Technological innovation and interfirm cooperation: an exploratory analysis using survey data from manufacturing firms in the metropolitan region of Vienna

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Keywords: Electronics, Manufacturing, Innovation, Networking, Regional Innovation Systems

Abstract
This paper centres around two research questions: *first*, the identification of five types of networks that manufacturing firms located in the metropolitan region of Vienna may have created for different purposes; and *second*, the question to what extent the likelihood of interfirm cooperation is conditioned by the general profile of manufacturing establishments and their technological resources. Although this paper focuses on the manufacturing sector a special emphasis is placed on the electronics industry. The study utilizes a recent postal survey providing data on size and organization, products and markets, research and development, innovation and interfirm relationships. The analysis of the first question finds that: *first*, networking does not yet seem to be a popular managerial and organisational concept for manufacturing firms located in the metropolitan region of Vienna; *second*, networking activities are primarily based on vertical relationships (customer, manufacturer supplier and producer service provider networks) rather than on horizontal linkages (producer networks, industry-university linkages); *third*, networks focusing on the later stages of the innovation process are less common than those focusing on the earlier stages; *fourth*, firms tend to rely on sources of technology from national and – especially – international networks. It appears that metropolitan networking is less common than has been thought. For technical advance spatial proximity does not seem to be very important. Turning to the second research question of the study, focusing on the adoption of the managerial and organizational concept of networking, the results are bolstering the argument that establishment traits and technology related-capabilities do play a role. The results achieved reveal, for example, that in-house research skills are a very good predictor for industry-university relationships.

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Abstract

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1. Introduction

The extensive use of the terms cooperation and networking may owe something to fashion, as does globalization. But it also reflects an initial – though still imperfect – recognition that technological innovations are less and less the outcome of isolated efforts of the individual firm. They are increasingly created, developed, brought to the market and subsequently diffused through complex mechanisms built on interorganisational relationships and linkages. Interfirm relations are built when costs of governance are outweighted by gains provided by the specialisation of activities, by sharing costs of joint infrastructures, interfaces and indivisibilities, and by the advanatages associated with technological externalities created by cooperation partners. Innovation-related cooperation has been around for some time, but during the past two decades there has been an upsurge of interest in this kind of collaboration. This may be attributed to several factors: particularly, to the increased pace of technological development, the rising complexity and variety in knowledge necessary for technological innovation, the trend towards the fusion of disciplines in previously separate fields, and the need to share research and development costs.

The literature on such networks has also grown rapidly in recent years. But most of it is theoretical or conceptual in nature. There is a need to move beyond theoretical reasoning and to identify the various types of networks that firms in specific regional environments create for different strategic purposes in order to gain deeper understanding on interfirm cooperation (Malecki et al. 1999). This paper makes a modest attempt to, first identify five types of networks that manufacturing firms located in the metropolitan region of Vienna may have created, and, then to explore to what extent the likelihood of interfirm cooperation is conditioned by the general profile of the establishments and their technological resources, using logit analysis. Although our paper focuses on the manufacturing sector a special emphasis is placed on the electronics industry.

The remainder of the paper is structured as follows. Section 2 outlines the background theory of this study which lies at the crossroads of the resource-based view of the firm and the network approach of innovation research. Section 3 follows with a brief description of the survey approach and the general traits of the manufacturing firms surveyed in the metropolitan region of Vienna. Section 4 focuses on the first question, centred on the identification of five types of networks: customer, manufacturing supplier, producer service provider and producer network relations as well as cooperations with universities/research institutions. Section 5 brings together strands of the resource-based view of the firm with analysing the second research question, results of logit analysis used to discuss the extent to which establishment traits and technology-related capabilities condition interfirm networking of various types. The final section summarizes the research findings and points to directions for future research.

2. Background theory

This paper lies in the tradition of the network approach of innovation research which departs from the single-act philosophy of innovation and views technological innovation as much a social process as a technical process. This social process of technological innovation involves interaction between individuals within the system, both internally within the firm and between members of the firm and outside organizations. The network school of innovation research (see, e.g., Häkansson 1987) attempts to explain the innovation process in terms of the network relationships between these various actors. Network principles are seen to apply both within and between organizations. Internally, networking occurs between R&D, production and marketing through new forms of product development practice, and externally through relations between the producers, its suppliers, customers and other organisations, notably research institutions and universities (see, e.g., Lundvall 1988).

The notion of absorption capacity of a firm is central to the networking approach of innovation. The absorption capacity of an organisation refers to the ability to learn, assimilate and use knowledge developed elsewhere through a process that involves substantial investments, especially of an intangible nature (Cohen and Levinthal 1989). This capacity crucially depends on the learning experience which in turn may be enhanced by in-house R&D activities. The concept of absorption capacity tells us that in order to be able to access a piece of knowledge developed elsewhere it is necessary to have done R&D on something similar (Saviotti 1998). Thus, R&D may be viewed to serve a dual, but strongly interrelated role: first, to developing new products and production processes, and second, to enhancing the capacity to learn.

