



**Institut für Regional- und Umweltwirtschaft**  
**Institute of Regional Development and Environment**



Michaela Tripl, Franz Tödting, Lukas Lengauer

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Local buzz without global pipelines?**

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# **The Vienna software cluster: Local buzz without global pipelines?**

Michaela Trippl  
Franz Tödting  
Lukas Lengauer

michaela.trippl@wu-wien.ac.at  
franz.tödting@wu-wien.ac.at  
lukas.lengauer@wu-wien.ac.at

Institute for Regional Development and Environment  
Vienna University of Economics and Business Administration  
UZA 4, Nordbergstrasse 15, A-1090 Vienna, Austria

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## **Abstract**

The goal of this paper is to examine innovation activities in the Vienna software industry and to get a better understanding of the nature and geography of knowledge linkages in this sector. In the literature there seems to be a growing consensus that innovation rests on both informal local knowledge linkages and formal global networks, i.e. a combination of “local buzz” and “global pipelines”. Recent studies on the software sector, however, show that the importance of different types of knowledge sources, the spatial dimension of knowledge transfer and the relevance of different channels of knowledge exchange in the software industry remain poorly understood. Drawing on a firm survey and qualitative face-to-face interviews with companies we will show that in the Vienna software industry the transfer and exchange of knowledge is highly localised and strongly informal in nature, pointing to a high significance of “local buzz” and a lack of “global pipelines”. This specific pattern raises the question whether the Vienna software sector is exposed to a danger of lock in.

# 1 Introduction

Software is considered to be an industry of essential importance. This is due to the significance of the sector itself as well as its impact on other industries. Notwithstanding its youth (Weterings and Boschma 2006), the sector is already of considerable size, both in terms of number of firms and employees (see, for example, Florida et al. 2003). In the past decade, it has been one of the fastest growing knowledge-intensive industries (Tsang 2005). Furthermore, the software sector is ascribed to be a crucial source of value-added for virtually all other industries (Nowak and Grantham 2000) and a key driving force of productivity gains and overall economic growth (Florida et al. 2003).

Due to the high pace of innovation in the software industry and the dominance of entrepreneurs and small firms, knowledge linkages and partnerships are recognised to be of vital importance (Segelod and Jordan 2004). In the meantime there exists a considerable body of work, trying to unravel the relational dimension of the software industry. The evidence, however, is at least to some extent contradictory. This concerns the importance of different types of knowledge sources as well as the spatial dimension of knowledge transfer. Moreover, the relevance of different channels of knowledge exchange in the software industry is under-researched.

The aim of this paper is to investigate innovation processes in the Vienna software industry and to get a better understanding of the nature and geography of knowledge linkages in this sector. More specifically, we will examine the following research questions:

- What is the nature of innovation activities in the Vienna software cluster and what are main innovation barriers?
- What are the key knowledge sources and innovation partners of Vienna software companies and what is the geography of these interactions?
- What are the crucial channels for knowledge transfer? Do the companies in the Vienna software cluster rely more on informal modes to get access to external knowledge and expertise, or is there a dominance of formal mechanisms of knowledge exchange?

The remainder of the paper is structured as follows. Section 2 introduces the “local buzz and global pipelines” argument and proposes a conceptual differentiation between various types of knowledge interactions that serves as theoretical background for the empirical part of the paper. Furthermore, it provides a literature review on key features of the software sector, its geography and it discusses empirical studies on the relational dimension of innovation in this industry. Section 3 presents the results of the empirical analyses of innovation interactions and knowledge flows in the Vienna software sector. Based on data from a firm survey and qualitative interviews with companies we will show that the transfer and exchange of knowledge is highly localised and strongly informal in nature. Finally, Section 4 summarises the main findings and draws some conclusions.

## **2 Theoretical concepts and literature review**

In this section we discuss relevant theoretical concepts and provide a short literature review, summarising key insights into the organisation of the software sector and its main characteristics. A special emphasis will be given to studies dealing with the nature and geography of knowledge interactions in this industry. It will be shown that these central issues are far from being resolved. This is partly due to the fact that empirical evidence is at least to some extent contradictory and not clear-cut. Finally, we are going to introduce a typology of knowledge linkages that forms the theoretical base for the empirical part of this paper.

