An exploratory analysis of networking, R&D and innovativeness in the Spanish electronics sector

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Abstract: Using survey data of electronics firms in the three major electronics clusters in Spain, we examine whether those engaged in networking tend to be more innovative and whether local and extra-regional networking have different effects upon innovativeness. We find a positive relation between different types of network relations and innovativeness. In particular, our findings suggest that subcontracting relationships are a way of exchanging technological know-how and are a potentially important element in the innovation process. With regard to the spatial extent of network relations, we find only weak results for differences between local and extra-regional networking.

Keywords: Innovativeness, cooperations, subcontracting, R&D, small firms, electronics sector, local networks.

European Network on the Economics of the Firm (ENEF)

Discussion Paper, 2007

1. Introduction

The last two decades have witnessed important changes in industrial organisation in favour of interconnected production, the outsourcing of non-core activities and global sourcing. Given this background, firms have increasingly been perceived as forming part of networks of inter-linked companies, which has led to a growing interest in networks as organisational forms which affect company performance (Dyer and Singh, 1998; Lechner and Dowling, 2003; Witt, 2004) and, in turn, local economic competitiveness (Sornn-Friese and Sørensen, 2005). Simultaneously, new technologies and companies' innovative capacity are playing an increasingly important role in competitiveness; in other words, technological innovation has become the driving force behind economic growth in modern economies (Romer, 1986).

It has also been argued that the need for new technologies is changing the organisational structure of companies. Innovation is increasingly perceived as the outcome of interactions among multiple actors (von Hippel, 1988; Powell et al., 1996; Harris et al., 2000, Chiaromonte, 2002), and thus inter-company cooperation, via networks, has attracted increasing attention. Despite a steady growth in the subject literature (for a review of research into the relationship between networking and innovation, see Sako, 1994, and more recently, Pittaway et al., 2004), inter-firm networks are still a complex issue and little is yet known about the relationship between company networking and their innovative capability. Theories of agglomeration economies and industrial districts suggest that networking among local firms in agglomerations facilitates knowledge exchange and, subsequently, the innovation process; however, it has also been increasingly recognised that firms seek relationships in geographically wider-ranging networks, in order to satisfy their needs for technological development (Malmberg and Power, 2005).

This issue is of great practical interest; various authors claim that network-based policies would help companies to become more innovative and thus promote the technological and industrial development of cities and agglomerations.

In this paper, we study high-tech companies located in agglomerations, in order to examine whether those engaged in networking tend to be more innovative and whether local and extra-regional networking have different effects upon innovativeness. We also analyse different types of network relations and companies of different sizes.

We find a positive relation between networking and innovativeness. Networking firms always display innovation advantages compared to their non-networking counterparts, even when we analyse sub-samples of firms (e.g. small firms); networking and innovation are associated not only, as expected, within R&D networks but also in all types of networks. Indeed, the firms involved in R&D cooperations are not necessarily more innovative, at least in the short-run, than those involved in other types of cooperations, particularly subcontracting. We also find that companies engaged in R&D cooperation tend to have spatially more extensive network relationships i.e. they cooperate with foreign partners. However, with regard to innovativeness, we find only weak results for differences between local and extra-regional networking.

2. Networking and R&D

Most studies of inter-firm relations draw upon transaction cost theory (Williamson, 1975, 1985) and property rights theory (Grossman and Hart, 1986). According to the seminal work of Coase (1937), a firm will outsource an activity when the perceived costs are lower than those of undertaking the task in-house. This trade-off is affected by the uncertainty associated with the transaction (such as fluctuations in market demand), the frequency of transactions, and the need for transaction-specific investment (asset specificity). The decision is also determined by the cost of establishing and maintaining an external relationship (Williamson, 1975, 1985), which involves search and information costs, bargaining and decision costs and monitoring and enforcement costs (Grossman and Hart, 1986). Both the transaction costs and property rights approaches emphasise the importance of incomplete contracts and ex-post opportunistic behaviour in the decision of whether to engage in networking relations with other companies.

