Effects of the Internet on the spatial structure of innovation networks

Alexander Kaufmann[1], Patrick Lehner[2], Franz Tödtling[2]

[1] ARC Seibersdorf research
Systems research technology-economy-environment,
Seibersdorf, Austria
alexander.kaufmann@arcs.ac.at

[2] University of Economics and Business Administration,
Dep. of City and Regional Development,
Vienna, Austria
patrick.lehner@wu-wien.ac.at
franz.toedtling@wu-wien.ac.at

ERSA-Conference 2002 Dortmund
27-31 August 2002

Draft version

Abstract

Research on innovation systems and innovative milieux has shown that the innovation process of companies is strongly interrelated with activities of other firms and organisations. Internet is a new information- and communication-technology with a considerable potential to change such relationships and networks. An often held expectation is that the Internet will allow firms to interact with distant partners more easily and that, as a consequence, innovation networks become independent from geographical space. A contrasting view argues that local and regional networks and innovation systems will keep their importance, due to the fact that tacit knowledge, face-to-face communication and institutional factors are still of key relevance. In the paper we are going to investigate to which extent and how the Internet changes innovation networks of companies. Does the use of Internet stimulate companies to interact with new types of innovation partners or with partners at wider spatial scales? We have analysed the effects of the Internet on innovation-related networks and knowledge-flows of companies by conducting a WWW-survey of Austrian firms amongst other investigations. In the present paper we report on the results of this Web-survey.

1 Introduction

In recent years it has become generally accepted that the innovation process is to be characterised as non-linear and highly interactive (Kline and Rosenberg 1986; Dosi 1988; Malecki 1997). Non-linearity implies that innovation is stimulated and influenced by many actors and sources of information, both inside and outside the firm. Besides the knowledge of scientists and engineers from R&D-departments, ideas and experience from production and marketing as well as from external actors such as customers contribute to the innovation process of companies. Interactivity, thus, refers to the internal collaboration between departments of a company (R&D, production, marketing, distribution, etc.) as well as to external links and co-operations with other firms (especially with customers and suppliers) and knowledge providers (universities, research organizations, technology centres and training). Thus, a wide range of partners may contribute to a firm's capacity to innovate.

The concept of 'innovation systems' is based on these ideas (Lundvall 1992; Edquist 1997). An innovation system is constituted by actors and elements which interact in the production, diffusion and the use of economically useful knowledge and it is characterised by interactive learning and by dynamic selfreinforcing innovation processes (Lundvall 1992). Studies on national innovation systems have shown that the innovation process of national economies is shaped by their economic structure, knowledge base and institutional specificities (Nelson 1993). More recently, and influenced by the concept of the "innovative mileu" (Camagni 1991; Maillat 1991, Ratti et al. 1997), there has been a growing interest in innovation systems at the regional level (Simmie 1997; Autio 1998; Braczyk et al. 1998; Cooke et al. 2000). Questions raised are to which extent innovation systems can be found at the regional level, how they are functioning, and how they are linked with systems at higher spatial levels. The importance of the regional level results from the fact that tacit knowledge is tied to individuals and organizations. Its transfer requires either face-to-face contacts or the mobility of personnel, both predominantly done within rather narrow spatial limits.

The question now arises, what the effects of modern information and communication technologies (ICTs) on these innovation networks are? Is it justified to argue for the

"death of distance" (Cairncross 1997) due to modern ICTs in general and the Internet in particular? Basically, ICTs lower transaction costs of innovation co-operations by increasing the speed and volume of exchangable information and they make new innovation partners accessible which were too remote before. 'Remote' in this context does not only refer to spatial distance but also to unrelatedness of activities. In this respect, the Internet very likely favours networking in the innovation process. Nevertheless, networking requires coordination, trust-building as well as establishing shared languages, views and objectives. As far as these issues are concerned, the assessment of the effects of ICTs remains ambiguous. Andersen (2001) found evidence for positive effects of the Internet on innovation only in the case of more dynamic and complex industries like electronics and instruments, but no significant effects in the case of more mature and low-technology industries like food, clothing and furniture. In general, however, there is little empirical evidence on these questions so far.

In order to find out to which extent the Internet changes innovation networks of companies we have undertaken a two year project for Austria (RINET). In this context we have conducted a telephone survey, personal interviews and a WWW-survey of Austrian firms. In the present paper we report on the results of the Web-survey. We will focus on the following questions:

- What are the effects of the Internet on the structure of companies' innovation networks?
- Does the use of the Internet extend the spatial scope of innovation relations?
- Does the use of the Internet lead to changes in the composition of innovation partners?
- Are there characteristic differences regarding these effects between firms?

2 The Internet and the geography of innovation networks

The potential of modern information and communication technologies, the Internet in particular, to spread networks to a global level, reducing or even eliminating the barriers of geographical distance, leads some authors to the proposition that geographical space will loose any importance in the near future. Cairncross (1997) calls this the "death of

distance". These general claims, however, are deduced from special uses like advertising, e-commerce, customer information, selection of suppliers (of standard goods or services), and to some extent teleworking or distance collaboration (between employees of the same company but at different locations). The reduction of the distance barrier by use of ICTs, however, depends on the extent to which business activities can be performed electronically and the extent to which knowledge can be codified and transmitted through ICTs. However, this extent varies considerably, especially regarding innovation and R&D. Geographical space therefore still matters, as is supported by the following arguments:

Highly complex and uncertain situations - like innovation projects, especially those with a more radical nature - usually require substantial knowledge inputs and the change of cognitive frames. This can hardly be done without informal face-to-face communication. Formal communication like e-mail is more adequate for simple and stable communication environments (Daft and Lengel 1986; Castells 1996). Today innovation requires increasingly diversified and specialized knowledge, too diversified to be managed by individual specialists. In particular major innovations require the combination of different sets of specilized knowledge (Grant 1996). In order to integrate these different sets of knowledge it is necessary to develop a shared language, overlapping knowledge structures and common cognitive frames. This is a complex process, hardly possible without face-to-face interaction (Nonaka and Takeuchi 1995; Storper 1997; Hämälainen and Schienstock 2000).