The degree to which R&D is important for the development of a firm's absorption capacity largely depends on the pace of advance and the characteristics of outside knowledge (such as the degree of codification and the degree of appropriability) in a specific technology field. The faster the pace of advance of the field is, the lower is the degree of codification, the higher is the degree of appropriability and the greater is the effort needed to keep up with the developments. The more tacit a specific piece of knowledge, the more time and effort are usually required to learn the code of that piece and to transform it into commercially and firm specific relevant knowledge.

Firms, especially smaller firms, that lack appropriate in-house R&D capacities have to develop and enhance their absorption capacity by means of other sources, such as by learning from customers and from suppliers, by interacting with other firms and by taking advantage of knowledge spillovers from other firms and industries (Lundvall 1988). These sources provide the know-why, know-how, know-who, know-when and know-what important for entrepreneurial success (Johannisson 1991, Malecki 1997). Network arrangements of different kinds provide a firm that assistance necessary to take advantage of outside knowledge.

The paper links strands of the resource-based view of the firm with analyzing the likelihood of interfirm cooperation. The resource-based view of the firm, with its focus on firm-specific characteristics for analyzing firm behaviour and competitive strategy, has its roots in the work of Penrose (1959), Nelson and Winther (1982) and other work on industry life cycles, and has been developed by Wernerfelt (1984), Barney (1986), Teece (1988) among others, largely as a reaction to Porter's (1980) „competitive forces" scheme of firm strategy. In Porter's framework, the performance of a firm is essentially determined by the structure of the industry within which it operates, namely by the five forces of entry barriers, substitutes, buyers´ and suppliers´ bargaining power, and intra-industry rivalry. Thus, the primary determinants of success are external to the firm, resting on characteristics of the industry structure rather than on the firm's internal managerial, technological, marketing, and other resources. Therefore, the competitive forces view of the firm says little, if anything, on the firm's ability to innovate (Mowery et al. 1998).

In contrast, the resource-based view of the firm argues that a business firm is best viewed as a collection of tangible and intangible resources that each firm develops in an idiosyncratic way. It emphasizes the inherent inmobility of such resources and the long time horizon involved in generating new resources through continual learning and search activities. Such resources may be physical such as product designs or production techniques, or intangible such as knowledge of specific user needs or idiosyncratic routines for handling the marketing and distribution of products. Such capabilities are context-specific and partially knowledge-based. Much of the relevant knowledge – especially the newer parts that we consider the frontier – resides within tacit forms in the minds of experienced individual researchers or engineers. This person-embodied knowledge is generally difficult to transfer and is often only shared by colleagues if they know the code through common practice. On the one side a given type of knowledge may become more codified as it matures, on the other side the act of embodying it into specific goods and services may reintroduce some tacitness again (Fischer 1999).

Market transactions for the sale or acquisition of such firm-specific resources are difficult to organize and are subject to considerable risks of failure (Teece 1982). The same characteristics that enable a firm to extract a sustainable rent stream from its resources make it also difficult for firms to acquire technological knowledge from external sources through market channels (Morwey et al. 1998).

3. Sampling methodology and general traits of the surveyed firms

Any empirical study of innovation and network activities requires primary data collection, postal or interview based surveys, taking the individual manufacturing firm as unit of analysis rather than the enterprise of which it may be part of. We have chosen a postal survey of manufacturing firms as the appropriate methodological tool for eliciting basic quantitative data. Although such an approach allows the data to be tailored to specific research needs, it is not necessarily problem-free. Its most often cited disadvantages include potential problems of external and internal validity. External validity refers to the ability to generalize research findings and internal validity to the lack of non-random error or biases in survey responses (see, for example, Sivitanidou, 1999). As in most survey efforts, both such biases may be well present in this study, thus calling for a careful interpretation of the survey results. Particularly, sampling issues that might contribute to problems of external validity may have not been fully addressed due to the lack of an error-free comprehensive list of manufacturing firms. Problems of internal validity may be present to a lesser extent due to substantial efforts towards designing the questionnaire.

More specifically, building on an extensive review of the relevant literature and similar survey efforts, a set of preliminary survey questions was first developed and then pre-tested within the framework of an international project of the Regional Potential and Innovative Networks in Metropolitan Regions in Europe. The questionnaire was then revised and mailed to a larger sample of over 1,300 manufacturing companies (with at least 20 employees) using the *Firm and Product Database Register* (1995) obtained from the Austrian Research Centre Seibersdorf. The latter included many addresses that were invalid and, as evident from the returned questionnaires, addresses of companies that were out of business or were offering services, but were not engaged in manufacturing. 908 manufacturing firms were identified in this way to define the population of firms relevant for this study.

