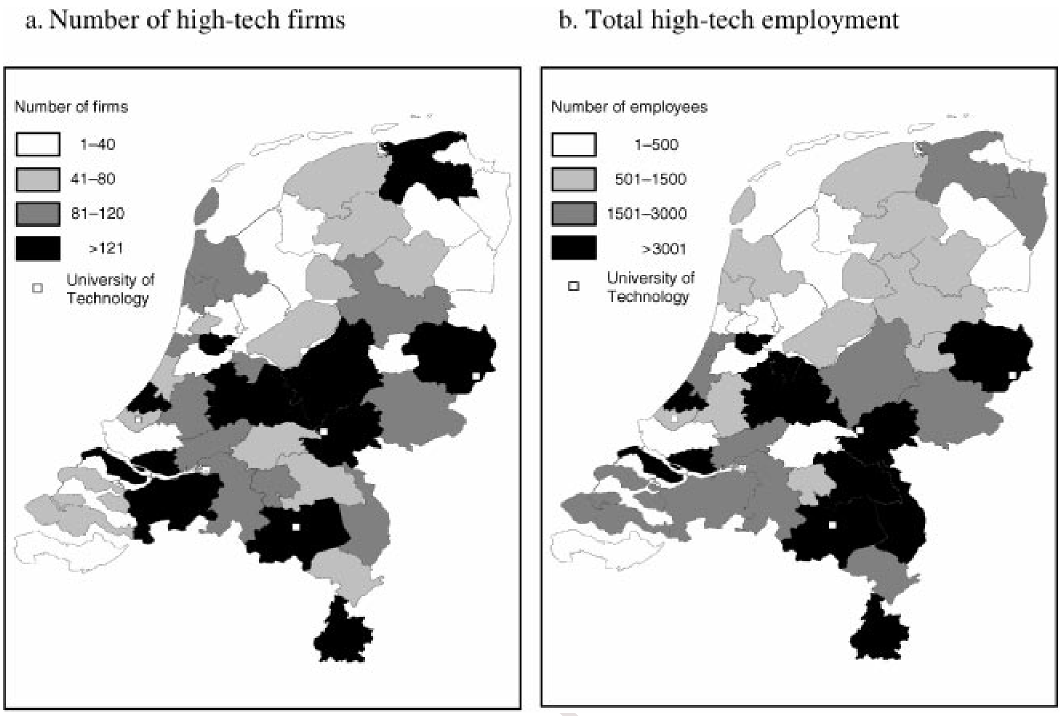

Source: Calculations based on data available from Marktselect plc, 2002.

Figure 1. *Location pattern of high-tech firms (A) and total high-tech employment (B), by corop region.*[1]

activity. We show that material reasons for the spread of economic activity through the Netherlands, at least for high-tech, become less important, indicating that the Netherlands is indeed an 'urban field'; regional differences in material factor endowments do not seem to have any systematic impact on the location pattern of high-tech activity.

In the second section, the location factors deemed important in the literature are discussed. The third section presents the model with which the high-tech location pattern will be explained. The results are discussed in the fourth section. The fifth section elaborates on the original model, testing the causality of relations between location factors and the location pattern. The final section ends with concluding remarks.

LOCATION FACTORS

Economic activity tends to have an uneven geographic spread. It is not surprising, therefore, that firms in high-tech industries are not evenly distributed across the Netherlands (see Figure 1). The literature generally recognises three factors on the basis of which firms decide on their location. These are in line with Alfred Marshall's (1920) industrial district argument. They are well understood nowadays and need little elaboration. Marshall has argued that the local labour market may have particular characteristics that are attractive to firms. The type of products and the production process used may require employees with particular skills and knowledge. Assuming that the labour market is not perfect and may be fragmented regionally as well as according to skills and knowledge, firms may not scatter evenly as would be the case in the perfect market of neoclassical economics. A second factor discussed by Marshall is that of agglomeration externalities. Suppliers to or buyers (customers) of a firm may be concentrated in a region. In the case of high transport costs, in particular, agglomeration externalities may be strong. In what increasing numbers of observers call an (emerging) 'knowledge' economy, factors hinted at by Marshall, such as knowledge spillovers and things being 'in the air' in the context of a region, become more important.