ICTs can make communication easier and more efficient but they do not necessarily contribute to the emergence of a widely accepted common understanding. In fact, it seems that they tend to reinforce boundaries between communities. It is more important to belong to the same community than to the same organization. Sense-giving and sense-reading in the communication process within a community correspond to each other. As a consequence, people who belong to the same community can easily cross organizational boundaries (Walsham 2001).

We conclude therefore, that ICTs have more often a reinforcing than an initiating effect on innovation networking. Once a common understanding and a shared knowledge base are established, ICTs support interactive learning (Ernst and Lundvall 1997), but the

Internet is more a medium adequate for maintaining relationships than establishing trust-based new relationships (Leamer and Storper 2001). Network relations require some time to develop as well as intensive communication, reciprocity and a high level of trust to be maintained (Lundvall and Borras 1998; Malecki and Oinas 1999; Hämälainen and Schienstock 2000).

An important constraint in the use of ICTs in innovation networks is the fact that only codified knowledge can be transmitted. But, as Nonaka and Takeuchi (1995) observe, the production and processing of knowledge in companies can be described as a continous spiral movement between tacit and codified forms of knowledge. As a consequence, hardly any type of knowledge is perfectly codifiable. The transmission and use of knowledge therefore is always constrained by tacit elements, although to a varying extent (Ancori et al. 2000). Often, knowledge which in principle could be codified is not codified due to economic reasons - the cost of codification is too high and/or there is a lack of benefit for the codifying person or organization (Cowan et al. 2000). But codification is not only a matter of economics. Regarding the creation and utilization of knowledge, tacit and codified knowledge are complementary, they are no substitutes (Nonaka et al. 2000; Johnson and Lundvall 2001).

Tacit knowledge is a major constraint to computer-based knowledge management. Knowledge cannot be made explicit without tacit knowledge, and the latter differs between individuals. Therefore knowledge management can never be fully codified and computer-based. Direct interaction enabling "communities-of-practice" are a necessary part of any successful knowledge management system (Walsham 2001). The greater the share of codified knowledge to be exchanged in (innovation) networks, the more powerful the Internet will be in shaping the networks. If knowledge is to a large extent tacit, then it cannot be transferred electronically but only by direct face-to-face interaction. Of course, one can also communicate personally via the Internet (e-mail, teleconferences), but actually these technical means are no perfect substitute for face-to-face communication because they lack the non-verbal qualities of the communication process which are very important in non-routine activities like exchanging or sharing tacit knowledge.

The need for face-to-face communication varies as an innovation project proceeds. It is usually very high in the beginning when the project is designed. Afterwards it decreases because development follows the schedule and objectives as defined in the design phase. Communication can be done by using ICTs, personal meetings are only required in the case of a few important milestones. Usually, the need for face-to-face communication increases again at the end of the project. Joint innovation projects are most often conducted in a modular way and the integration of the project components is rarely an easy task (Hähnle 1998).

The ever-increasing (international) division of labour has also pushed up coordination needs. As far as complex and unfamiliar coordination is concerned, long-term and close relations are necessary. This applies especially to innovative activities which therefore tend to cluster spatially. Only routine standardized tasks are adequate for long-distance coordination via ICTs (Storper 1997; Leamer and Storper 2001).

Overall, we think that these arguments cast doubt on the general statement that the innovation process will become "placeless" due to the Internet. ICTs and in particular the Internet do not have the potential to eliminate distance barriers, but they do have the potential to reduce them. To what extent this is already happening was the subject of the RINET project. The results will be presented in the following sections.

3 Effects of the Internet on the structure of firms' innovation networks - Results from a survey of Austrian firms

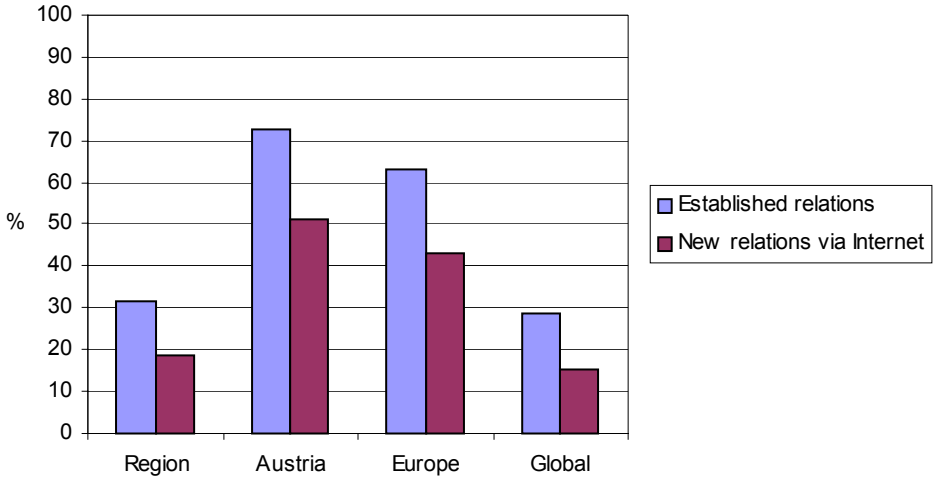
This article is based on data from a WWW-survey of Austrian firms conducted in 2001. Approximately 2000 Austrian firms were invited per e-mail to fill an electronic questionnaire. Technically the questionnaire was an html-form which could be filled by the respondents by using any usual web browser. Approximately two thirds of the firms belonged to the manufacturing sector, one third to the service sector (data processing and engineering). Eventually 204 firms responded (10%), with a similar sectoral composition like in the original sample. The respondents were asked to indicate their primary responsibility in the firm's innovation process – whether it was research, development, production or marketing. So the respondents could concentrate on their