### **Conceptual background: Types of knowledge linkages and their geography**

In the past years the relevance of knowledge interactions for successful innovation processes has been intensely discussed in the academic literature (Keeble 2000). In this debate a special emphasis has been given to the nature and geography of knowledge linkages (Gertler and Wolfe 2005, Tödtling et al. 2006; Tödtling and Tripl 2007). Localised flows of know-how and expertise are regarded to be of key significance for the innovation capacity and competitive strength of clusters and regions (Porter 2000, Malmberg and Maskell 2002). There seems to be a growing consensus among many scholars, however, that it is not only local knowledge

circulation that fuels innovations. Interactions with international knowledge providers are acknowledged to also play a central role (Bunel and Coe 2001, Amin and Cohendet 2004, Lagendijk and Oinas 2005), enabling firms to get access to expertise which is not generated and available within the limited context of the region.

More specifically, it is often argued that the interplay between local and global knowledge flows is vital during the innovation process (Gertler and Levitte 2005; Cooke et al. 2007). Already Camagni (1991) in his theoretical work on innovative milieus pointed to the complementary character and interrelatedness of local knowledge exchange, which is mainly informal in nature and formal global networks. More recently, Bathelt et al. (2004) proposed the concept of “local buzz and global pipelines” to highlight that innovation in clusters rests on both myriad informal linkages at the local level and more formal knowledge interactions with distant sources and partners.

**Figure 1: Types of linkages to external knowledge sources and partners**

	<b>static (knowledge transfer)</b>	<b>dynamic (collective learning)</b>
<b>formal / traded relation</b>	<i>market relations</i> <ul style="list-style-type: none"> <li>• contract research</li> <li>• consulting</li> <li>• licenses</li> <li>• buying of intermediate goods</li> </ul>	<i>cooperation / formal networks</i> <ul style="list-style-type: none"> <li>• R&amp;D cooperations</li> <li>• shared use of R&amp;D facilities</li> </ul>
<b>informal / untraded relation</b>	<i>externalities / spillovers</i> <ul style="list-style-type: none"> <li>• recruitment of specialists</li> <li>• monitoring of competitors</li> <li>• participation in fairs, conferences</li> <li>• reading of scientific literature, patent specifications</li> </ul>	<i>milieu / informal networks</i> <ul style="list-style-type: none"> <li>• informal contacts</li> </ul>

In the following we suggest a more differentiated typology of knowledge interactions (see also Tödting et al. 2006, Tödting and Trippel 2007, Trippel and Tödting 2007) that rests on two dimensions (Figure 1). We distinguish between static knowledge transfer versus dynamic interactive learning on the one hand and formal / traded and informal / untraded linkages on the

other hand. Based on these two distinctions we can identify four types of knowledge links, including

- market relations,
- cooperations or formal networks,
- externalities / spillovers and
- milieu / informal networks.

In Figure 1 important examples for these different types of knowledge interactions are shown.

In Section 3 we will examine empirically the relevance of these different types of knowledge linkages for the Vienna software sector. We expect to find market relations and formal networks mainly at the international level, whereas spillovers and milieu effects might be confined to the local level. Before doing so we will discuss key features of the software sector and provide an overview about empirical studies dealing with the nature and geography of knowledge interactions in this industry.

### **The software industry: Key features, innovation and knowledge linkages**

The software industry is regarded to be a significant knowledge base for other sectors, fuelling innovation processes in client companies (see also Hertog 2002, Isaksen 2006). Following Isaksen (2006), we might distinguish between three roles of software companies in this context. Software firms are key “innovation agents”, acting as

- facilitators of innovation by supporting their customers in the innovation process as specialist consultants;
- carriers of innovation by propelling the diffusion of innovations such as new software solutions within the economy; and
- sources of innovation by initiating and developing innovation in client firms.

The software sector could be characterised as a young industry with low entry barriers (Weterings and Boschma 2006) and rapidly changing technology (Dayasindhu 2002). Young, radically innovative companies are acknowledged to be key agents in this sector (Engelhardt 2004). Knowledge

and creativity are the main driving forces of the development of the industry (Florida et al. 2003) and talent or skilled labour input are widely recognised as being of crucial importance (Grimaldi and Torrasi 2001; Dayasindhu 2002; Florida et al. 2003; Swart et al. 2003; Ibert 2004; Tsang 2005).