The postal survey was launched from September 4 to December 15, 1997 in the metropolitan region of Vienna, that is the city of Vienna and related communities. The package forwarded to all the 908 firms included a covering letter explaining the aims of the survey and guaranteeing the confidentiality of the information provided, the text of the questionnaire (together with the definitions of the crucial terms used) and a pre-stamped reply letter.

Remainder letters were forwarded to non-respondents 3-4 weeks after the first mailing. Follow-ups were undertaken to elicit responses to questions left unanswered.

The returned questionnaires represent 22,5 percent of the identified population. This figure is not as high as expected, but still acceptable given the conditions under which the survey was carried out. Factors contributing to this outcome include the following: *first*, the high number of surveys and questionnaires to which manufacturing firms are asked to respond; and *second*, the nature of the topic which many small firms think does not concern them, but rather is intended for large firms with formal R&D networking activities.

Table 1 presents a breakdown of the sample responses and illustrates the response rates for seven industry sectors, using the standard NACE classification on the basis of information such as product description as provided by the firms, and for four firm size classes as measured by employment. The sample can be seen broadly to reflect the overall structure of the total population. Most of the firms in the industry sector "Electrical and Optical Equipment" in table 1 are classified as electronics companies. As expected, the lower response rate by small local manufacturing units may be attributed to the fact that such firms are less likely to undertake any kind of formal R&D activity, since they tend to lack the resources for this. They therefore might display a tendency to dismiss the questionnaire as irrelevant to their circumstances. This is a general problem and not one that is specific to this study. A telephone-based survey of a small subsample of 90 non-respondents, however, indicates that the problem is not significant. The majority of surveyed firms are very small (67.2 percent less than 100 employees, compared to 68.4 percent of the identified population), and many of these (49.6 percent of those with a known starting year) have been in business since 1970. In terms of organisational status, 111 firms (55.0 percent) were independent, the remainder operated within a wider parent company group as a main plant (36.1 percent) or as a branch plant (8.9 percent).

Table 1: Response patterns of manufacturers

	Total Number of Registered Firms 1995		Number of Responding Firms 1997		Response Rate
Industry Sector					
Textiles & Clothing	*72*	*(7.9%)*	*13*	*(6.4 %)*	*18.1 %*
Food Industry	*112*	*(12.3 %)*	*24*	*(11.8 %)*	*21.4 %*
Wood, Paper & Printing	*198*	*(21.8 %)*	*49*	*(24.0 %)*	*24.8 %*
Chemicals, Plastics & Rubber	*185*	*(20.4 %)*	*38*	*(18.6 %)*	*20.5 %*
Electrical and Optical Equipment	*115*	*(12.7 %)*	*28*	*(13.7 %)*	*24.4 %*
Basic Metals and Metal Products	*108*	*(11.9 %)*	*24*	*(11.8 %)*	*22.2 %*
Machinery & Transport	*118*	*(13.0 %)*	*28*	*(13.7 %)*	*23.7 %*
Total	*908*	*(100.0 %)*	*204*	*(100.0 %)*	*22.5 %*
Employment Size					
≤ 49	*396*	*(43.6 %)*	*88*	*(43.1 %)*	*22.2 %*
50 – 99	*225*	*(24.8 %)*	*49*	*(24.0 %)*	*21.8 %*
100 – 499	*232*	*(25.5 %)*	*54*	*(26.5 %)*	*23.3 %*
≥ 500	*55*	*(6.1 %)*	*13*	*(6.4 %)*	*23.6 %*
Total	*908*	*(100.0 %)*	*204*	*(100.0 %)*	*22.5 %*

Note a: number of responding manufacturing firms divided by total number of registered firms multiplied by 100
Note: electronics firms are included in the Electrical and Optical Equipment sector
Source: Innovation Survey 1997, Data compiled by Vera Mayer

Table 2 shows a brief profile of the surveyed firms utilizing five indicators. The first three indicators attempt to capture the resources to which the manufacturing firms have access for the purposes of innovation:

- the presence of continuous on-site R&D facilities,
- R&D employment in terms of the R&D personnel ratio, and
- R&D expenditure in terms of the R&D expenditure intensity [in percent of sales turnover].

Another set of two indicators focuses on innovation activities or outcomes and includes

- the actual introduction of new products [averaged over 1994-1996] per 1,000 employees [i.e. the product innovation rate], where a new product is defined as being new to the business, and
- the share of turnover accounted for by new or improved products [averaged over 1994-1996] where the definition of a new product is as above while improved products are defined as outcomes of substantial improvements in current products (e.g., in components used, performance/quality levels, or product or image design).

The second of these measures is an indicator favoured by many of the management experts as a measure of a firm's innovativeness and is a widely accepted measure in the benchmarking literature (see, for example, Zairi 1992). It relates product innovations to economic activity. It is accepted that the definition of what constitutes a new or improved product is problematic. Although there is a need to capture some of the more complex characteristics of the innovation process, attempts to distinguish between fundamental and incremental innovation in the past have not always been entirely successful. Thus, no attempt has been made to capture differences in the degree of novelty of the product innovations. Innovation was defined as new to the establishment and not necessarily a world or Austria-first commercial application of technology. This approach was adopted because a narrower approach restricted to world or Austria-firsts would result in too few cases. Moreover, such an approach could seriously underestimate the total innovation effort made in the region by ignoring incremental innovation that clearly has a significant impact on economic and perhaps technological developments.