specific tasks, functions, competences and experience, increasing the validity of their answers.

3.1 Effects of the Internet on the spatial scope of innovation networks

The respondents were asked to indicate their partners in the innovation process and whether the Internet had a decisive function for finding a new innovation partner or whether the traditional communication means and channels were sufficient. In addition, they were asked where these newly accessed partners are located and to what category (customers, suppliers, service firms, universities and technology centres) they belong. Let us first turn to the location of the new innovation partners (see figure 1).

Figure 1: The spatial scope of innovation networks - established versus new relations of firms.



Most frequently the new innovation partners that could be accessed by means of the Internet are located on the national level, i.e., in other parts of Austria outside the home region. 51% of the respondents indicated new partners in other parts of Austria. New partners on the European level are also frequent, 43% referred to respective cases. These are clearly the two most important spatial levels of new partnerships established via the Internet. The levels at the lower and upper end of the spatial range - regional and global - are clearly less important. As far as the regional level is concerned, this is hardly surprising, because the range of potential partners is rather well known in a

regional and local environment. That only 15% of the respondents could find new partners on the global level, however, casts doubt on the potential of the Internet to globalize innovation networks to a substantial extent.

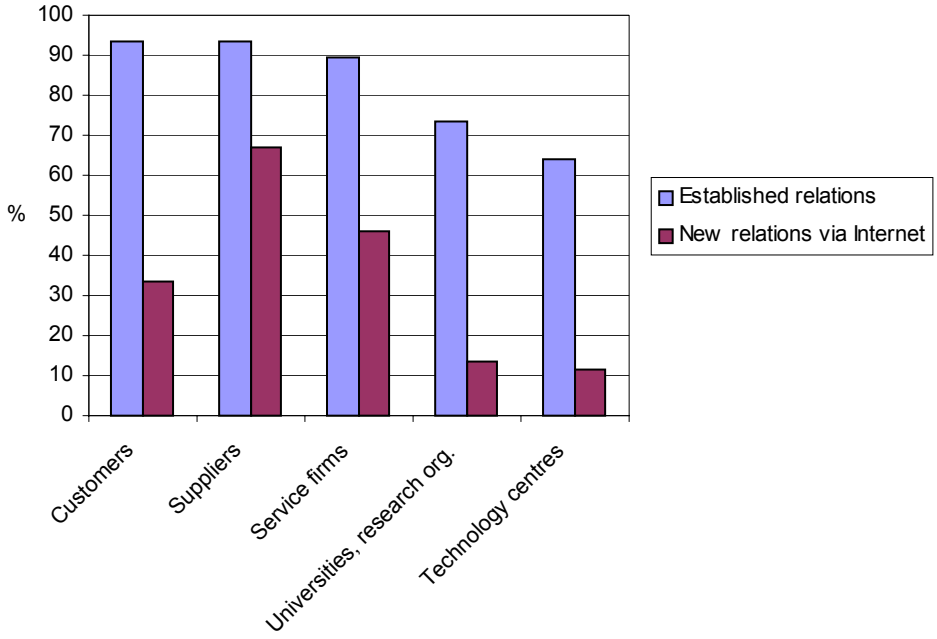
The relative importance of the spatial levels of the new innovation partners corresponds with the importance of the spatial levels of the already established innovation networks, although on a lower level of frequency. The ranking - 1) national, 2) European, 3) regional, 4) global is the same regarding new as well as established relations. More interesting is the spread between new and established relations. It is low on the Austrian and European levels. The spread is greater on the regional and especially the global levels. In the latter case, new relations via the Internet account for only 53% of the already established relations. This is an important result of the survey: The spatial level where the Internet is usually expected to have the strongest effects - the global - turns out be actually the level with the comparatively weakest effects.

The results presented in figure 1 concern the spatial level of all newly established innovation relations, comprising also new innovation partnerships on a level where the firm has already relations with other organizations. This is actually by far the most frequent case. Only few firms were able to extend the spatial scope of their innovation networks, i.e., to establish an innovation relation with a partner located on a level where the firm has not been present at all before. Only 11% of the responding firms could actually extend their innovation networks to the European level, and only mere 3% to the global level. The actual spatial extension of innovation networks is very rare. This applies especially to the globalization of innovation networks, i.e., entering this spatial level, not increasing the share of partners on this level.

3.2 Effects of the Internet on the structure of innovation partners

The types of partners with whom firms could establish new relations by means of the Internet are presented in figure 2. Again the new relations are compared with the already established relations.

Figure 2: The partner mix of innovation networks - established versus new relations of firms.