A key feature of the software sector is its dual structure and fragmented nature. The industry consists of a few major players at the one hand and a large number of small, niche market companies at the other hand (Nowak and Grantham 2000). This specific structure of the sector, i.e. the dominance of entrepreneurs and small firms, implies that interorganisational networks are highly important. Indeed, there is a widespread consensus in the literature that knowledge linkages, alliances and partnerships are a crucial characteristic of the software industry (Segelod and Jordan 2004). Grimaldi and Torrasi (2001), for example, distinguish between different types of linkages, including commercial agreements between software producers and distributors, resellers, and retailers; contractual relationships between large software producers and smaller firms (outsourcing); and joint R&D partnerships. Furthermore, it is argued that the relevance of interorganisational relationships will grow even more in future. This is strongly related to new challenges and trends that emerged recently. These mainly comprise (Nowak and Grantham 2000)

- the transformation from an object-oriented programming paradigm to a component-based software development paradigm, which implies an increasing specialisation of work, enhanced quality, lower development times and costs, and
- the creation of a global marketplace due to the growth of the Internet as a low cost channel for the marketing, sales and distribution of new software products.

The emergence of a new software development paradigm, the internationalisation of markets and the resulting increased global competition, thus, fuel the pace of innovation and further enhance the significance of knowledge linkages.

Knowledge-intensive industries tend to concentrate geographically (Audretsch and Feldman 1996; Cooke 2002). The software sector is no exception in this respect; it is strongly clustered in space (see, for example, Florida et al. 2003). It is often argued that clusters promote the innovation capabilities and competitiveness of firms within them (Baptista and Swann 1998; Porter 1998).

Isaksen (2006) compared the behaviour and performance of firms in the Oslo software cluster with those of similar companies in Norway that are not located in clusters. He found some evidence that software firms in Oslo cooperate more with local partners and experience more innovation pressure from local competitors. Moreover, he showed that software firms in Oslo are relatively more involved in innovation and R&D activities. The differences between clustered firms and non-clustered firms, however, were not as pronounced as expected.

Recently, Weterings and Boschma (2006) suggested that cluster effects are related to the age of the industry under consideration. More precisely, they distinguished between different dimensions of agglomeration economies, including urbanisation economies, localisation economies by specialisation, and localisation economies by related variety and hypothesised that given the early stage of development of the software sector urbanisation economies and localisation economies by related variety matter more than localisation economies by specialisation. Their empirical study on Dutch software firms, indeed, has shown that companies perform better in locations with related variety. No evidence, however, has been found for the relevance of urbanisation economies in the innovation process.

A key implication that could be derived from the cluster literature is that local knowledge transfer and exchange are of vital importance for regional development. In the past years a considerable body of work has emerged, trying to unravel the precise nature of local knowledge interactions and to explore their interplay with global linkages (Keeble and Wilkinson 2000; Malmberg and Maskell 2002; Bathelt et al. 2004; Gertler and Levitte 2005; Gertler and Wolfe 2005; Maskell et al. 2006; Tödting and Trippel 2007a, 2007b). Looking specifically at the software sector it must be stated, however, that the relational dimension of innovation in this industry remains poorly understood.

As noted above, technological and other inter-firm linkages are a key feature of the organisation of the software industry (Grimaldi and Torrasi 2001). Strong knowledge interactions are crucial in the innovation process in this sector, being, as Segelod and Jordan (2006) have shown, not only a precondition but also a result of successful innovation activities. There is, however, little consensus regarding the precise relevance of knowledge relations, the types of innovation partners and knowledge sources, and the nature and geography of these linkages.

Several authors have argued that close linkages between software companies and their client firms are of crucial importance in the innovation process (Bettencourt et al. 2002; Hertog 2002; Ibert 2004; Isaksen 2004, 2006). A particularly interesting contribution in this respect has been made by Segelod and Jordan (2004) who analysed the importance of knowledge sources in computer software development projects. Departing from a four stage model of product innovation made up of an idea phase, a decision phase, a development phase and a commercialisation phase, they demonstrated that customer linkages were the most important ones during the whole process. Suppliers and hardware manufacturers had some relevance in the development phase whereas competitors have been found to be more significant in the idea and decision phases. The importance of linkages to universities, in comparison, turned out to be very low.

Other scholars, however, present different findings and insights into the relational dimension of software development. Romijn and Albaladejo (2002), for example, analysed the determinants of innovation capability in small electronics and software firms in southeast England and found that the overall intensity of external linkages did not play a role for innovativeness. Moreover, they demonstrated that there was little evidence for the relevance of geographical proximity to knowledge sources in this respect. Only strong local linkages with R&D institutions and suppliers proved to be statistically significant, whereas interactions with other agents such as clients or competitors did not matter for innovative performance. A positive association between an orientation towards leading international markets and innovative performance has been found, whereas firms with local or national customer networks appeared to be performing comparatively less well.