Some account needs to be taken of the fact that product innovations will take different forms in different sectors. In some industry sectors such as food industry and textiles & clothing new and especially improved products may appear rapidly while in others four or five years developmental cycles may be the norm and in such as machinery and transport, for example, very long leading times are still the case.

Following Malecki and Veldhoen (1993) we classified firms as innovative, based on the following criterion: if product innovations introduced during the past three years comprised more than 20 percent of the firm's yearly turnover. Defined in this way, there were only 50 (26.5 percent) innovative firms, 64.0 percent of these were smaller than 100 employees; 16 had fewer than 50 employees. The sectoral distribution indicates that innovative firms are to be found especially in the Electrical and Optical Equipment sector (ÖNACE 30-33; 11 firms) which includes electronics. Besides electronics firms machinery and transport (ÖNACE 29, 34-35; 11 firms) and basic metals and metal products (ÖNACE 27-28; 3 firms) are indicated to be dominated by innovative companies. These three sectors account for 50 percent of all the innovative firms. Of the non-innovative firms, 45.3 percent are engaged primarily in custom production, 26.6 percent in batch production and another 5.0 percent in custom and batch production. This suggests that flexible production, particularly of custom products for individual customers, is the norm rather than the exception among the firms surveyed, whether or not the concept of 'new/improved' products is appropriate.

Table 2: Innovation and R&D activities of surveyed firms (1994 – 1996)

	Innovation Rate[a]	Share of Turnover by Product Innovations	Firms with Continuous On-Site R&D 1997[b]	R&D Personnel Ratio[c]	R&D Expenditure Intensity
Industry Sector					
Textiles & Clothing	60.4	0.2	2 (15.4 %)	17.8	4.7
Food Industry	32.3	0.3	3 (12.5 %)	25.5	1.7
Wood, Paper & Printing	26.0	0.1	4 (8.2 %)	11.4	1.4
Chemicals	22.5	0.1	5 (13.2 %)	52.6	4.9
Electrical & Optical Equipment	6.1	0.5	7 (25.0 %)	250.4	15.8
Basic Metals & Metal Products	11.7	0.5	2 (8.3 %)	115.1	2.2
Machinery & Transport	4.0	0.5	7 (25.0 %)	24.8	2.4
Employment Size					
≤ 49	105.5	0.2	7 (8.0 %)	51.1	2.1
50 – 99	75.4	0.2	7 (14.3 %)	29.3	3.0
100 – 499	6.0	0.2	11 (20.4 %)	31.8	3.0
≥ 500	2.1	0.4	5 (38.5 %)	136.0	7.8
Production Size					
Custom Production	26.8	0.3	11 (12.1 %)	36.4	4.5
Batch Production	13.7	0.4	6 (10.7 %)	174.5	11.2
Custom & Batch Production	33.7	0.1	1 (12.5 %)	30.9	2.6
Mass Production	5.6	0.2	10 (29.4 %)	66.2	6.7

Note a: denotes number of new products per 1,000 employees
Note b: percentage of all firms of the corresponding raw category
Note c: per 1,000 employees
Note b: percentage of all firms of the corresponding raw category in brackets
Note: electronics firms are included in the Electrical and Optical Equipment sector
Source: Innovation Survey 1997, Data compiled by Vera Mayer

R&D may be misleading or is at least incomplete as an indicator of technological capability, because it does not include network activities, learning, informal R&D and other means of enhancing a firm's knowledge base (Malecki 1997). Firm performance may be best viewed as a product of the interplay between in-house R&D efforts to innovate and external innovation networks for knowledge transfer. The knowledge needed to compete comes most often from customers, suppliers (manufacturing suppliers and producer service providers) and from other firms and institutions. The innovativeness supported by interfirm networks not only supports existing firms, it also offers opportunities to open up new businesses in order to serve newly identified markets. The importance of networks and of innovative niches sparks innovation in both high-technology industries and in traditional sectors.

4. Networks and network formation

In recent years, new forms of interfirm agreements bearing on technology have developed alongside the traditional means of technology transfer – licensing and trade in patents – and they often have become the most important way for firms, regions and countries to gain access to new knowledge and key technologies. The network form of governance can overcome market imperfections on the one side and the rigidities of the vertically integrated hierarchy on the other. The limitations of these two modes of transactions in the context of knowledge and innovation diffusion have pushed interfirm agreements to the forefront of corporate strategy in the last decades (Chesnais 1988).