Suppliers are clearly the most frequent innovation partners with whom firms were able to establish new innovation relations by means of the Internet (indicated by 67% of the respondents). Service firms are also frequent partners (46%). This is obviously due to the often rather standardized nature of suppliers' and services' contributions to firms' innovation activities which can be more easily communicated electronically. Compared to these two types of innovation partners, the Internet is less important for finding new innovation partners on the demand-side. Only one third of the respondents claimed to have found customers as new innovation partners due to the Internet. A reason for this may be that the innovation initiative often comes from the client and not the respective firm (von Hippel 1988). The position of the client in a joint innovation project, thus, is often predominant. Firms have to respond to the customers‘ needs, constraining their possibility to initiate a joint innovation process, in particular by impersonal electronic means. Least successful are firms in finding partners from universities or other research organizations (14%) and technology centres (11%). These two categories show the biggest spread between new and established relations; new relations via the Internet account for only about 18% of the already established relations. Beyond the business

sector personal contacts and relations are obviously especially important to establish new innovation partnerships.

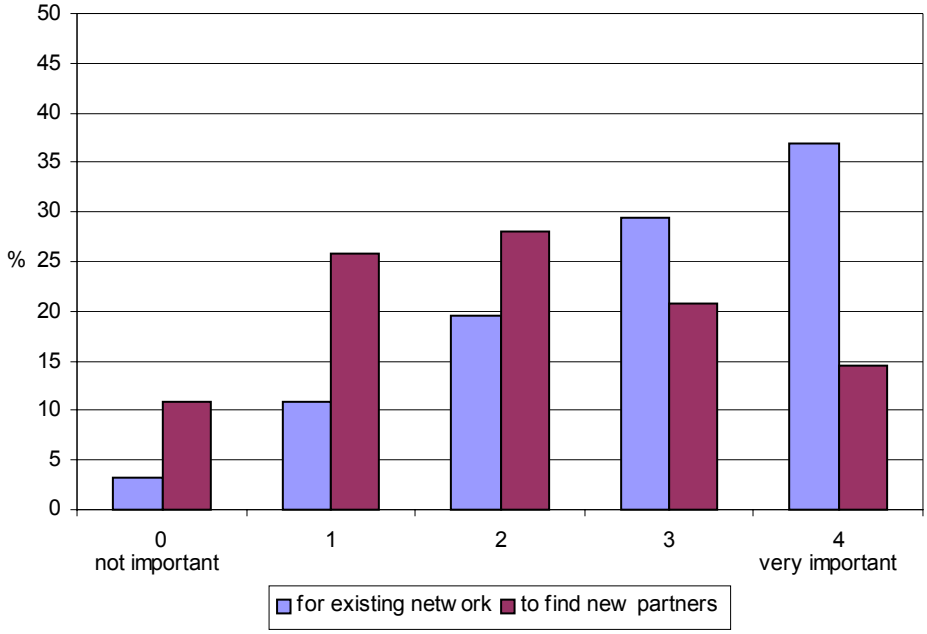
Especially as far as business partners are concerned, most firms claimed to have some kind of innovation relation. Therefore it is self-evident that there is hardly a firm which was able to establish a relation to a new type of innovation partner. All but one responding firms established new relations only to new organizations but not to new types of partners. The only case in our survey concerns a firm which found a new innovation partner from the service sector by using the Internet without having any innovation relations with this sector before. This means that almost all firms establish new innovation partnerships where they have already previous experience with partners of the same type.

4 Factors constraining the extension of innovation networks through the Internet

The results presented in chapter 3 lead to the conclusion that the Internet primarily helps to extend the number of partners or to substitute for certain partners on the already well-known spatial levels. In general, the firms stay with the types of partners they have already experiences with. To access new spatial levels and types of partners is comparatively rare. In this respect the effects of the Internet are rather limited. What might be the reasons for this result? We will concentrate in the following on three arguments which might explain the limited effects of the Internet on the extension of innovation networks.

- The Internet affects the innovation process primarily by improving the communication between exsiting innovation partners than by supporting the search of new partners.

Figure 3: The importance of the Internet for improving relations in the existing innovation network compared with its importance for finding new partners.



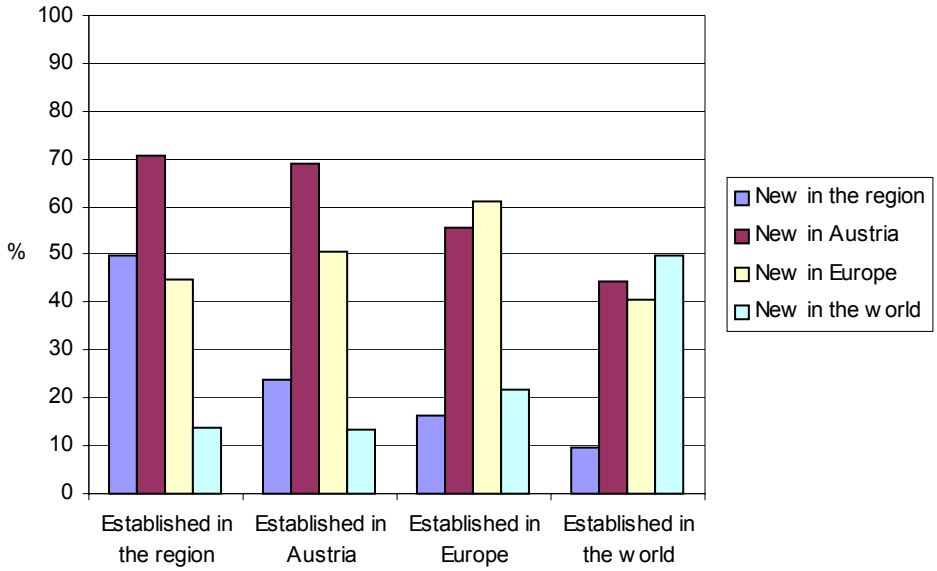
The survey shows unambiguously that the Internet is a technology which helps to increase the efficiency of communication in already established networks. It is effective after the difficulties of initiating communication relations like establishing trust, a common understanding and shared perspectives have been settled, which is usually done in personal meetings. Almost two thirds of the responding firms assessed the importance of the Internet in existing innovation networks to be high or very high (3 and 4 on a scale from 0 to 4). On the contrary, slightly more than half of the firms assessed the importance of the Internet for finding new partners to be only 1 or 2. For only one third the Internet really matters in this respect (3 or 4). This result confirms the arguments quoted in chapter 2 that ICTs are not well suitable for initiating communication, especially if it concerns more complex communication and trust-based relations often necessary in co-operative innovation projects.