Weterings and Boschma (2006) have shown for the Netherlands that strong relations with customers and competitors do not enhance the innovative performance of software firms. Another key finding was that being located close to the former employer had a negative effect when software firms were also inserted into a strong relationship with the parent organisation (see also Weterings and Koster 2007). According to Weterings and Boschma (2006) this result points to the danger of an “over-embeddedness” of local contacts, where too strong relationships turn into an obstacle for innovation.

Regarding the mechanisms or channels of knowledge exchange there is also a lack of clear evidence. Recent research suggests that a large variety of mechanisms play a role. Tsang (2005), for example, investigated the role of

knowledge transfer and exchange for the growth of the software industry in Boston, London and Dublin and demonstrated that academic spin-offs, recruitment of alumni, personal relationships, scanning research publications, labour mobility and research collaborations had some relevance. Segelod and Jordan (2004) have shown that in software development projects informal interactions, the engagement of temporary staff (mainly consultants), licensing agreements and recruitment of new employees matter, whereas formal agreements were less frequent and important.

To summarise, the evidence on knowledge linkages in the software sector is at least to some extent contradictory. This concerns the importance of different types of knowledge sources and innovation partners as well as the nature of the spatial dimension of knowledge transfer and exchange. Moreover, the relevance of different mechanisms or channels for getting access to knowledge that is external to software firms is under-researched.

### **3 Innovation and knowledge linkages in the Vienna software cluster**

#### **Methodology**

The empirical analysis of this article draws on a web-based survey on innovation and knowledge networks in the Viennese ICT cluster. Some 1084 Viennese ICT firms were listed in the AURELIA database. 73 firms responded, yielding a rate of return of about 7%. Most firms (69 companies) specified the ICT subsector they belong to. The overwhelming majority of these companies (64 or 93%) were from the service sector, only 5 (7%) belong to the ICT manufacturing sector. 42% of the respondents were software firms (NACE 72.20) representing the largest subsector. In the following we will focus on the results for this segment.

For the data analysis methods of descriptive statistics were applied. In another research step, and after a first statistical analysis of the surveyed companies, we have tried to substantiate the survey results in qualitative interviews with 20 firms from the software subsector. This was to deepen our understanding of innovation processes and knowledge links in this subsector.

## Characterisation of the Vienna software cluster

The region of Vienna could be regarded to be Austria's most important centre for software development. Almost 660 companies (representing 45 % of all Austrian software firms listed in the Aurelia database) are located in Vienna, indicating a heavy concentration of the sector in space<sup>1</sup>.

The Vienna software cluster is dominated by rather young and small firms. Almost 30 % have been founded after the year 2000; and another 37 % have been established between 1996 and 2000. The remaining 34 % are older than 10 years (Table 1). More than 60 % of all software firms located in the cluster is small, employing not more than five workers (Table 2). The average size of the firms in the database is 21 employees. Larger firms are clearly overrepresented in the sample.

**Table 1: Age of software firms in the database and the sample**

Year of foundation	Database		Sample	
	number of firms	share of firms in %	number of firms	share of firms in %
before 1990	114	17 %	3	11%
1990-1995	111	17 %	9	32%
1996-2000	241	37 %	7	25%
after 2000	191	29 %	9	32%
Total	657	100 %	28	100%

**Table 2: Size of software firms in the database and the sample**

Number of employees	Database		Sample	
	number of firms	share of firms in %	number of firms	share of firms in %
1 – 5	411	63 %	7	32%
6 – 20	151	23 %	9	41%
more than 20	87	13 %	6	27%
Total	649	100 %	22	100%

<sup>1</sup> According to another source, i.e. the firm census ("Arbeitsstättenzählung"), in 2001 the Vienna software industry hosted 1425 companies employing more than 12.000 workers. In the past years the cluster exhibited a dynamic growth, both in terms of number of firms (+ 105 % compared to 1991) and employment (+ 118 % compared to 1991).

## Innovation and knowledge interactions in the Vienna software cluster

Drawing on the results of the firm survey in the following we will investigate for the Vienna software cluster the relevance of different location factors, the character of innovation activities and the nature and geography of knowledge interactions.