In a knowledge economy, the first factor may take a different role. Various characteristics of potential employees in the region may become important. The need that they should respond adequately to the economic and technological dynamism has increased the demand for employees with a formal education. Professionalisation and the need for objective criteria regarding the selection of future employees illustrate the eminence of the regional labour market as a genuine location factor (Malecki 1991; Weiss 1995). High-tech industries in particular, need employees who are trained in engineering, for example at the academic level. De Grip and Willems (1996) show that Dutch high-tech firms indeed employ more professionals relative to medium- and low-tech firms.

Agglomeration externalities may also differ in a knowledge economy. In addition to Marshall's industrial districts argument, agglomeration can offer a favourable environment for the innovating firm in which to create and sustain its knowledge base. As distance hinders the exchange of tacit knowledge (Jaffe 1989), the regionally bound stock of tacit knowledge increasingly becomes a source of competitive advantage for the region (Maskell & Malmberg 1999). Moreover, proximity fosters collaboration (Fritsch & Schwirten 1999), which creates relations of trust among economic actors within the agglomeration (Harrison 1992). Hence, agglomerations not only offer the advantages of Marshall's 'traded linkages', but possibly also the more elusive 'untraded interdependencies' (Storper 1997). As Hägerstrand (1967) has shown that in Europe, innovations tend to be introduced in major cities and then spread across the urban hierarchy. More recently, it has been shown empirically that innovative activities tend to be concentrated in agglomerated milieus in the USA (Audretsch & Feldman 1996), the UK (Baptista & Swann 1998) and France (Carrincazeaux *et al.* 2001). As such, agglomerations are alleged breeding places for innovations (Brouwer *et al.* 1999). Proximity may thus economise on communication and interpretation costs involved in the creation of new knowledge.

For firms in high-tech industries, particularly, the role of knowledge-creating and diffusing institutes such as universities and non-academic research centres, both private and public, could play an important role in understanding regional economic differences (cf. Florax 1992). In line with other research, the authors conceive of (non-) academic research institutes as constituents of the regional knowledge infrastructure and as a separate location factor for high-tech firms. Joint research projects, the spillover of research undertaken at these institutes, and the informal exchanges of (tacit) know-how are their main contributions to the regional knowledge base. As these effects are regional, firms in high-tech industries might benefit from knowedge spillovers if and when they locate nearby knowledge institutes. Jaffe (1989), for example, provides evidence that knowledge can spill over from university research to industrial R&D efforts (see also Audretsch & Feldman 1996; Mansfield & Lee 1996; and Anselin & Varga 1997). In Germany, the same holds for universities that engage in applied sciences (Engel & Fier 2000) as well as for non-academic research institutes (Fritsch & Schwirten 1999; Sternberg 1999). For this paper's purposes, and from a theoretical point of view, it seems reasonable to separate knowledge infrastructure from the more general agglomeration effect. This paper's focus on high-tech industries points in this direction. The course that modern economies in general take towards a knowledge economy is a more general argument in favour of including the knowledge infrastructure as an explanatory variable in this analysis.

Although this study is able to explain the location of high-tech activity throughout the Netherlands, it should be clear that the set of location factors included is not exhaustive: the location pattern of high-tech activity may also be affected by regional living amenities appreciated by qualified personnel, by the regional physical infrastructure and industrial zoning policies (cf. Ouwersloot & Rietveld 2000; Atzema 2001). These location factors reach beyond the scope of this study, however.