- The effects of the Internet are cumulative, extension builds upon already established networks.

That the primary effect of the Internet is of a reinforcing nature is further supported by the analysis of the correlation between existing and new innovation relations. The data

presented in figures 1 and 2 (chapter 2) showed that the patters of already established and new relations are similar. We will analyse the underlying dependency in more detail now.

Figure 4: Share of firms (in %) having found any new innovation partners via the Internet on a specific spatial level in the total of firms with already established relations on this or other levels.



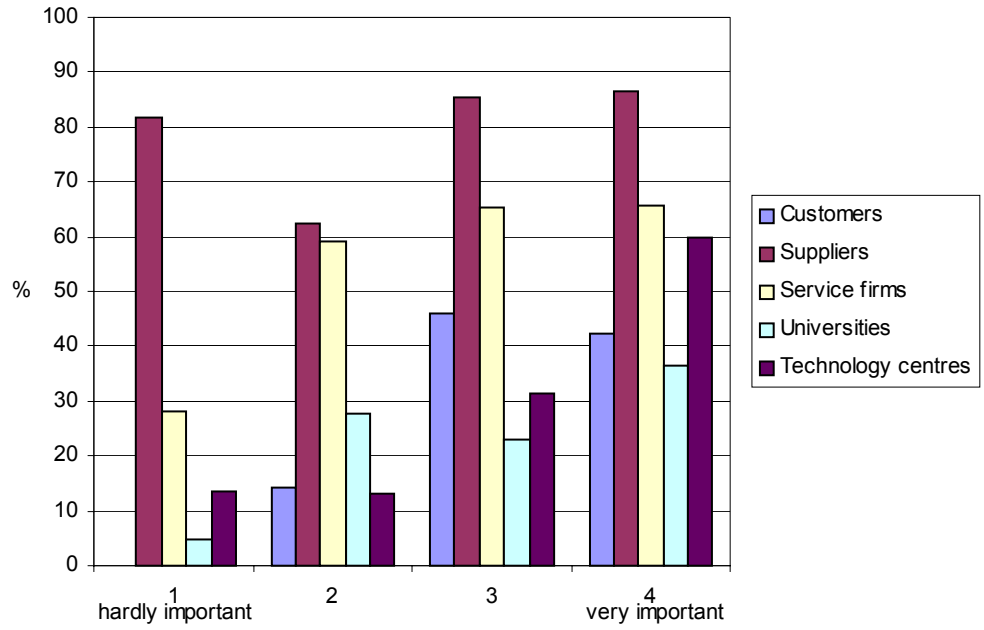
Each column shows how many of those firms with already established relations on a certain spatial level were able to find new innovation partners on the same or other spatial levels. For example, 50% of the firms with innovation relations on the regional level found new innovation partners in the region via the Internet, 71% found new partners in Austria (beyond the home region), and so on.

The cumulative nature of the Internet's potential to support new innovation relations is, in general, supported by this analysis. From the national to the global level most firms were able to find new innovation partners on those spatial levels where they had already network links. The regional level is an exception: With relations on this level, more firms could find new partners on the national than the regional level. This seems to be a consequence of the fact that ICTs do not matter within rather short distances. Most interesting in our context, however, is that the Internet has hardly a globalizing effect. While 51% of the firms with network links within Austria could establish new relations in Europe, only 14% of them could do this on the global level beyond Europe. Even

from those firms involved already in European networks only 22% could find partners outside Europe. To extend innovation networks beyond Europe is obviously a very difficult task. When this barrier is overcome, new partnerships can be established more easily. Half of the firms with global links found new global partners by means of the Internet.

The cumulative effects are less clear as far as the types of newly found innovation partners are concerned (see figure 5).

Figure 5: Ratio (in %) of firms with new innovation partners found via the Internet to the total number of firms with relations to this type of innovation partner, differentiated by the importance of the respective relation.



If the Internet had "perfectly" cumulative effects, the frequencies of any new type of innovation partner would continuously increase from "hardly important" to "very important". This applies best to technology centres, less to universities and research organizations. The other types of innovation partners show more often similar frequencies of new partnerships disregarding the importance of existing relations. An especially striking result is that 82% of those firms who considered their innovation relations to suppliers to be of little importance said that they could find new suppliers

for their innovation network via the Internet. This can only be explained by rather standardized minor contributions of many suppliers who can easily be substituted.

- The more important face-to-face communication, the less important is the Internet for finding new innovation partners.