**Table 3: Location factors in the region of Vienna**

	Importance (a)	Assessment (b)
Labour force	90	73
Customer	79	83
Supplier	20	73
Competitor	34	74
Service Firm	66	100
Commercial R&D	30	74
University	59	100
Technical College	62	85
Non-Profit R&D	17	77
Technology Transfer Center	25	71
Funding	69	54
general economic „climate“	90	59

% of firms, (a) rating the regional existence of factors as very important or important / (b) assessing the real regional presence of factors in Vienna as very good or good

Which location factors are regarded to be generally important for securing innovation capabilities and competitive advantage? For the Vienna software firms it is primarily the availability of labour and the presence of a favourable economic “climate” that matters (see Table 3). Furthermore the existence of customers, service firms, a strong knowledge infrastructure (universities, technical colleges) and funding opportunities are ascribed to be significant. How does the Vienna region perform in terms of critical location factors? From the perspective of the investigated software firms Vienna has above all excellent service firms and universities. Moreover, there is a high level of satisfaction concerning the customers, technical colleges, and non-profit R&D institutes which are present in the region. A comparatively poor assessment has been found for the factors funding opportunities and general economic “climate”.

Out of 29 firms, 27 (93%) reported that they have carried out innovation activities in the recent years. As it is shown in Table 4 the innovation activities in the Vienna software cluster are strongly concentrated on development and market implementation. Basic and applied research activities seem to be less significant in comparison.

**Table 4: Innovation activities in the Vienna software cluster**

	Total	Regularly	Occasionally
Basic Research	35	14	21
Applied Research	56	28	28
Development	93	86	7
Design	62	38	24
Market Implementation	76	52	24

% of firms

Looking at the innovation output we have found that the Vienna software cluster is very strong in terms of incremental innovations (improvement of existing products). But also modifications and technology adoption (innovations new to the firm) as well as more radical innovations (i.e. those which are new for the market) can be observed (see Table 5). In spite of relatively little research activities (see Table 4), thus, innovation in the Vienna software cluster is not only incremental in nature. The cluster also exhibits some capacity to place radically new products on the market. A similar pattern – i.e. high levels of radical innovations despite little research – was also found for the Austrian knowledge intensive business sector in general (see Tödting et al. 2006).

**Table 5: Type of innovation**

	total
improvement of existing products	83
innovation, new to the firm	60
innovation, new to the market	66
Process innovation	41

% of firms

Notwithstanding their good innovation performances, the Vienna software firms seem to face considerable innovation barriers. As it is demonstrated in Table 6 the main factors in this context include the high risk and costs of innovation as well as a lack of finance sources. For about one fifth of the firms also a lack of talent hampers innovation. This confirms the results

found on the relevance of this key location factor in the region of Vienna (see Table 3). Furthermore, there seem to be problems regarding the presence of adequate cooperation partners as well as conservative attitudes of customers.

**Table 6: Innovation barriers**

	strong barrier
high economic risk	48
high innovation costs	48
lack of financing	52
organisation problems within the company	10
lack of adequate labour force	24
lack of information about technologies and markets	7
lack of cooperation partners	17
legislation, regulations, norms	3
lack of acceptance of new products or services by customers	10

% of firms

### **Nature and spatiality of knowledge interactions**

As argued in Section 2 knowledge linkages with a variety of different partners are regarded to be significant in the software industry. The literature on the nature and geography of knowledge flows suggests a high relevance of both informal local relationships and global formal ties. In other words: It is the combination of “local buzz” and “global pipelines” (Bathelt et al. 2004) that matters for innovation. To what extent do the Vienna software firms rely on external knowledge sources during the innovation process and which partners are most important? The companies in our sample estimated that, on average, about 30 % of the knowledge that is required for innovating stems from sources outside the firm. Customers constitute the most important partners in this context, but also competitors and universities play an important role in the innovation process (see Table 7).

Exploring the spatial dimension, it has been found that regional knowledge sources are assessed as highly relevant by the Vienna software firms. Almost 50 % of the firms stated that the region is important for the transfer and exchange of expertise and competences. The existence of local customers, local competitors, local service firms and local universities seems to be most significant in this respect. What are the main reasons for the importance of the region? From the perspective of the Vienna software companies the key advantage of the local level results from an easier and

faster exchange of knowledge. Moreover, the region allows for informal communication (35 % of firms) and lower costs of interaction (28 %).

**Table 7: Importance\* of Knowledge Sources**

	Total
Group	24
Customer	69
Supplier	38
Competitor	48
Service Firm	41
Commercial R&D	31
University	45
Technical College	31
Non-Profit R&D	10
Technology Transfer Center	24

% of firms, rating knowledge source as important or very important

An analysis of the geographical dimension of knowledge sources confirms the high relevance of the local level as space for knowledge flows (see Table 8). For interactions with almost all types of sources the region constitutes the most important level. The firms in the Vienna software cluster, however, also use national and European customers, suppliers, competitors and service companies as knowledge sources. Relations to the knowledge infrastructure (universities, technical colleges), in contrast, are strongly local and national in nature. To summarise, in the Vienna software cluster there is a strong reliance on locally available expertise. To tap into global knowledge pools does not seem to be an important strategy of the cluster firms. This specific pattern, i.e. the rather weak use of global innovation partners and knowledge sources points to a potential danger of lock-in.