THE MODEL

The OECD definition of high-tech industries is used. When, on average, firms in an industry spend at least 4.5% of total sales on research and development, that industry is considered high-tech (OECD 1986). The creation and use of new knowledge is then important. Industries covered by this definition include pharmaceuticals, office equipment, computers, electronic devices, communication devices, scientific instruments and aerospace. For the Netherlands, this adds up to 4424 high-tech firms, or 0.4% of the total population of firms. The definition used by OECD is not the only one, and has several drawbacks (cf. Kleinknecht 2000). For example, it focuses on the level of the industry. Firms in industries that the OECD does not recognise as high-tech could spend more than 4.5% of revenue on R&D – intra-branch differences with respect to R&D intensity may be considerable. Statistical information used to establish the extent to which an industry is innovative, such as that used by the OECD, tends to underestimate innovation in service industries. The OECD classification is based on R&D inputs only, whereas output measures are more direct proxies of innovativeness. However, the branches designated as high-tech by this OECD definition are also classified as such by most alternative definitions. Moreover, the OECD definition is most common in scientific research; using it here makes this study comparable to other studies.

In this model, the three sets of regional factors discussed in the section above (labour market characteristics, agglomeration externalities and knowledge infrastructure) are tested to see if they can explain the spread of high-tech activity in the Netherlands, explaining the pattern in Figure 1. Malecki (1991) emphasises the need for employees with a strong technical background. We therefore use two indicators for the regional labour market: those who have a university degree (master's) or a degree from a polytechnic for vocational training (bachelor's) in a field of the natural sciences on the one hand, or who have such a degree in another field of study. Data provided by Statistics Netherlands are used for these indicators.[2] The hypothesis, derived from the literature, is that the higher the proportion of BAs and MAs – technical or non-technical – in a region's labour force, the more likely it is that high-tech firms will locate there. Although these labour market characteristics are correlated to some degree, tests show that this is not significant and does not preclude both variables from being included in the model.[3]

In the literature, linkage-density parameters among proximate firms are used to catch the influence of agglomeration externalities (Richardson 1973). Inter-firm linkage-density, however, is an inappropriate indicator for agglomeration. Agglomeration externalities enhance the local knowledge base, which is resembled by 'traded' linkage-density parameters to a very limited extent only (Malmberg & Solvell 1997). Indeed, for the Netherlands, it is acknowledged that inter-firm linkage density does not run parallel with physical proximity (Wever & Stam 1999; Atzema 2001; Heijs & Schmitz 2001). Rather than measuring linkage densities, the authors therefore test whether agglomerated regions accommodate more high-tech firms compared to less agglomerated regions. Manshanden's (1996) agglomeration index is used as an indicator of agglomeration externalities. It distinguishes five ordinal degrees of agglomeration externalities according to physical distances between a Corop region's central town and those in all other Corop regions, weighted by the region's population density. Similar to the linkage-density approach, this index does not capture all relevant dimensions of agglomeration externalities, e.g. the degree of specialisation, competition and diversity of the local production milieu (Ouwersloot & Rietveld 2000; Van Oort 2002). Nevertheless, the indicator is used for reasons of data availability and comparability; other scholars in the field have also used it (Kleinknecht & Poot 1992; Manshanden 1996; Brouwer *et al.* 1999).

The third hypothesis is that the regional knowledge infrastructure, measured by number of knowledge institutions in Corop regions, is conducive to high-tech economic activity in a region. In particular, we test whether the presence in a region of a university, a university of technology or non-academic (private) research institutes (for agricultural, medical, scientific and societal research) makes a difference in terms of high-tech activity. The Netherlands has 11 universities without any clear focus on technology and a further 4 universities of technology in Delft, Enschede, Eindhoven and Wageningen. Non-academic research institutes add up to 1820 in total. The regional impact achieved by such institutions obviously depends on their size. To account for size differences, the presence of non-academic research institutes is weighted by total employees.