There are many definitions of *innovation networks* (see DeBresson and Amesse 1991, Freeman 1991). The one offered by Tijssen (1998) captures the most important points of the network mode. He suggest defining a 'network as an evolving mutual dependency system based on resource relationships in which their systemic character is the outcome of interactions, processes, procedures and institutionalization. Activities within such a network involve the creation, combination, exchange, transformation, absorption and exploitation of resources within a wide range of formal and informal relationships.' In a network mode of resource allocation, transactions neither occur through discrete exchanges nor by administrative fiat, but through networks of individuals or institutions, engaged in reciprocal, preferential and supportive actions (Powell 1990).

Networks show a considerable range and variety in content. The content differs according to specific circumstances. Its nature will be shaped by the objectives for which network linkages are formed. For example, they may focus on a single point of the R&D-to-commercialisation process or may cover the whole innovation process. The content and shape of a network will also differ according to the nature of relationships and linkages between the various actors involved (see Chesnais 1988). At the one end of the spectrum lie highly formalised relationships. The formal structure may consist of regulations, contracts and rules that link actors and activities with varying degrees of constraint. At the other end are network relations of a mainly informal nature, linking actors through open chains. Such relations are very hard to measure (Freeman 1991).

Networks are for firms a response to quite specific circumstances. Where complementarity is a prerequisite for successful innovation, network agreements may be formed in response to firm-specific proprietary tacit knowledge. The exchange of such complementary assets can take place only through very close contacts and personalized and generally localised relationships (OECD 1992). When technology is moving rapidly, flexibility and reversibility along with risk sharing represent other reasons for preferring a network mode. Interfirm agreements are easier to dissolve than internal developments or mergers. The network mode provides much higher degrees of flexibility (OECD 1992). Porter and Fuller (1986) stress speed among the advantages that networks have over acquisition or internal development through arm's length relationships. The timing advantage of networks is becoming increasingly important as product life cycles have shortened and competition has intensified. High R&D costs may be another distinct reason for networking and may force management to seek ways of pooling resources with other firms, in some cases even with competitors (OECD 1992).

Network activities were elicited directly from company executives using the survey instrument. Building on the existing literature, these executives were asked about their innovation-related network linkages, the intensity of such relationships measured in terms of a four-point scale ranging from no linkage to very intensive linkage(s), the location of the partners and the valuations of spatial proximity in networking activities. The picture that emerges from the survey is one of continuous interactive learning that occurs in the context of formal and informal relationships between firms. Interfirm collaboration is an important source of knowledge. It enhances organisational learning and provides access to knowledge and resources that are otherwise unavailable. Interfirm collaboration is organised around five types of networks (see Fischer 1999):

- *customer networks* which are defined as the forward linkages of manufacturing firms with distributors, marketing channels, value-added resellers and end-users, that may facilitate the process of acquiring information about markets, a critical input in the process of new and incremental product innovation,

- *manufacturing supplier networks* which are defined to include subcontracting, arrangements between a client (the focal manufacturing firm) and its manufacturing suppliers of intermediate production inputs,

- *producer service provider networks* which are defined to include arrangements between a client (the focal manufacturing firm) and its producer service partners (esp. computer and related service firms, technical consultants, business and management consultants, market research and advertising),

- *producer networks* which are defined to include all co-production arrangements (bearing to some degree or another on technology) that enable competing producers to pool their production capacities, financial and human resources in order to broaden their product portfolios and geographic coverage, on the one side and to outsource less essential functions to allow management and production to become more focused in areas of greater priority on the other,

- *co-operations with research institutions or universities* (pre-competitive stage) pursued to gain rapid access to new scientific and technological knowledge and to benefit from economies of scale in joint R&D.

Firms pursue such co-operative arrangements in order to tap into sources of know-how located outside the boundaries of the firm, to gain fast access to new technologies or new markets, to benefit from economies of scale in joint R&D and/or production, and to share the risks for activities that are beyond the scope or capabilities of a single firm. The picture which emerges from the evidence of the current study is that of a maze of different networks. They range from highly formalized to informal network relations, from highly specialized and rather narrow networks to looser and much wider networks such as, for example, technical alliances involving firms as corporate entities, from networks focusing on the pre-competitive stage of the innovation process to those involving the competitive stage.

Table 3 provides some empirical evidence on the above five types of networks, from the point of view of the focal manufacturing firm, and highlights the fact that

- co-operation in the pre-competitive stage [i.e. in the early stages] of the innovation process is generally more common than in the competitive stage. External information tends to be particularly relevant during the early stages of the innovation process when perception of problems and evaluations of technological possibilities take place.

- Customer and user-producer [i.e. manufacturing supplier and producer service provider] relationships are much more frequent than horizontal co-operations such as producer networks and research institution-industry linkages. Customer networks represent the most frequent form of interfirm co-operation, with activities with customers and suppliers constituting 35.3 percent of all such activities. Manufacturing suppliers and producer service providers have strong incentives to establish close relationships with user firms and even monitor some aspects of their activity. Knowledge produced as a result of learning-by-using can only be transformed into new products if the producers have direct contact with users. In turn, user firms will generally need information about new products or components. This may not only mean awareness, but also quite specific inside information about how new, user-value characteristics relate to their specific needs.