R&D intensity could discourage inter-firm linkages, as high-tech companies attempt to protect specific know-how and intellectual property rights (Teece, 1986, Acemoglu et al., 2004).[1] Contracts are more difficult to specify where exchange is technologically more intensive. Such relationships often imply greater relationship-specific investment compared to, for example, the outsourcing of standardised inputs or processes, which increases the danger of opportunistic behaviour on behalf of the supplier. At the same time, decision rights over investments that require tacit knowledge or particular human capital are more difficult to assign between the two parties. The empirical literature provides some examples of regions where networking and innovativeness at the plant level are not associated (Love and Roper, 2001).

However, networking can also be positively associated with innovativeness.[2] Several authors have argued that innovations are the outcome of interactions between actors,

[1] In the context of international outsourcing, Bardhan and Jaffe (2005), for example, find that the more innovative firms did not offshore their R&D activities.
[2] See Pittaway et al. (2004) for an excellent review.

rather than the efforts of one firm in isolation (Lundvall, 1992). Networking between firms may augment the sharing and diffusion of technological knowledge, which thereby increases the innovative capability of such firms (Powell et al., 1996). Inter-firm cooperation in joint R&D, in particular, can permit companies to share the costs and risks of innovation. Networking can also allow firms a greater specialization of innovative labour; in general, it permits companies to concentrate on their core technological competences and combine their capacities with other companies, in order to create new products they could not have invented by themselves. With regard to outsourcing in the supply chain, subcontracting networks can enable firms to improve their individual products and thereby increase overall innovation by saving both capital and labour resources which may then be redirected towards R&D activities (Suárez-Villa and Rama, 1996).

A further innovation-linked reason for networking is that firms which possess accumulated capital (technological, commercial and social) enjoy advantages in the cooperation "market", as other companies view them as attractive potential partners (Ahuja, 2000).

Network roles, types and plant size: In outsourcing networks, the nature of contracts and the level of trust between clients and subcontractors may determine whether networking stimulates or discourages innovativeness among network partners.

As Sako (1994) argues, subcontractors develop process innovations only when their contracts or agreements with clients enable them to profit from the gains resulting from increased efficiency. Previous research also suggests, according to this author, that suppliers' involvement in product innovation is usually the result of a trustful relationship with clients who otherwise would be unwilling to transfer new knowledge.

One case study finds that, within an Italian textile-apparel network, suppliers are *"better versed in the more technical aspects"*, while clients understand better the needs of the final consumer (Romano and Vinelli, 2001). This result may imply that suppliers focus on process innovation while clients are responsible for direct product innovation within the network. In this paper we study the association between networking and innovation among both clients and subcontractors.

The concept of networking has been used to describe very different kinds of organization (Hobday, 1994), and thus we must distinguish between different types of networks before assessing their relationship to innovation. In addition to subcontracting networks, we specifically examine R&D networks.

The importance of networking for innovation has been particularly emphasised in the case of SMEs (Freel and Harrison, 2006). As they suffer more material constraints, small and medium-sized firms are less able to innovate by themselves, and thus networking is often vital. The empirical literature, however, does not clarify whether the general relationship between networking and innovativeness holds true for such companies. Analysing over 1,600 Spanish manufacturing firms, Bayona et al. (2001) find that size has a positive and significant effect upon R&D cooperation, since large companies enjoy more absorptive capacity. Using Community Innovation Survey data for the UK, Torbett (2001) concludes that the larger the firm, the more positive are the effects of technological collaboration on its innovation intensity (i.e. expenditure on R&D, the acquisition of machinery and training, as a proportion of company turnover); by contrast, he finds a far more positive effect of technological collaboration upon innovation performance (i.e. the proportion of turnover due to new products) among small firms than among larger companies. Consequently, he recommends taking company size into consideration when assessing the impact of collaboration upon innovation. These studies, however, focus on all types of networked firms, and not exclusively firms in agglomerations. Suárez-Villa and Rama (1996) show that small networked electronics companies clustered in intra-metropolitan Madrid use their resources available for innovation more efficiently than firms, of whatever size, located in peripheral regional locations. In the present study, we investigate whether networking and innovation are associated when the clustered firms are small.