**Table 8: Geographical location of knowledge sources**

	Region	Austria	EU	Rest
Group	14	3	10	3
Customer	55	48	38	10
Supplier	28	21	24	16
Competitor	38	31	24	20
Service Firm	35	24	14	16
Commercial R&D	24	17	7	7
University	35	17	7	0
Technical College	24	28	3	0
Non-Profit R&D	3	7	3	0
Technology Transfer Center	21	14	3	0

% of firms

Examining the relevance of various channels of knowledge exchange we found that for firms in the Vienna software cluster informal knowledge linkages, i.e. the reading of literature and patent specifications, informal contacts, monitoring of competitors, recruitment of specialists and participation in fairs and conferences are of key importance. Spillover and milieu effects, thus, clearly dominate, whereas formal networks and market links play only a minor role (see Table 9). To put it differently: In the Vienna software cluster the mechanisms of knowledge transfer could be characterized by a high relevance of “buzz” and a low significance of “pipelines”.

**Table 9: Knowledge Transfer Channels**

	total
<b>Market relations</b>	
Contract research	35
Consulting	31
Licenses	14
Intermediate goods	24
<b>Cooperation / formal networks</b>	
R&D cooperation	38
Shared use of R&D facilities	10
<b>Milieu / Informal contacts</b>	
Informal contacts	69
<b>Externalities / spillovers</b>	
Recruitment of specialists	52
Monitoring of competitors	59
Fairs, conferences	45
Reading of scientific literature and patent specifications	79

% of firms

Looking specifically at movements of skilled people as a specific mechanism of knowledge flows (see, for instance, Keeble 2000) we found that the local labour market is highly relevant (see Table 10). Local universities play a crucial role as source of highly qualified talent for the Vienna software firms. But also the technical colleges present in the Vienna region and local firms are key providers of skilled labour. Although not as important as the local level, also the national and international scales are significant for recruiting specialists. Thus, there is an inflow of expertise from outside the region into the software cluster.

**Table 10: Recruiting of specialists: sources and geography**

	regional level	national level	international level
Universities	66	24	24
technical college	45	35	10
other firms	41	28	17

% of firms

### R&D cooperations

As argued in Section 2 it is often claimed in the literature that formal innovation networks and R&D cooperations at the global level are vital, complementing the local buzz in clusters. Which role do such formal linkages play in the Vienna software industry and what is their geography?

We found that about 40 % of the software companies in our sample are involved in collaborative linkages. Regarding the areas of R&D cooperation software firms in the Vienna region mainly collaborate in the medium stages of the innovation process (see Table 11). Development, applied research, and prototyping and testing constitute the most important areas of cooperation. The main objectives of R&D cooperations are more radical innovations, i.e. innovations that are new for the market. Also the entering of new technological fields plays a role (see Table 12).

**Table 11: Areas and objectives of R&D cooperation**

	total
Areas of R&D Cooperation	
Basic Research	10
Applied Research	24
Development	35
Prototyping, Testing	24
Commercialisation	14
Objectives of R&D Cooperation	
Improvement of existing product	21
Innovation, new to the firm	14
Innovation, new to the market	35
Patent development	7
Entering new technical fields	24
Joint publication	10

% of firms

Investigating the geographical dimension we found that formal R&D networks as knowledge interactions in general are a highly localised phenomenon (see Table 12). Local commercial R&D firms, competitors, customers and universities play an important role as cooperation partners for the Vienna software companies. To a lesser extent R&D cooperations can also be observed at the national level, whereas international partnering is negligible. This contrasts expectations of global R&D partnerships and innovation networks as stated by Camagni (1991), Bathelt et al. (2004) and others.

**Table 12: Geographical location of R&D cooperation**

	<b>Region</b>	<b>Austria</b>	<b>EU</b>	<b>Rest</b>
Group	7	3	3	0
Customer	14	10	3	3
Supplier	7	3	0	0
Competitor	17	7	0	0
Service Firm	10	3	3	0
Commercial R&D	21	10	3	0
University	14	3	0	0
Technical College	10	10	0	0
Non-Profit R&D	3	3	0	0
Technology Transfer Center	7	3	0	0

% of firms

To get access to complementary technologies and knowledge (35 % of all firms) is the main motive to cooperate. Other reasons including the speeding up of the innovation process (21 %), the reduction of innovation costs (21 %), and the reduction of innovation risk (14 %) seem to matter to a lesser extent.