- 37.7 percent of the manufacturing firms are integrated into customer networks, 27.9 percent into manufacturing supplier networks, 46.6 percent into producer service provider networks, and only 18.6 percent have set up co-operative relations with research institutions and/or departments of universities, despite the active promotion of university-industry programmes in Austria.

Table 3: Network Activities of Manufacturing Firms

		Customer Networks	Manufac-turing Supplier Networks	Producer Service Provider Networks	Producer Networks	Co-operations with Research Institutions
Pre-Competitive Stage		c	c	c	c	c
Information Exchange	**a**	199	135	165	66	61
	b	64 (26.1 %)	45 (23.0 %)	63 (34.5 %)	27 (30.3 %)	25 (32.8 %)
Identification of New Ideas	**a**	190	122	148	64	57
	b	57 (25.8 %)	39 (24.6 %)	57 (34.5 %)	25 (28.1 %)	20 (31.6 %)
Research and Development	**a**	179	118	148	49	56
	b	55 (25.7 %)	37 (23.7 %)	56 (34.5 %)	20 (26.5 %)	22 (30.4 %)
Competitive Stage						
Prototype Development	**a**	175	108	96	37	47
	b	53 (24.6 %)	34 (23.1 %)	36 (32.3 %)	16 (27.0 %)	20 (31.9 %)
Pilot Projects	**a**	167	97	101	28	47
	b	51 (25.1 %)	30 (24.7 %)	41 (34.7 %)	12 (32.1 %)	20 (29.8 %)
Market Introduction	**a**	183	82	105	49	19
	b	56 (26.2 %)	25 (25.6 %)	38 (34.3 %)	20 (22.4 %)	9 (31.6 %)

Note: **a** denotes the number of such network activities of the manufacturing firms
Note: **b** denotes the number of manufacturing firms with such network activities,
Note: **c** denotes the share of such network activities with a focus on the metropolitan region of Vienna [number of network relations with partners located in the metropolitan area divided by all network relations]

Consumer and user-producer relationships basically involve two types of transactions. One is interdependent, functioning as a cooperative or relational mode, relying on tacit performance agreements, trust and reciprocal adjustment and is more common in the high-tech sector, where short product cycles and continuous innovation are crucial. The second is more of a contractual, competitive or 'arm's-length' mode, where interfirm trust and familiarity may be very limited, or missing altogether. The first type in various ways expects subcontractors to add value beyond the simple transaction requirements, such as providing knowledge and expertise on the development of the goods they supply, coordinating design and quality control with the contractors' own production routines, and having the willingness to coordinate or reduce output whenever market demand subsides, regardless of initial expectations. It seems that both types of transactions are common and tend to coexist in the metropolitan region. This reveals some of the complexity of networking activities, where a firm may dualistically engage in both types of transactions, and where the determination to engage in one or the other form may hinge on previous interfirm experiences, perceived reputation, initiation of competitors' arrangements or even managerial personalities and friendships (Suarez-Villa and Fischer 1995).

There are good reasons to assume that spatial proximity encourages the creation and diffusion of knowledge, especially new knowledge that is unstructured and mostly tacit in nature, and can be best transformed by personal contacts. Metropolitan agglomerations facilitate knowledge transfers not only between firms, but also between firms and other organisations that are likewise important sources of knowledge, in particular universities. For example, Mowery (1995) noted that proximity to a network of other firms, universities, and producer services is crucial to innovations. Indeed, innovation is a process facilitated by diverse types of expertise and knowledge available in metropolitan regions (Kline and Rosenberg, 1996). This idea of a positive relationship between spatial proximity and firms' innovation performance rests upon the assumption that distance reduces the ability to receive knowledge (Echeverri-Carrol and Brennan, 1999). Thus, one might expect that firms' innovations are more dependent on metropolitan than on external linkages. This study does not support this hypothesis. Considered overall, external networks operating at the scale of the metropolitan region of Vienna are less prevalent than might have been expected.

Only about one quarter [third] of the customer and manufacturing supplier and producer network [producer service providers and industry-university] connections are localised within the metropolitan region. This suggests a relatively modest level of local networking, or local systems of integration, in terms of the product development process. The firms tend to rely far more often on national and especially international linkages in both the pre-competitive and competitive stages of the innovation process. About half of the customer, manufacturing supplier, producer network and industry-university linkages were established and maintained with partners in the European Union, Central and Eastern Europe and in the rest of the world. Nevertheless, it seems that metropolitan relationships are of the most strategic especially in the case of smaller firms, because timeliness and face-to-face communication and information exchange encouraged by tacit vertical interactions are important for rapid product development.

Network forms and activities are critical to the competitiveness of small and large firms, but we still know too little about how they operate. In particular, we need to know more abut the variety of organisational forms, about trust and power relationships in networks. Such issues are difficult to measure and no doubt would require in-depth interviews with key firms and institutions in the region.