The assertion that proximity, and thus the direct personal communication between innovation partners, loses importance due to modern ICTs, frequently put forward in the discussion of potential effects of the Internet on innovation and networks, has to be rejected according to the results of our survey. There is a highly significant negative correlation between the importance of the Internet for finding new innovation partners and the importance of face-to-face communication in joint innovation projects. This is obviously a very serious barrier constraining the use of the Internet in the innovation process of firms in general, because the same (but slightly weaker) negative correlation exists between the importance of the Internet for the efficient communication within already established innovation networks and the importance of personal meetings (see table 1).

Table 1: Correlation between the importance of the use of the Internet in the innovation process and the importance of barriers impeding the use (importance ranging from 0 "not important" to 4 "very important").*

	Importance of the Internet			
	for the existing innovation network		**to find new innovation partners**	
	Correlation coeff.	Significance	Correlation coeff.	Significance
Need for face-to-face communication	-0.176	0.019	-0.253	0.001
Lack of trust	0.023	0.760	0.123	0.097
Transmission security	-0.005	0.947	0.006	0.932
Project complexity	-0.125	0.097	0.075	0.311
Inadequate internal organization	-0.205	0.007	0.029	0.698

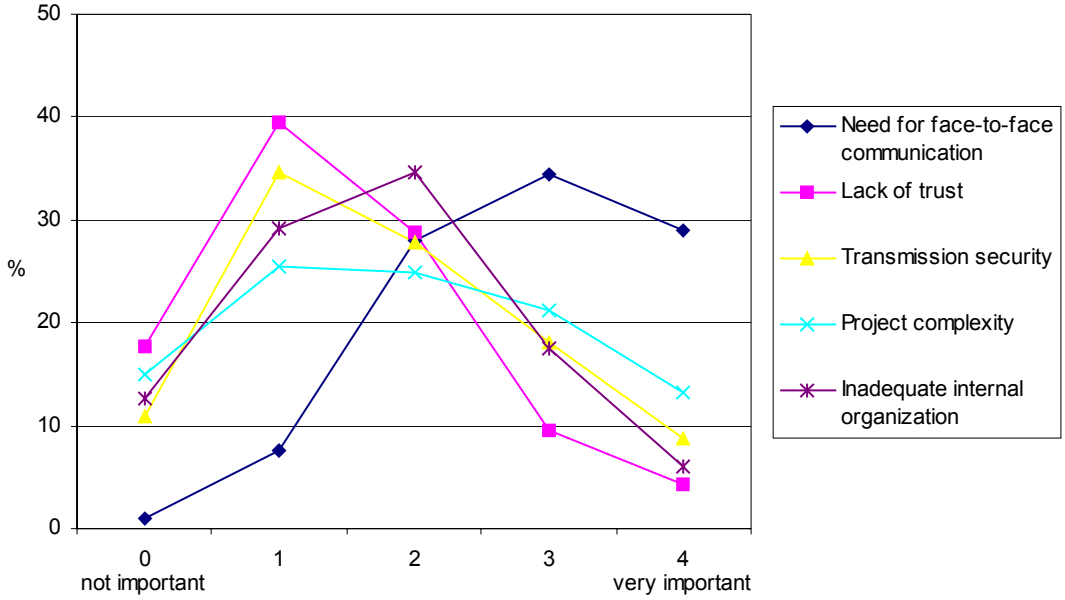
* Spearman ordinal correlation coefficient

Other problems impeding the use of the Internet for extending innovation networks do not matter much in comparison. The frequently mentioned problem of insecure data transmission is actually insignificant. This is also true of the barriers to use the Internet resulting from the complexity of innovation projects. Worth mentioning is only the

negative influence of an inadequate internal organization on Internet-communication in existing innovation networks. Surprisingly, this is no significant barrier for finding new innovation partners via the Internet.

In general, most barriers have been indicated to be of rather low importance (see figure 6). Only the need for face-to-face communication in joint innovation projects is a serious problem for most firms that impedes their use of the Internet.

Figure 6: Frequency of problems constraining the use or the effects of the Internet in the innovation process.



After having analysed the effects of the Internet on the structure of firms' innovation networks in general, we will turn to the question whether there are characteristic differences between firms regarding the effects of the Internet in the following chapter.

5 Differences between firms regarding the effects of the Internet on the spatial structure of their innovation relations

In this chapter we will analyse whether there are significant differences between certain types of firms concerning the successful search of new international innovation partners. For this purpose we have conducted binary logit models, new innovation partners on the

European as well as on the global level being the dependent variables. The results are presented in table 2:

Table 2: Factors influencing the probability of being able to access new innovation partners located on the European as well as the global level by means of the Internet - general firm features and type of Internet use.

Dependent Variable:	**New innovation partners in**			
	Europe only		**other parts of the world**	
	Coefficient	Prob.	Coefficient	Prob.
C	-2.499	0.132	-3.138	0.083
Function:				
Research and development	0.637	0.367	-2.199	0.058
Marketing	-0.284	0.758	-1.795	0.205
Sector:				
High technology sector	1.133	0.309	0.541	0.672
Service sector	-0.249	0.724	0.168	0.880
Location:				
Peripheral / rural	0.115	0.849	-0.363	0.671
R&D-intensity:				
R&D in % of turnover	-0.030	0.284	0.049	0.236
Innovation relations established				
in Europe	2.946	0.007		
on the global level			3.002	0.003
Communication with innovation partners:				
Importance* of face-to-face communication	0.065	0.836	-0.086	0.827
Importance* of the Internet				
Instrument for knowledge management	-0.228	0.334	0.446	0.236
Model:				
McFadden R^2	0.197		0.395	

Method: Maximum likelihood binary logit model

* Importance ranging from 0 (not important) to 4 (very important)

Several variables have been applied to characterize the firms:

The term 'function' refers to the position of the respondent in the innovation process of his/her firm. Research and development comprises scientific and applied research as well as the development and design of a new product. This group consists of 90 respondents. Unfortunately the number of respondents who indicated 'research' is too

small (7 cases only) to be analysed separately. 33 respondents have a marketing function, comprising market research, market analyses and the commercialization of the new product. The other respondents indicated innovation-related functions closer to the manufacturing process.