A comparison of the results from the model developed here with an earlier study using data from Statistics Netherlands lacking data on total employees (Van der Panne & Dolfsma 2001) indicates that the availability of more detailed information on this count is highly valuable. Marktselect, a private firm, offers such detailed data for non-academic research institutes and high-tech firms by complementing data provided by Chambers of Commerce with information concerning the exact number of establishments (Statistics Netherlands on the other hand, rounds off in units of 5). For each non-academic research institute and high-tech firm, not only is size in terms of total employees known, but also the year of foundation.

Estimation results naturally hinge on the level of aggregation applied, especially regarding agglomeration externalities (Van Oort 2002). The authors analyse both dependent and explanatory variables at the regional level of Corop, distinguishing 43 regions that are relatively homogeneous though aggregated in economic terms. Alternatively, the focus might be on a more local level, such as city or postal code. It does not seem, however, that such more disaggregated geographical demarcations are more economically homogeneous.[4] In addition, as the Corop level is the prevailing level of analysis in Dutch research on economic geography, its use makes this analysis more comparable to other studies.

The data used allow for use of ordinary-least-squares-technique, which offers results that are most readily interpretable.[5] Two models are estimated, one in which the number of high-tech firms in a region is the dependent variable (Figure 1a), the other, in which high-tech employment in a region is explained (Figure 1b). Both models are relevant: whereas the first is more likely to indicate reasons for a high-tech firm to select a location, the second takes size differences into account and may therefore indicate growth potential. The explanatory variables relate directly to the factors deemed important in the theory. As the relationship between the variables cannot be presumed to be linear at this stage, their logarithms are used. Hence, the following models are estimated at the Corop level:

$$\ln Y_{1,2} = \alpha + \beta_1 \ln(\text{share of bachelors and professionals in the regional labour market}) + \beta_2 \ln(\text{share of technicians in the regional labour market}) + \beta_3 \ln(\text{agglomeration externalities}) + \beta_4 \ln(\text{university}) + \beta_5 \ln(\text{university of technology}) + \beta_6 \ln(\text{non-academic research institutes}) + \varepsilon$$

Where: Y_1 = number of high-tech firms in Corop region (Fig. 1a), and
Y_2 = total high-tech employment in Corop region (Fig. 1b)

Table 1 presents the results of our analysis. The models using logarithms of variables perform better than models where they are not used (not presented in this paper). This indicates that the relationships between the variables are indeed non-linear. The results of each of these models are discussed in the following section, which also compares the two in order that some of the dynamics of high-tech economic activity throughout the Netherlands might be understood.

RESULTS

Care should be taken in interpreting Fig. 1. A number of elements are striking. The economically-active Rotterdam region shows little high-tech: its main sectors are transport and the chemical industry. The southeast again proves to be the region where technology-intensive firms locate (Wintjes 2001). It remains to be seen if the Twente region, a Central-eastern Corop region bordering Germany with a university of technology in the city of Enschede, can convert itself from being a low-tech region traditionally strong in textiles etc., and become a high-tech region. The region is home to a few larger high-tech firms, subsidiaries of other firms that do most of the research (Ministry of Economic Affairs 1997). A comparison of Figure 1a and Figure 1b shows which regions have relatively smaller high-tech firms, the Central Veluwe and Northern Groningen being cases in point. Regions with relatively far more larger high-tech firms show up where Corop regions in Figure 1b have a darker shade of grey than in 1a.

Table 1. *Two models explaining the location of high-tech activity.*

		Number of high-tech firms (fig 1A)		Total high-tech employment (fig 1B)	
		Beta	t-value	Beta	t-value
Labour market	Technicians	–0.08	–0.35	–0.32	–0.71
	Bachelors and professionals	0.23	1.23	0.50	1.29
Agglomeration externalities	Agglomeration Index‡	0.37	0.72	1.44	1.37
Knowledge infrastructure	University	–0.29	–1.43	–0.62	–1.45
	University of technology	0.32	1.18	0.48	0.84
	Research institutes	0.39	8.68*	0.60	6.50*
Adjusted R-squared		0.76		0.59	

* Significant at 1% level.
‡ Values given are averages of 4 dummies representing 5 ordinal categories of agglomeration.