5. Exploring the role of firm characteristics in the likelihood of networking

In the above section we have revealed some empirical evidence on customer, manufacturing supplier, producer service provider and producer network relations and industry-university relations of manufacturing firms located in the metropolitan region of Vienna. In this section attention is turned to the research question to what extent the likelihood of networking is influenced by firm-specific attributes as suggested by the resource-based view of the firm.

The restricted nature of the postal survey limits the number of independent variables available; however the following variables were incorporated: organisational structure, turnover, employment size as a proxy for scale economies, years in operation proxying a learning by doing effect, ownership and export intensity, as basic profile attributes along with some proxies for technological resources and opportunities such as R&D expenditure, in-house research capacity, presence of on-site R&D facility and innovation competence as defined in Table 4. The relatively small sub-sample of 21 electronics firms does not permit a complex analysis of the networking behaviour of companies belonging to the electronics industry. However, the dummy variable "Electronics" is included in the model to test whether, relative to the rest of the companies included in our sample, electronics firms exhibit distinct networking characteristics.

Table 4: Firm-specific variables included in the logit analysis

Independent Variable	Variable Type	Variable definition
Basic profile attributes		
Electronics	dummy	=1 denotes electronics sector =0 otherwise
Organisational structure	dummy	=1 denotes multi-unit =0 otherwise
Turnover	continuous	annual turnover [averaged over 1994-1996]
Employment size	continuous	Total employment per establishment [natural logarithm]
Years in operation	continuous	Establishment age, calculated as '1998 minus years formed'
Ownership	dummy	=1 denotes foreign [some share of total capital] =0 otherwise
Export intensity	dummy	=1 denotes high export intensity [over 50% of turnover] =0 otherwise
Proxies for technological resources and opportunities		
R&D expenditures	continuous	annual R&D expenditure in % of turnover [averaged over 1994-1996]
In-house research skills	continuous	research personnel in % of R&D personnel [averaged over 1994-1996]
Presence of on-site R&D facility	dummy	=1 denotes presence =0 otherwise
Innovation competence	continuous	share of turnover accounted for by new or improved products [averaged over 1994-1996]

The research question is analysed via logit modelling as an attempt to overcome the difficulties inherent in bivariate analysis with the rigour of multiple-regression modelling for categorical data with a dichotomous response variable (for more detail, see, e.g., Fischer and Nijkamp 1985). In the model results that follow, with the exception of the continuous variables, the parameter estimates may be interpreted with respect to the reference category. The reference category is a function of the particular parametrization used by estimating the model and is set to zero. The reference category consists of domestic independent establishments in the low technology sector with no on-site R&D facilities and a lower level of export orientation.

Table 5 indicates the degree to which firm-specific attributes increase or decrease the probability (strictly the logarithmic odds) of external networking. There is no intention that the results presented in this table should in any sense represent an ‘optimal’ model. Rather, the approach is essentially exploratory and the intention is to demonstrate which variables are important and to identify the directions of these. The study relies on a subset of 82 firms that provided the necessary information.

Table 5: Network activities of manufacturing firms: parameter estimates (t-values in brackets)

Variable	(a) Customer Networks	(b) Manufac-turing Supplier Networks	(c) Producer Services Provider Networks	(d) Producer Networks	(e) Industry-University Linkages
Constant	-3.5	-6.2	-2.1	-15.1	-8.4
	(-2.3)	(-3.0)	(-1.5)	(-0.07)	(-2.8)
Electronics	0.7	0.6	-0.1	2.4*	2.6*
	(0.9)	(0.8)	(-0.2)	(2.9)	(2.5)
Organisational Structure	-0.9	-0.2	0.6	-0.2	-2.6*
	(-1.3)	(-0.3)	(1.0)	(-0.2)	(-2.0)
Turnover	-0.0004*	-0.001*	0.0001	-0.0003	0.001
	(-2.6)	(-1.7)	(0.6)	(-1.0)	(1.5)
Employment (Log)	2.4*	2.02*	0.5	0.3	2.1
	(2.9)	(2.04)	(0.8)	(0.4)	(1.6)
Years in Operation	-0.01*	0.0001	-0.004	-0.001	-0.01
	(-2.0)	(0.009)	(-0.8)	(-0.1)	(-0.7)
Ownership	1.4*	0.3	0.5	0.1	3.3*
	(2.1)	(0.5)	(0.8)	(0.1)	(2.7)
Export Intensity	0.3	0.3	0.2	-0.6	1.4
	(0.5)	(0.4)	(0.2)	(-0.8)	(1.5)
R&D Expenditures	0.1	0.02	-0.1	0.1	0.2*
	(1.6)	(0.4)	(-1.6)	(1.0)	(2.2)
In-house Research Skills	-0.7	1.6	3.9*	0.9	5.2*
	(-0.5)	(1.2)	(2.3)	(0.6)	(2.2)
On-Site R&D Facility	-0.4	1.6	1.0	12.8	1.7
	(-0.5)	(1.4)	(1.3)	(0.1)	(1.1)
Innovation Competence	-0.009	0.006	0.01	0.0005	-0.1*
	(-0.8)	(0.4)	(0.8)	(0.03)	(-2.6)
Number of Observations	82	82	82	82	82
Log-Likelihood	-44	-43.9	-48.6	-33.6	-22.5
Likelihood Ratio Test Statistic	25	17.5	15.7	16.6	48.2
Rho Squared	0.2	0.2	0.2	0.4	0.6
Adjusted Rho Squared	0.1	0.1	0.1	0.3	0.5
Prediction Success (%)	70	74	67	83	87