Space: Theories regarding agglomeration economies and industrial districts argue that networking among firms in clusters facilitates knowledge exchange. The reasoning is that knowledge is costly and its long-distance transmission is difficult (Jaffe et al., 1993); thus, spatial proximity helps firms to share information and diffuse knowledge, particularly tacit knowledge (von Hippel, 1994). Proximity facilitates face-to-face interaction, which is often argued to be essential for interactive learning and innovation (see, for example, Feldman (1999) for a review of innovation and agglomeration economies). Studies of industrial districts furthermore emphasise the importance of shared values, trust and social embeddedness among network partners (Becattini, 1990, Brusco, 1999). The innovation milieu model of Camagni (1991) also stresses informal relationships between firms and collective learning that is facilitated by geographical proximity. There is also a growing literature on "learning regions" that link the concepts of innovation and locality (see, for example, Asheim, 1999).

Traditionally, the literature has focused on the formation and benefits of network relations among small and medium-sized enterprises (SMEs) and other local actors. Recent research into this topic, however, indicates that the focus on local relations has obscured the importance of relations that clustered firms with their non-clustered counterparts. It has been argued that extra-regional relations have been both underestimated and largely overlooked (see, for example, Henderson et al., 2002; Coe et al., 2004; Giuliani et al., 2005; Malmberg and Power, 2005; and Wai-chung et al., 2006). Particularly, companies in high-tech sectors require an increasingly wide range of technologies to produce goods, which may force them to look for outside suppliers for at least part of their innovation needs (Dyer and Singh, 1998, Brusoni et al., 2001). In this context, cross-locality relations are important to access knowledge produced in different spatial contexts; such relations increase local capabilities by enhancing firms' abilities to adapt to a rapidly changing and global economy.

In this paper, we explore both the intra- and extra-local networks of companies, concentrating on their R&D networks.

3. Data

The data used in the following statistical analyses were obtained from a plant-based survey conducted in 1999 and focused on electronics establishments principally involved in manufacturing. The firms included in the survey were selected by consulting the 1996 ANIEL (the National Association of Electronics Industry) directory. From the 322 questionnaires sent to establishments in the regions of Madrid, Catalonia and the Basque Country, we obtained 184 responses suitable for use in the present analysis.

Our study is limited to the electronics industry for several reasons. Firstly, by concentrating on a particular sector, the problem of unobserved heterogeneity is reduced, since firms in different sectors are likely to show different patterns of spatial behaviour, due to fundamental differences in product characteristics. One of the reasons for selecting the electronics sector is that cooperative agreements of the type studied in this paper have been increasingly used in this industry (see, for instance, European-Commission, 1997). At the same time, R&D has attained vital importance in the competitiveness of the electronics sector. Although this industry has attracted increasing attention from researchers, analyses of Southern European countries, such as that undertaken by the present study, are rare. The particular interest in this sector stems from the fact that many successful firms are apparently clustered and therefore benefit from local linkages (Arita and McCann, 2002).

We concentrate on electronics companies located in Madrid, Catalonia and the Basque Country. According to figures based on the National Survey of Companies by the National Statistics Institute (*Instituto Nacional de Estadística- INE*) for the year 1997, these three regions house 77.3% of all Spanish electronics establishments. ANIEL (1998) estimates that together they account for over 84% of Spanish electronics production. Rama and Calatrava (2002) define these three regions as distinct clusters of electronics firms; remaining production in Spain is geographically dispersed among many other regions. The three regions selected include different sub-sectors of electronics production (Rama and Calatrava, 2002): Madrid specialises in telecommunications, defence and industrial electronics, Catalonia in consumer electronics and the Basque Country in industrial electronics (for more details on the specific characteristics of production networks in these three regions, see Rama and Calatrava, 2002).