Table 1 shows that the regional labour market is not explanatory for high-tech location. Foreign studies indicate that labour markets are an important factor in deciding the attractiveness of various regions (cf., Malecki 1991; Weiss 1995). So the Netherlands stand out in this respect. Observations on the Amsterdam region, with relatively many high-tech firms and substantial high-tech employment as shown by Figure 1, corroborate the authors' results about the labour market: a third of Amsterdam's labour force does not live in the region and commutes to and fro (Van der Vegt *et al.* 2000). Indeed there was in the Amsterdam region during 1988–93 an increase in numbers of 'higher technicians, mathematicians and natural scientists' (Van der Vegt *et al.* 1995). Indicating considerable willingness to commute, this is consistent with the authors' finding that regional labour market characteristics are not explanatory.

As is the case for the labour market, agglomeration externalities do not play a role in explaining the location of high-tech: the coefficients are not significant. This agrees with Atzema (2001) with regard to the Dutch ICT sector. Following Atzema, this may be due to the structure of the Dutch urban system: in a polynuclear urban system, agglomeration externalities arise almost throughout the Netherlands (Atzema 2001). Brouwer *et al.* (1999), however, find that the degree of urbanisation correlates positively with the announcements of new products in specialist trade journals. This seems to be largely caused by their use of a different indicator of innovation.[6] The findings on labour market and agglomeration combined confirm earlier conclusions derived from studies with a slightly different focus that the Netherlands is an 'urban field' (Wever & Stam 1999; Atzema 2001; Heijs & Schmitz 2001).

Contrary to the above, a region's knowledge infrastructure does make a significant difference. The positive effect of the presence of knowledge institutes is consistent with Winter's (1984) argument that high-tech economic activity is science-based. We have delved more deeply into what it is about the knowledge infrastructure that attracts high-tech firms to locate in one region rather than another. Universities and universities of technology make little difference. This contrasts with international research (Engel & Fier 2000), but corroborates results obtained by Ouwersloot & Rietveld (2000) for the Dutch case. Non-academic research institutes have the strongest effect on the location of high-tech in the Netherlands. This finding runs parallel with Fritsch & Schwirten (1999), but contradicts partly with Engel & Fier (2000), who observe that regions with non-academic research institutes do not accommodate many high-tech start-ups.

The two models presented in Table 1 explain 76% and 59% respectively of total variance in high-tech activity. The remaining unexplained variance may be accounted for by additional location factors mentioned earlier, such as living amenities, physical infrastructure and industrial zoning policies (e.g., Ouwersloot & Rietveld 2000).

DISCUSSION: CAUSATION

Statistical significance is not synonymous to scientific significance (cf. McCloskey & Ziliak 1996). In order to stand on firmer ground in the claim that the pattern for the spread of high-tech activity throughout the Netherlands can be explained by the presence or absence of some three variables, some additional tests are presented. The data allow the discrimination among ages of firms and to disentangle the process of cumulative causation that underlies geographical clustering. Is an economic activity located in a particular region because of its specific characteristics, or does the region apparently have attractive characteristics (partly) as a result of the firms that are located there? Assuming that the decision to start a firm at a specific location is a rational one, weighing all important costs and benefits, it makes sense to study the clustering of younger firms. The model presented earlier has been regressed for firms of 3 and 10 years; both for the number of high-tech firms as for high-tech employment. We present only the findings on the number of high-tech firms as these dynamics can be assumed to be more pronounced. Results are presented for 3 and 10-year-old firms (772 and 2222 firms, respectively). After three years, firms in the Netherlands are no longer entitled to any tax breaks intended to encourage entrepreneurship.[7] Three years is thus an important threshold. Ten years is another threshold as during that period, a knowledge base or absorptive capacity of some kind can be assumed to have been established. Subsidiaries of foreign firms in the Netherlands, for example, irrespective of sector, move to another location in the Netherlands within few years in order to take advantage of the knowledge infrastructure in the new location (Wintjes 2001).