## **Knowledge sources, mechanisms of knowledge transfer and different types of innovators**

To substantiate the results of the firm survey 20 qualitative face-to-face interviews with software companies in the region of Vienna have been carried out. In this sample young firms (year of foundation after 1995) are dominating (65 %). Moreover, there is a dominance of smaller firms in the sample. About 20 % of the companies employ fewer than 5 persons. Almost half of the firms (45 %) have 6 to 20 employees and only 35 % are larger, employing more than 20 persons. As in the quantitative part of our research the focus of the qualitative interviews was on knowledge interactions. Their importance has been accessed by looking at the number of relations with different sources and not – as done in the quantitative analyses – by calculating the share of firms which sustain linkages with the respective partners. Furthermore, a key goal of the qualitative interviews was to identify different segments of firms and to examine how they differ regarding their knowledge sourcing and innovation activities.

Which external knowledge sources are used by these software firms? Clients are the most important partners (28 % of all knowledge links). Furthermore, a strong role of competitors (18 %), universities (14 %) and service firms (11 %) could be found. Examining the spatial dimension of these knowledge links we found a high importance of the region as interaction space. More than 40 % of all knowledge linkages are local in nature. But also the national level (27 %) and the international level (32 %) turned out to be significant. The results of the personal interviews, thus, confirm the pattern found in the quantitative analysis.

The results presented above, however, conceal strong differences between different types of innovating firms regarding the importance of various knowledge sources, their geography and mechanisms for knowledge transfer. Drawing a distinction between different types of innovators provides further insights into the issues dealt with here. We distinguish between

- adaptors (6 firms),
- incremental innovators (5 firms), and
- radical innovators (7 companies).

Two firms in the sample could not be classified to one of these groups and they are, therefore, not considered in the following analysis.

**Table 13: Number of knowledge links and types of innovating firms**

	total (in %)	Adaptors (6 firms)			Incremental innovators (5 firms)			Radical innovators (7 firms)		
		regional	national	global	regional	national	global	regional	national	global
Customer	28	5	5	1	2	2	3	4	4	2
Supplier	9	2	0	1	1	0	0	2	0	3
Competitor	18	5	2	2	1	0	3	1	1	3
Other software companies	5	0	0	5	0	0	0	0	0	0
Service firm	11	3	1	0	1	2	2	1	1	0
University	14	0	0	0	1	1	0	5	3	4
Technical College	7	0	0	0	0	0	0	3	3	1
Non Profit R&D	8	0	0	1	1	0	0	3	2	1
Commercial R&D	1	0	0	0	1	0	0	0	0	0
	<b>101</b>	<b>15</b>	<b>8</b>	<b>10</b>	<b>8</b>	<b>5</b>	<b>8</b>	<b>19</b>	<b>14</b>	<b>14</b>
		45%	24%	30%	38%	23%	38%	40%	30%	30%

The firms which have been classified as „adaptors“ are mainly specialised in providing client-specific adaptations of existing software and consultant services. Our analysis has shown that these firms are overwhelmingly concentrated on the local and national market. Only one software company in this group exhibit strong export activities (40-50 % of turnover). An investigation of the external knowledge sources and channels for knowledge transfer shows that direct informal contacts to local and national clients are of key importance for the adaptors. Additionally, informal relationships to local competitors play a role. Contacts to internationally dispersed software developers, which are mainly about a free exchange of knowledge in internet forums also turned out to be important. Generally, for the group of adaptors in the Vienna software cluster the internet is a key channel for knowledge exchange (7 indications). It is used to discuss problems with other software developers dispersed around the world, to keep ahead with the latest technologies, and to monitor markets and competitors. Other types of spillovers such as the participation in conferences and fairs (5 indications), the reading of scientific publications (3 indications) are also relevant. Furthermore, market linkages including the buying of licenses (4 indications) and software (3 indications), consulting (3 indications) play a role.