The sample is representative of establishments with over 20 employees. The survey covers 61% of all such establishments in the Madrid region, 65% in Catalonia and 80%

in the Basque Country, and targets small firms; in the final sample, 76 firms have 20 or fewer employees. However, our sample is less representative in this case, covering approximately 35% of such firms in Madrid, 10% in Catalonia and 20% in the Basque Country.

The sampled companies were asked about different types of cooperations, and subcontracting relationships in particular, as well as about R&D intensity and product and process innovations. Other information collected by the survey concerns the size, age, ownership and company structure related to the location of the headquarters and other plants owned by the company.

4. Empirical results

Cooperations are very common among electronics firms in the three Spanish clusters, subcontracting being the principal form of cooperation. Of the 184 companies in the sample, 94 engaged in some form of cooperation, and 88 of these in subcontracting. In turn, 85 of these establishments subcontracted out, while 3 worked exclusively as subcontractors and 54 companies were involved in two-way subcontracting i.e. they acted as both clients and suppliers.

The establishments involved in some form of cooperation, or specifically engaged in subcontracting as clients, are generally older, larger and multi-plant firms. This contradicts the view that it is particularly small firms which employ external linkages to supplement and complement their limited internal resources. Costs related to establishing, monitoring and reinforcing network relationships should be less onerous for larger firms, as these are likely to have the necessary human and physical capital and market power necessary to gain information and enforce contracts.

However, we find no evidence that performing subcontracting functions is associated to plant size, in line with an earlier study of Madrid electronics industries (Rama et al., 2003). In distinction to the hub-and-spoke districts studied by other authors (Gray et al., 1996), subcontractors in Spanish electronics agglomerations are not necessarily small firms.

4.1. Networking and innovation

Table 1 displays the inputs used by firms to produce innovation. We find that the networked firms in our sample are significantly more R&D intensive. This holds true whether R&D intensity is measured in relation to the number of employees or sales and costs. Networked firms also tend to have a comparatively large number of engineers.

Distinctions are also apparent when we compare the outputs of companies' innovative activities. In line with other recent linkage studies, we find that networked firms are more likely to innovate (see, for example, Eraydin and Armatli-Köroğlu, 2005). A significantly higher percentage of networking firms have launched new products and offer a greater average number of new products which represent a greater share of total sales. The literature on networking interprets a high share of new products in turnover as an indicator of the commercial success of a company's innovative activities (Love and Roper, 2001; Torbett, 2001). Firms that work as subcontractors have also launched significantly more new processes i.e. an average number of almost four processes in the previous three years, compared to an average of only one for non-networkers. Our data suggests that subcontractors are no longer mainly used as a source of cheap labour for the client, as was the case in an early phase of the Madrid electronics industry (Benton, 1990). On the other hand, our results agree with those of Roper (2001), in that networking is positively related to innovation; by contrast, his study of networking Irish firms does not conclude that such companies are more likely to launch successful innovations. The lower part of Table 1 displays the relationship between different types of cooperations and R&D and innovativeness in SMEs[3]. In general, the pattern of relations is very similar.

To summarise, networked firms are not only significantly more innovative, but their innovations are more successful. While networked firms show greater R&D expenditure, innovation in networked companies may also benefit from learning-by-doing and shop-floor inventions,. As argued by Suárez-Villa and Rama (1996) networked companies may make more efficient use of the financial and human resources at their disposal for innovation, owing to their increased flexibility.