Regarding industries we classified the firms into three categories: high technology firms, firms belonging to mature sectors and the service sector. The high-tech class comprises the NACE industries 24, 30, 32, 33 and 73 (20 firms in total), services consist of 72 and 74 (49 firms), the majority (112 firms) belongs to mature or low-tech industries. The R&D/turnover-ratio in the case of the high-tech firms is 26% on average, in the service group 16%, in the mature sector only 4%.

As far as the location of firms is concerned, we distinguished between the Vienna urban region (the city and its surrounding municipalities), the other Austrian urban centres (e.g., the capitals of Austrian provinces) and all other peripheral or rural locations. 58 firms were located in the Vienna urban region, 56 in other urban areas and 73 had peripheral locations in rural areas of Austria.

The other independent variables concern issues already discussed in the paper - the established innovation relations on the European (129 cases) and global level (59 cases) as well as the importance of the need for face-to-face communication in the innovation process - and the importance of the Internet in the knowledge management of the firm.

The results of the two logit models lead to the following conclusions:

First of all, most of the usual firm characteristics make no significant contribution to explaining the fact whether a firm was successful or not to find a new international innovation partner by means of the Internet, neither in Europe nor on the global scale. The survey shows that more or less active and skillfull use of the Internet in the innovation process does not vary along traditional approaches to classify firms like technological level, R&D-intensity, industry. Other factors like age and strategy might matter more but were not investigated in our survey.

The lack of significant influences in other cases is even more interesting, however. This concerns issues which are thought to be strongly affected by the Internet:

- The function in the innovation process is irrelevant as far as the search of innovation partners within Europe is concerned. On the global level, however, research and development is negatively correlated with the successful establishment of a new innovation partnership. At first glance this seems to be strange, because it is particularly research that is usually thought to be globally embedded. But there are two plausible reasons for this unexpected result: Firstly, the global nature of networks applies primarily to scientific research, not applied research and development. Taking only the seven respondents who qualified their function as 'research', the picture is different. Here we find a positive correlation, but we have too few cases to state this as a general result. Secondly, many R&D co-operations are highly sensitive, characterized by mutual trust and exchange of tacit knowledge, making the initiation of partnerships by electronic means rather unlikely.

- Location does not matter. Firms located in peripheral regions cannot benefit more than those located in urban regions from using the Internet with respect to establishing new innovation partnerships. The argument that the Internet is an especially effective way to overcome the disadvantages of peripheral locations is not supported by the results of our survey.

- The importance of face-to-face communication has no significant influence on finding a new international innovation partner. This is a surprising result, because as we have seen in chapter 4, there is a negative correlation between the importance of the Internet for finding new innovation partners and the importance of face-to-face communication in the innovation process. Obviously, the general importance of the Internet is not accordingly correlated to the successful search of specific innovation partners and on specific spatial levels, respectively.

- Whether the firm uses the Internet as an instrument of knowledge management or not does not influence significantly the successful establishment of new

international innovation relations. Obviously, the problem of integrating the Internet into intra-organizational knowledge management systems is still far from being solved in a satisfactory way.

There is only one factor that significantly explains the success of finding an innovation partner via the Internet - already existing experience with other partners located on the same spatial level. This confirms the descriptive results discussed in chapters 3 and 4. Overall, the spatial structure of the established innovation networks to a large extent determines where new innovation partnerships are sucessfully initiated via the Internet. The role of the Internet concerning the extension of firms' innovation networks is - so far - rather limited.

6 Conclusions

According to the results from our survey of Austrian firms, the actual effects of the Internet concerning the spatial extension of firms' innovation networks are primarily to be found on the national and the European level, less on the global. Regarding the types of innovation partners, new supplier and service firms are predominant, less customers and organization beyond the business sector like universities, research organizations and technology centres.

In general, the Internet is more effective for improving the communication within existing innovation networks than for finding new innovation partners. To some extent this is a consequence of the cumulative nature of establishing innovation relations, at least by means of the Internet. Already existing experience with relations on a specific spatial level or with certain types of innovation partners is of crucial importance for finding new partners. Therefore the "real" extension to new spatial levels and types of partners, without being based on already established relations on the same level and with the same type, is a very rare effect of the Internet.

The importance of face-to-face communication in co-operative innovation projects is certainly a considerable barrier constraining the use of Internet. Other problems seem to be less serious in comparison. Nevertheless, it has to be considered that the constraining

effects of the need for face-to-face communication on the actual establishment of new international partnerships is ambiguous. The role of personal meetings should not be overemphasized when discussing the potential role of the Internet in supporting the extension of innovation networks.

We found no evidence that the Internet can be a technology helping to counterbalance the locational disadvantages of peripheral regions. Furthermore, our data do not support the view that specific sectors like high-technology or producer services are able to benefit more from using the Internet in their innovation process than other firms.