Consistent with the findings for the total population of high-tech firms (see Table 1), an attractive labour market does not attract high-tech start-ups. This consistency applies for agglomeration externalities as well, except for agglomeration at the medium level. Agglomerated areas at the medium level do accommodate more high-tech start-ups relative to the least agglomerated regions. The findings for the regional knowledge infrastructure also follow the authors' earlier findings closely: a comparison of the findings presented in Table 2

Table 2. *Explaining the location of young high-tech firms.*†

		Number of high-tech firms (3 year old)		Number of high-tech firms (10 year old)	
		Beta	t-value	Beta	t-value
Labour market	Technicians	–0.13	–0.42	–0.10	–0.32
	Bachelors and professionals	0.26	0.24	0.31	1.47
Agglomeration externalities	Agglomeration Index‡				
	category 1	–	–	–	–
	category 2	–0.07	–0.42	–0.12	–0.84
	category 3	0.71	2.99*	0.52	2.59*
	category 4	0.10	0.40	–0.17	–0.68
	category 5	0.23	1.22	0.22	0.93
Knowledge infrastructure	University	–0.30	–1.04	–0.21	–0.95
	University of technology	0.36	1.02	0.41	1.11
	Research institutes	0.37	4.32*	0.33	4.18*
Adjusted R-squared		0.65		0.65	

* Significant at 1% level.

† Ordinary Least Squares Estimation with White heteroskeasticity-consistent standard errors and covariance.

‡ The Agglomeration Index would be an average of the 4 dummies representing 5 ordinal categories of agglomeration shown.

with those of Table 1 indicates that a strong case can be made about the causality of the presence of a relevant knowledge infrastructure on the location choice of a high-tech firm.

CONCLUDING REMARKS

Of the three factors recognised in the literature – labour market, agglomeration externalities and knowledge infrastructure – the first two are insignificant in explaining the spread of high-tech economic activity throughout the Netherlands. As far as these location factors are concerned the authors agree with other research that the Netherlands is an 'urban field'.

These findings are also noteworthy: the significance of the knowledge infrastructure. This paper shows that some elements in the knowledge infrastructure are more important than others. Non-academic research institutes have a positive influence on the activity of high-tech firms in a region, whereas universities and universities of technology do not.

There are indications of causation; the general findings for groups of firms of more recent origin are tested, the same pattern emerges: younger firms in high-tech industries also tend to locate close to non-academic knowledge institutes and, in contrast to older firms, preferably in agglomerations at the medium level. As proximity appears relevant for specific knowledge relations only, the role of proximity in those relations can be considered at odds with the findings.

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Notes

1. Depicting the data in relative numbers yields roughly the same patterns.
2. Survey Labour Force/Enquête beroepsbevolking (CBS 1999).
3. Variance Inflation Factors are well below critical levels, indicating that multicollinearity is absent.
4. As the aggregated level of the Corop region can be assumed to be more economically homogeneous relative to more disaggregated levels of analysis, one would expect agglomeration effects to show up as a stronger significant factor when measured on the aggregated Corop level than if a more disaggregated level were chosen. The fact that agglomeration proves not to be a factor even under these circumstances indicates the robustness of the authors' findings.
5. The Gauss-Markov theorem suggests that, under the circumstances, the ordinary-least-squares-method is the most appropriate (best linear unbiased estimator). The detailed nature of the data available – where every Corop region, for instance, has at least one high-tech firm – means that the tobit model estimated earlier on the basis of data provided by Statistics Netherlands (Van der Panne & Dolfsma 2001) does not have to replicated here.
5. We refer to Kleinknecht (2000) for a discussion of the advantages and disadvantages of different ways of measuring innovation.
7. Dutch policy to stimulate innovation is mostly of the generic type, with tax measures playing a significant role (Ministry of Economic Affairs, 2002).

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