In Table 2 we present some controlled associations between internal sources for innovation and networking as an external source and innovativeness at the plant level. We carry out probit estimations where the dependent variables are binary indicating, respectively, whether or not the establishment has introduced new products and new processes over the three years previous to the survey. For internal innovation sources, we include R&D expenditure measured as proportion of R&D in total turnover and skilled labour defined as the proportion of engineers in the workforce. In terms of external sources of innovation we test for cooperations in general (column 1) and more specifically for subcontracting out (column 2), and working as subcontractor (column

[3] Here we define SMEs as firms with less than 100 employees.

3).[4] Finally we include controls for the size of establishments (measured as total number of employees), and unreported dummy variables for product type and region-specific differences. The estimation results indicate that product innovation is significantly related to R&D expenditure as well as to co-operations in general, subcontracting out, and working as subcontractor. For process innovation, our results indicate a positive relation to size and to co-operations in general and working as subcontractor in particular, but not to subcontracting out. Consistent with Romano and Vinelli (2001) and the results in Table 1 this supports the view that suppliers focus on process innovation while clients are in a better position for direct product innovation.

4.2. R&D cooperations

We turn now to a specific type of cooperation i.e. in R&D. While production subcontracting is the most common form of inter-firm cooperation, cooperations for technological innovation are the second most frequent form of cooperation in our sample. Indeed, firms which state that they participate in R&D cooperations are also more likely to engage in subcontracting. In our sample, 95% of firms involved in technology cooperations are also engaged in subcontracting (92% subcontracted out, while the rest accepted subcontracted projects). In general, firms which cooperate in R&D are more likely to cooperate in other spheres. Of the 39 firms in our sample which cooperated in R&D, only 2 exclusively collaborated in R&D ventures

As with cooperations in general, companies who collaborate in R&D are in general larger and part of multi-plant companies. Establishments which cooperate in R&D also

[4] These are not exclusive categories, thus we introduce the different types of networking in alternative specifications.

tend to be more R&D intensive and employ more engineers than non-cooperating firms (Table 1); this also holds true for SMEs. In Table 1 we compared networking and non-networking firms. In Table 3 we present a comparison of firms specifically involved in R&D cooperations and those involved in other types of cooperation. Results demonstrate that companies specifically involved in R&D cooperations display not only greater R&D intensity than non-networking firms but also significantly greater expenditure on R&D than those firms engaged in other types of cooperations (Table 3).

This indicates that in-house R&D and R&D cooperations are complements rather than substitutes. This result contradicts the findings of Love and Roper (2001) for UK, German and Irish plants. As with cooperations in general and subcontracting, establishments engaged in R&D cooperations seem more innovative than firms which are not involved in R&D cooperations (Table 1). Nevertheless, firms involved in R&D cooperations are not necessarily more innovative than those involved in other types of cooperations, and nor are their innovations more successful in the market, as measured in terms of the share of new products in turnover (Table 3). Indeed, in the controlled associations reported in column 4 of Table 2, R&D cooperations are not significant. This could indicate that, for instance, outsourcing and the exchange of the face-to-face, tacit knowledge commonly involved in this type of organization is, *per se,* a source of product and process innovation at the plant level, even in the absence of specific formal R&D agreements between partners. Another possible interpretation is that companies engage in R&D networking for a different reason than they engage in production networking, namely to explore new knowledge, which usually does not bring immediate rewards. However, the results should be treated with some caution, given that R&D networks and other types of networks overlap in our sample.

4.3. Local versus cross-locality networking and innovation

Regarding the differences in the geographical location of partners among sampled firms that have engaged in various forms of cooperation, our data indicates that production networking (e.g. joint production or subcontracting) is the most localised type of cooperation, together with joint purchase of inputs and materials. In contrast, firms engaged in cooperations involving joint export activities and joint technological innovation have more spatially extensive relationships. On average, approximately 57% of firms' network partners are located locally, 22% nationally and 17% in other countries. Firms engaged in networks involving technological cooperation display a significantly greater extent of cross-border cooperations than other types of collaboration (27.8%) and somewhat fewer local and national linkages.