Overall, we found only a weak globalizing effect of the Internet in most phases of the innovation process, maybe except for scientific research. As a general conclusion we think that our survey of Austrian firms shows that, even if the potential of the Internet for improving the capabilities of firms to benefit from extended innovation networks is still to be explored, experience and proximity will matter in the future too. The Internet cannot change these fundamentals. The distance barrier will likely be reduced by Internet-technologies, but distance "will not die" as far as firms' innovation relations are concerned.

Acknowledgements

This research project was supported by the Austrian National Bank (OeNB-Jubiläumsfonds).

References

Ancori, B., Bureth, A., Cohendet, P., 2000: The economics of knowledge: The debate about codification and tacit knowledge. Industrial and Corporate Change, Vol. 9, No. 2.

Andersen, T. J., 2001: Information technology, strategic decision making approaches and organizational performance in different industrial settings. Journal of Strategic Information Systems 10, pp. 101-119.

Autio, E., 1998: Evaluation of RTD in regional systems of innovation. European Planning Studies 6/2, 131-140.

Braczyk, H., Cooke, P., Heidenreich, M. (Eds.), 1998: Regional innovation systems. London: UCL Press.

Cairncross, F., 1997: The Death of Distance. How the Communications Revolution Will Change Our Lives. Boston: Harvard Business School Press.

Camagni, R. (ed.), 1991: Innovation Networks – Spatial Perspectives. London: Belhaven Press.

Castells, M., 1996: The rise of the Network Society. Volume 1. Oxford: Blackwell.

Cooke, P., Boekholt, P., Tödtling, F., 2000: The governance of innovation in Europe: regional perspectives on global competitiveness. London: Pinter.

Cowan, R., Foray, D., David, P.A., 2000: The explicit economics of codification and the diffusion of knowledge. Industrial and Corporate Change, 6, pp. 595-622.

Daft, R.L., Lengel, R.H., 1986: Organizational information requirements, media richness and structural design. Management Science, 32, pp. 554-571.

Dosi, G., 1988: The nature of the innovation process. In: Dosi, G., Freeman, C., Nelson, R., Silverberg, G., Soete, L. (Eds.), Technical change and economic theory. London: Pinter, pp. 221-238.

Edquist, C. (Ed.), 1997: Systems of innovation: technologies, institutions and organizations. London: Pinter.

Ernst, D., Lundvall, B.-A., 1997: Information technology in the learning economy. DRUID Working Paper No. 97-12, Aalborg.

Grant, R., 1996: Toward a knowledge-based theory of the firm. Strategic Management Journal, special issue Dec. 96, pp. 109-122.

Hähnle, M., 1998: R&D collaborations between CERN and industrial companies: Organisational and spatial aspects. IIR-Discussion Paper 56, Vienna.

Hämälainen, T.J., Schienstock, G., 2000: Innovation networks and network policies. Unpublished.

Johnson, B., Lundvall, B.-A., 2001: Why all this fuss about codified and tacit knowledge? Paper presented on the DRUID Winter Conference January 18-20 2001.

Kline, S. J., Rosenberg, N., 1986: An overview of innovation. In: Landau, R., Rosenberg, N. (Eds.), The positive sum strategy: harnessing technology for economic growth. Washington: National Academy Press, pp. 275-307.

Leamer, E. E., Storper, M., 2001: The economic geography of the Internet age. NBER Working Paper 8450, Cambridge, MA.

Lundvall, B.-A. (Ed.), 1992: National systems of innovation: towards a theory of innovation and interactive learning. London: Pinter.

Lundvall, B. and Borrás, S., 1998: The globalising learning economy: Implications for innovation policy. Report to the DGXII, TSER, Bussels.

Maillat, D., 1991: The Innovation Process and the Role of the Milieu, in E. Bergman, G. Maier and F. Tödtling (Eds.), Regions Reconsidered. Economic Networks, Innovation, and Local Development in Industrialised Countries. London/New York: Mansell.

Malecki, E. J., 1997: Technology and economic development. Harlow: Addison Wesley Longman.

Malecki, E. and Oinas, P. (Eds.), 1999: Making Connections: Technological Learning and Regional Economic Change. Aldershot: Ashgate.

Nelson, R. R. (Ed.), 1993: National innovation systems: a comparative analysis. Oxford: Oxford University Press.

Nonaka, I. and Takeuchi, H., 1995: The Knowledge Creating Company. New York: Oxford University Press.

Nonaka, I. and R. Toyama and N. Konno, 2000, SECI, B*a* and Leadership: a Unified Model of Dynamic Knowledge Creation. Long Range Planning, 33, pp. 5-34, Elsevier.

Ratti, R., Bramanti, A. and Gordon, R. (Eds), 1997: The Dynamics of Innovative Regions – The GREMI Approach. Aldershot: Ashgate.

Schumpeter, J. A., 1934: The theory of economic development. Cambridge/Mass: Harvard University Press.

Simmie, J. (Ed.), 1997: Innovation, Networks and Learning Region? London: Regional Studies Association.

Storper, M., 1997: The Regional World – Territorial Development in a Global Economy. New York/London: The Guilford Press.

Tödtling, F. and Kaufmann, A., 1999: Innovation systems in regions of Europe – A comparative perspective, European Planning Studies, Vol. 7, No. 6, pp. 699-717.

Von Hippel, E. (1988). The Sources of Innovation. Oxford: Oxford University Press.

Walsham, G., 2001: Knowledge management: The benefits and limitations of computer systems. European Management Journal, Vol. 19, No. 8, pp. 599-608.