A different picture can be found for the group of incremental innovators. Companies belonging to this group have developed own, often radical software solutions in the past, which are now improved continuously in an incremental way. Two companies have strong export activities (more than 80 % of turnover), and the remaining three firms are oriented on the national market, but intend to expand their markets in the near future. For the incremental innovators also clients are the most important knowledge source. In contrast to the patterns found for the adaptors, these clients could be mainly found at the international level. Furthermore, specialised service firms at all spatial scales and international competitors, which are monitored via internet, turned out to be important. Knowledge generating institutions are used in a sporadic way in the innovation process. Looking at the mechanisms for knowledge transfer, we can see that spillovers and milieu effects are of outstanding importance. These comprise the monitoring of markets and competitors (4 indications) via internet, consulting firms and clients, as well as fairs and conferences (3 indications) and the reading of scientific literature (3 indications). Specific types of market relations such as contract research (3 indications) and formal R&D cooperations (3 indications) also play a role.

The group of radical innovators are oriented on generating products and services new for the market. For these firms the most important knowledge sources are local, national and international universities. Furthermore, other types of knowledge generating institutions such as technical colleges and non-profit R&D institutions are relevant. Finally, regional and national clients play an outstanding role. An analysis of the mechanisms of knowledge transfer shows that all firms belonging to the group of radical innovators sustain R&D cooperations (i.e. formal network links), mainly with knowledge generating organisations (7 indications). Milieu effects and spillovers are relevant, too. A strong role of informal contacts (6 indications), the reading of scientific literature (6 indications), the monitoring of markets and competitors (5 indications) and participating in fairs and conferences (5 indications) could be found. Market relations such as the buying of licenses (4 indications) and software (3 indications) are of minor importance.

To summarise, the more radical the innovation is in nature, the larger is the number of different types of knowledge sources and the stronger is the diversity of mechanisms of knowledge transfer.

With respect to highly qualified people as knowledge source we found an outstanding role of universities and technical colleges as providers of these specialists (24 indications). Other companies (7 indications), in comparison, do not play a comparable role. Again, the regional level is of crucial importance. Also the national level is important (12 indications), whereas the international level is negligible. Labour markets are, thus, still to a high degree regional and national in nature. Distinguishing between different types of innovating firms (see above) shows that adaptors recruit their specialists both from other companies and universities or technical colleges, whereas incremental and radical innovators almost exclusively employ alumni from higher education institutes.

## **4 Summary and conclusions**

Due to the high pace of innovation in the software sector and the prevalence of small companies, external knowledge linkages are recognised to be of growing importance for firms in this industry. The significance of different types of knowledge sources, their geography and the relevance of various

mechanisms for knowledge exchange, however, are still poorly understood in the literature.

In this paper an attempt has been made to examine these issues for the Vienna software sector. Drawing on the results of a firm survey it has been shown that customers, competitors and universities are the most important knowledge sources for innovative Viennese software companies.

Furthermore, the empirical analyses revealed that knowledge circulation is strongly localised in nature. Compared to other knowledge based sectors in Austria (see Tödting et al. 2006, Tödting and Tripl 2007, Tripl and Tödting 2007), an outstanding high relevance of the region as space for knowledge flows has been found. This holds true for interactions with almost all knowledge sources, and it has a particular significance for the use of expertise generated by local universities.

Regarding the mechanisms of knowledge transfer, a dominance of more informal types, i.e. spillovers and milieu effects, has been found. Market linkages and formal networks, in contrast, do not play such a vital role. To summarise, the transfer and exchange of knowledge in the Vienna software cluster is highly localised and strongly informal in nature, pointing to what has been termed “local buzz” (Bathelt et al. 2004) in the literature, whereas “global pipelines” (i.e. more formal and international knowledge linkages) seem to be missing.

This specific pattern found for the Vienna software industry raises the question whether the cluster is exposed to a danger of lock in. In the meantime there exists a considerable body of work that emphasises that local ties are far from being sufficient for sustaining strong innovation capabilities. To tap into international knowledge sources to get access to expertise and skills that are not available within the limited context of the region is considered to be of crucial importance (Camagni 1991, Bunnell and Coe 2001).

The results of the qualitative interviews lead us to note that the character of knowledge linkages is dependent on the nature of the innovations brought forward. It has been shown that the more radical the innovation, the larger is the variety of knowledge sources and the stronger is the diversity of mechanisms of knowledge transfer. We might conclude that in future work more attention should be given to examine the relation between different types of innovation and different types of knowledge interactions.

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Institut für Regional- und Umweltwirtschaft  
Wirtschaftsuniversität Wien  
Institutsvorstand : o.Univ.Prof. Edward M. Bergman, PhD  
Nordbergstraße 15  
A-1090 Wien, Austria  
Tel.: +43-1-31336/4777 Fax: +43-1-31336/705 E-Mail: [sre@wu-wien.ac.at](mailto:sre@wu-wien.ac.at)  
<http://www.wu-wien.ac.at/inst/sre>