In Table 4 we investigate whether firms with cross-locality networks are more innovative than more locally embedded firms. Our data indicates that firms with cross-locality networks have available more resources concerning R&D per employee and the average number of engineers. With regard to innovation output and its commercial success, we find no significant difference between those two groups of firms, with the exception of clients involved in cross-locality networks, who launched more new industrial processes than clients involved in intra-locality networks. By contrast, we could find no significant differences between firms involved in cross-locality networks and more locally embedded companies, with respect to the average number of new products launched by their plants in the preceding years or the share of these products in sales. However, when we look specifically at R&D cooperations we find that companies engaged mainly in local networking have launched significantly more new processes. Again, we specifically examined SMEs and found very similar results.

5. Conclusions

In this paper we have studied electronics firms in the three main electronics clusters in Spain, in order to investigate the relationships between networking, R&D and innovativeness.

We find a positive relation between networking and innovativeness. A greater percentage of networked firms in our sample have launched new products (with also a greater share in turnover), compared to non-networked firms. For establishments engaged specifically in R&D cooperations or working as subcontractors, we also find a positive relation with process innovation when comparing them to non-collaborative establishments. This finding confirms the specific importance of process innovation for suppliers in other industries (Romano and Vinelli, 2001). However, firms involved in R&D cooperations are not necessarily more innovative, at least in the short-run, than those involved in other types of cooperations; this indicates that other types of cooperation and, (in particular) subcontracting are mechanisms for exchanging technological know-how and are a potentially important element in the innovation process.

In our sample, networking firms devote more internal resources to innovation than non-networking firms, suggesting that external knowledge is a complement to rather than a substitute for internal knowledge. Theories regarding agglomeration economies and industrial districts have emphasised the importance of networking among local firms for the innovation process. In our study, we observe that while local networking is important, extra-regional cooperations are by no means negligible. In particular, R&D cooperations tend to involve cross-locality networking to a greater degree than other types of cooperations. However, in terms of innovativeness, conclusive differences between local and extra-regional networking are not apparent.

Our results support the view that network-based policies may contribute to increased levels of innovation in regions; however, at least in the high-tech electronics industry, companies involved in such programmes need to possess, from the very outset, a certain amount of in-house resources (i.e. expenditure allocated to R&D and skilled labour) for innovation. Otherwise, their policies may be unsuccessful.

A final note of caution should however be sounded. In this paper, we have presented relationships between different types of cooperations and a number of plant-level characteristics relating to in-house R&D and innovativeness. It is important to emphasise that results indicate associations, but should not be taken to prove causal relations. Firms make decisions regarding cooperations together with others concerning their size, R&D and a series of other company- and plant-level characteristics that cross-sectional data cannot easily control for.

6. Acknowledgements

A previous version of this paper has been presented at the Oslo Workshop on Entrepreneurship, Innovation and Innovation Policy – a look at SMEs, 9-10 November 2006. The authors gratefully acknowledge financial support from the Social and Economic Council of the Community of Madrid, as well as support from grants SEC97-1373 (CICYT) and 06/0092/1997 provided by the Community of Madrid.

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Table 1: Networking, R&D and innovations