* significant at the 10 % level

In the case of customer network relations, it should be clear from Table 5(a) that employment size and ownership are the dominant variables, and technological resources are not significant. The model simplifies to the size effect, the larger the establishment the higher the probability of networking with customers and to a strong ownership effect reflecting the fact that the probability of networking is much higher in foreign owned rather than in domestic firms. There is also a strongly negative, but relatively weak age effect. Table 5(b) shows that size is also an important significant factor in the case of manufacturing supplier relations, slightly less pronounced as in the case of customer networks. It seems that size matters simply because it captures subcontracting practices.

Table 5(c), on the other hand, indicates that there is very little variability in the case of producer service provider linkages. A very low level of adjusted rho-squared is accompanied by a predictive success of 67%. Only in-house research skills is significant. The statistical results summarized in Table 5(d) exhibit a higher probability of electronics firms to engage in producer networks. Firms working in areas where technology is evolving rapidly, as in the electronics sector, have to be able to keep abreast of technological developments. The knowledge intensity of production does not necessarily imply the capacity of every firm to carry out in-house R&D, but it certainly requires firms to belong to one or several networks where R&D is being done. The removal of all the other variables has negligible impact on the goodness of fit.

Table 5(e) reveals that the model for industry-university linkages is by far the most complex, with six significant variables, in-house research skills being by far the most important one. As one might anticipate, larger in-house research capacity increases the probability of cooperation with research institutions/universities. A related effect is indicated by the significant parameter of the R&D expenditures variable: the higher the share of R&D expenditures in the annual turnover the higher the probability of engaging in network relationships with research institutions. As is clearly indicated in the table, electronics firms are more likely to be involved in outside research cooperations than the rest of the industries included in the sample. Fierce international competition among electronics companies places a significant pressure on firms in the electronics sector to draw heavily upon outside knowledge resources available at universities and other public research institutions. Independent firms are more likely to engage in cooperation as do internationally owned firms rather than domestic ones. Innovation competence has a significant, but weak effect whereby establishments with higher competence show a lower probability of networking. This result suggests that firms exhibiting a higher level of innovation success appear to cooperate less with research institutions.

6. Concluding remarks

The relationship that manufacturing firms build with other organisations such as customers, manufacturing suppliers, producer service providers, competitors and research institutions enable them to deal with changes in technologies, markets and other aspects of the business environment. In this paper, we have reported results of an attempt to identify networking activities of manufacturing firms including electronics companies located in the metropolitan region of Vienna. The results achieved so far seem to suggest that: *first*, networking does not yet seem to be a popular managerial and organisational concept for the manufacturing firms in the metropolitan region of Vienna; *second*, network activities, if any, are primarily based on vertical relationships with customers, manufacturing suppliers and producer service providers rather than on horizontal relationships; *third*, networks focusing on the later stages of the innovation process are less common than those focusing on the earlier stages; *fourth*, firms tend to rely on sources of technology from national and – especially – international networks. Local networking is less common than has been thought. The concept of the innovative milieu seems to have little bearing on the reality of how manufacturing establishments pursue product development. This result reinforces findings by Alderman (1999) for the Northern region, the West Midlands and parts of the South East in the UK as well as by Malecki and Veldhoen (1993) for the area of Gainesville, Florida.

Turning to the second research question of the study, focusing on the adoption of the management and organisational concept of networking, the results of the logit analysis have bolstered the argument that establishment traits and technology related capabilities do play a role. With the exception of network relationships with producers and research institutions, electronics companies exhibit no distinct cooperation behaviour as compared to companies in the rest of the industrial sectors in the sample. Employment size is a dominant variable in the case of both customer and manufacturing supplier relations. It seems that size matters simply because it captures subcontracting and customizing practices. In-house research skills have been found to be most important in the case of producer service provider relations and cooperations with research institutions/universities.

The study has explored broad facets of networking activities of manufacturing establishments within the metropolitan region of Vienna. In-depth interviews may be necessary to gain further understanding of network activities, especially on the process of network formation and issues such as trust building. Studies in other parts of the countries and in other metropolitan areas may also be needed to shed light on the extent to which the conclusions can be generalized.

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