	Cooperations		Subcontracting out		Work as subcontractor		R&D Cooperations	
	yes	**no**	**yes**	**no**	**yes**	**no**	**yes**	**no**
All plants **No.**	94	90	85	96	57	121	39	141
R&D expenditure per employee (in euros)	**9285.2**	**4024.0 ***	**10194.7**	**3922.9 ***	8361.4	6072.0	**13886.0**	**4675.9***
R&D expenditure as proportion of total sales	**0.066**	**0.037 ***	**0.070**	**0.036 ***	**0.068**	**0.44 ****	**0.076**	**0.045 ***
R&D expenditure as proportion of total costs	**0.092**	**0.046 ***	**0.099**	**0.045 ***	0.090	0.061	**0.134**	**0.054 ***
Average number of engineers	**32.4**	**16.5 ****	**35.1**	**5.6 ***	20.9	18.9	**37.6**	**14.3 *****
Engineers as proportion of total employees	**22.3**	**17.1 *****	**23.8**	**5.9 ***	**25.4**	**17.7 ****	**27.6**	**17.7 ***
Firms launching new products	**91.1**	**67.8 ***	**92.5**	**67.7 ***	**90.7**	**74.4 ***	**94.4**	**75.0***
Average number of new products	**11.8**	**3.9 ***	**12.3**	**4.0 ***	**12.4**	**6.0 *****	12.1	7.0
Average share of new products in total sales	**35.6**	**21.9 ***	**34.7**	**22.9 ***	**36.6**	**25.0 ****	**40.1**	**26.1 ***
Firms launching new processes	51.2	42.4	50.7	42.9	**61.2**	**40.0 ***	55.9	44.7
Average number of new processes	2.3	0.99	2.40	1.03	**2.95**	**1.05 *****	**3.8**	**1.1 ****
SMEs **No.**	59	74	52	81	36	97	22	111
R&D expenditure per employee (in euros)	**7936.4**	**4050.2 ****	**8816.8**	**3929.0 ****	6031.4	5674.8	**12294.4**	**4441.6 ***
R&D expenditure proportion of total sales	**0.071**	**0.039 ***	**0.078**	**0.039 ***	**0.073**	**0.047 ****	**0.089**	**0.046 ***
R&D expenditure as proportion of total costs	**0.096**	**0.049 ****	**0.109**	**0.047 ***	0.083	0.066	**0.161**	**0.052 ***
Average number of engineers	5.0	4.0	5.4	3.8	4.9	4.3	**6.6**	**3.9 *****
Engineers as proportion of total employees	21.4	16.5	**23.4**	**15.8 ****	**24.4**	**17.1****	**29.7**	**16.3 ***
Firms launching new products	**91.1**	**68.5 ***	**93.9**	**68.4 ***	**91.2**	**73.6 ****	**95.0**	**75.0 ****
Average number of new products	**7.7**	**3.3 *****	**8.0**	**3.5 ****	**10.0**	**3.5 ***	4.3	5.5
Average share of new products in total sales	**35.0**	**21.1 ***	**33.0**	**22.4****	**34.7**	**23.7 ****	**39.1**	**25.0 ****
Firms launching new processes	46.3	42.9	44.7	43.4	**61.3**	**38.2 ****	57.9	42.3
Average number of new processes	2.7	0.83	2.8	0.89	**3.9**	**0.76 ****	**5.4**	**0.92 ****

Note: * denotes significance at the 1% level, ** the 5% level, and *** the 10% level based on Ttest of means difference for continuous data and Pearson chi2 test of independence for categorical data.

Table 2: Probit estimations

	Product innovation				Process innovation			
	(1)	**(2)**	**(3)**	**(4)**	**(1)**	**(2)**	**(3)**	**(4)**
Size: number of employees	0.001	0.001	0.002	0.002	0.003*	0.003**	0.002***	0.003**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
R&D expenditure as ratio to total sales	11.534 *	12.033 *	13.741 *	11.737 *	0.885	0.849	1.048	1.360
	(4.318)	(4.462)	(4.762)	(4.327)	(2.220)	(2.248)	(2.195)	(2.187)
% of engineers in total no. of employees	0.009	0.007	0.004	0.008	0.006	0.005	0.004	0.005
	(0.009)	(0.009)	(0.010)	(0.009)	(0.008)	(0.007)	(0.008)	(0.007)
Cooperations in general	1.000*				0.473***			
	(0.342)				(0.262)			
Subcontracting out		1.053*				0.357		
		(0.364)				(0.268)		
Working as subcontractor			1.150*				1.121 *	
			(0.457)				(0.310	
Cooperations involving R&D				0.547				0.308
				(0.452)				(0.300)
No of observations	150	148	147	150	146	144	143	146
Log likelihood	53.151	56.468	52.758	57.209	79.039	78.108	72.718	80.167
Pseudo R^2	0.278	0.283	0.263	0.223	0.217	0.216	0.2651	0.206

Note: * denotes significance at the 1% level, ** the 5% level, and *** the 10% level; all estimations include cluster dummies and electronic sub-sector dummies for establishments reporting important shares of turnover related to the following categories: electronic components, telecommunication equipment, informatics and office equipment, consumer electronics, other electronics products, non-electronic products, and services.

Table 3: R&D cooperations

	All plants		SMEs	
	with R&D cooperations	**with other types of cooperations**	**with R&D cooperations**	**with other types of cooperations**
R&D				
R&D expenditure per employee (in euros)	**13886.0**	**5979.8 ****	12294.4	5378.1
R&D expenditure as proportion of total sales	0.07	0.06	0.09	0.06
R&D expenditure proportion of total costs	**0.13**	**0.07 *****	**0.16**	**0.06 ****
Average number of engineers	37.6	29.6	**6.6**	**3.5 *****
% of engineers in total no. of employees	**27.6**	**18.7 ***	**29.7**	**15.7 ***
Innovations				
Firms launching new products	94.4	87.8	95.0	88.6
Average number of new products	12.0	12.2	4.3	9.7
Average share of new products in total sales	40.1	33.0	39.1	32.5
Firms launching new processes	55.9	48.9	57.9	41.2
Average number of new processes	3.8	1.4	5.3	1.1

Note: * denotes significance at the 1% level, ** the 5% level, and *** the 10% based on Ttest of means difference for continuous data and Pearson chi2 test of independence for categorical data.

Table 4: R&D, innovativeness and local versus cross-locality networking

	Cooperations		Subcontracting out		Work as subcontractor		R&D Cooperations	
	Local	**Cross-locality**	**Local**	**Cross-locality**	**Local**	**Cross-locality**	**Local**	**Cross-locality**
Number of establishments	47	38	68	15	29	24	18	21
R&D								
R&D expenditure per employee (in euros)	**6614.2**	**13750.8 *****	9312.5	15147.4	7760.7	10486.7	**6707.0**	**21065.0 *****
R&D expenditure as ratio to total sales	0.06	0.07	0.07	0.08	**0.09**	**0.04 ****	0.07	0.08
R&D expenditure as ratio to total costs	0.09	0.11	0.09	0.15	**0.11**	**0.04 *****	0.12	0.15
Average number of engineers	**7.1**	**53.0 ***	**24.8**	**80.2 ****	7.3	40.2	**7.8**	**61.6 ****
% of engineers in total no. of employees	20.8	25.7	22.7	28.2	27.6	26.2	26.6	28.5
Innovations								
Firms that launched new products	90.70	92.1	92.2	93.3	89.4	91.7	93.3	95.2
Average number of new products	13.0	6.2	13.4	7.3	12.9	11.9	18.2	7.1
Average share of new products in total sales	36.2	38.1	34.5	37.5	31.0	42.6	37.8	42
Firms that launched new processes	50.0	55.9	**46.7**	**71.4 *****	54.2	72.7	**73.3**	**42.1 *****
Average number of new processes	3.17	1.46	2.5	2.3	1.3	1.5	6.6	1.1

Note: Columns headed "local" summarise the characteristics of establishments with more than 50% of their net located within the same region. Columns headed "cross-locality" present the characteristics of establishments with more than 50% of network partners outside their own region. * denotes significance at the 1% level, ** 5% the level, and *** the 10% level based on Ttest of means difference for continuous data and Pearson chi2 test of independence for categorical data.