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The spatial multidimensionality of sectoral innovation – the case of information and communication technologies

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Abstract

The innovation system approach has become a current and frequently used tool for the assessment of innovative activities in different fields of study. So far, however, there is no unanimous agreement on the issue of the most relevant perspective which has to be taken when applying the approach to the study of individual cases – the territorial or the sectoral. This paper argues that it is both unlikely and analytically undesirable that any one of them should prevail. We will point out that taking the ICT sector as a case study, in most cases both territorial and sectoral determinants influence the development of innovative activities. We thus argue that neither the sectoral perspective can be thought of without taking into account territorial framework conditions nor vice versa. Even when the individual academic undertaking requires lying emphasis on one of the perspectives, the other needs to be included in the analysis.[1]

1 Introduction

Innovation is nowadays widely understood as a complex, interactive and distributed process, including contributions and feedback loops from different sources (Kline and Rosenberg, 1986). This understanding of innovation as interactive process is embedded in the conceptions of evolutionary economics, based on the assumption of evolving structures, bounded rationality, opportunistic behaviours of economic actors and particularly un-certainty, i.e. complex and unstable production environments, and information asymmetries as well as cumulative learning processes (Nelson and Winter, 1982; Lambooy and Boschma, 2001). The economic structure is characterised by growing variety and complexity through the development of technologies, organisations and firms. Evolutionary economics assumes that economic actors and the economic structure are inter-related and mutually influence each other.

Multiple and diverse knowledge sources are important for a successful innovation project (Drucker, 1985). As a matter of fact, the increasing openness and uncertainty of innovation processes is connected with an increasing significance of innovation networks: Inter-organizational networks have been analyzed as arenas for systemic innovation and learning processes (Freeman, 1991; Saxenian, 1994; Powell et al.; 1996). An arena for innovation and learning was defined by the concept of the national system

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1 This paper was presented at the DIME Workshop "Local and sectoral systems of innovations - Interdependencies and their development patterns over time" which took place from 21-23 May, 2008 at the University of Karlsruhe, Chair of System Dynamics and Innovation. This is a revised version taking many of the helpful suggestions from the discussion of the paper into account.

of innovation (NSI). According to Freeman (1987, p. 1), a NSI is a "…network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies". Lundvall (1992, p. 2) added to this definition the fact that the NSI "…encompasses elements and relationships (that are) either located within or rooted inside the borders of a nation state".

Although the NSI concept focuses on the specific institutional settings affecting innovation and technological development at the national scale, it is generally acknowledged by innovation economics that the adaptation of new knowledge and new technologies might be influenced by national or even regional institutional frameworks, but that the generation of new technologies goes far beyond the capacities of single nations. Freeman (1991) has already drawn attention to the fact that the increasing significance of networks is accompanied by the increasing importance of the different innovation systems (Edquist, 1997, 2001). This is especially the case when the role of multinational enterprises (MNEs) in technological development is analyzed. They establish cross-sectoral and cross-national networks in order to realise a multitude of synergies from the exploitation of different knowledge sources rooted in different geographical locations and sectoral innovation systems (Narula and Zanfei, 2005). Although it is often argued that MNEs are footloose (Görg and Strobl, 2003) and act globally, the global character of knowledge and technology however demands a cross-national, a cross-regional and sometimes also a cross-sectoral viewpoint in order to understand and analyze the multidimensionality in space and sectors of innovation processes (Bunnell and Coe, 2001; Carlsson, 2006).

The following paper has two starting points. Firstly, we will show that regional and national features have an important impact on sectoral innovative activity, depending on the systemic interaction between the national, regional and the sectoral systems. Secondly, we will point to the role MNEs play in the coordination process between sectoral and territorial innovation systems. Within this context, the focus of our analysis is on the spatial multidimensionality of sectoral innovation systems, in which territorial embeddedness and disembeddedness of firms in a dynamic perspective are two sides of the same coin. The sectoral innovation system we chose is the information and communication technology (ICT) sector, because it is a highly dynamic and knowledge based high-tech sector. Linkages to regional and global knowledge sources are equally important for the sectoral development as the embeddedness in supplier, client and service networks of different geographical scope (Narula and Santangelo, 2009; Mossig, 2008; Scott, 1998). At the interface between traditional industries and the ICT sector innovation increasingly takes place in form of transferring existing technologies into hybrid technologies (Kodama, 1995). This "technology fusion" approach and ongoing hybridisation tendencies of the ICT sector makes it an interesting object of study, given

the assumption that both territorial and sectoral determinants influence the development of innovative activities. On the background of theoretically derived theses we carried out three qualitative regional case studies in order to provide further insights into the interactions between territorialisation and sectoral activity.

2 The multidimensionality of innovation systems

The systems of innovation concept is a heuristic approach (or according to Edquist 1997, p. 28-29 a 'conceptual framework') by which "…all important economic, social, political, organizational, institutional, and other factors that influence the development, diffusion, and use of innovation" (Edquist, 2005, p. 182) can be identified and analyzed. The first approach towards the understanding of nations as national systems of innovation was made by Freeman (1987, 1988) who analyzed technology policy and economic performance in Japan and raised the question whether Japan is a new system of innovation. In the following years, Lundvall (1992) made important contributions to the theoretical advancement of the concept while Nelson (1993) enriched it with case studies examples. The major focus lay on the institutional set up defined by national boundaries and the factors influencing innovative activity at the national scale. This is predominantly a static perspective, because the analyses deal with functions and activities (Edquist, 2005, p. 189) and less with the dynamic evolution of innovation systems.

At the beginning of the 1990s, Cooke (1992) developed the concept of regional systems of innovation. Regional systems are not national systems writ small, but respond to different rationales, institutional and governance settings which can be found at the sub-national territorial level. It is a distinct element of the concept that a region does not offer all factors and institutions necessary for innovation, but that it is a part of a superior, i.e. national system, and has to cooperate with other regional or national systems in order to merge all necessary resources at the specific territory (Cooke et al., 2004, Asheim and Gertler, 2005). While the notions of NSI and RSI "…have been conceptualized widely independent from each other, …the international dimension has been introduced in relation to either the one or the other, or both" (Fromhold-Eisebith, 2007, p. 219). Also during the mid 1990s, Carlsson (1995) focussed on technological systems while Breschi and Malerba (1997) dealt with innovation among a group of firms within a specific sector.

While national and regional innovation systems are easily to define, i.e. generally by national or regional geographical boundaries, or by the degree of stickiness and the kind of the regional knowledge base and its relation to proximity (Asheim and Gertler, 2005, p. 310), a sectoral innovation system is more difficult to grasp. According to Bre-

schi and Malerba (1997, p. 131), a sectoral innovation system can be defined as a "group of firms active in developing and making a sector's products and in generating and utilizing a sector's technologies". More recently, Malerba (2002, p. 250) defines it as "a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of these products". Although the concept of innovation systems displays different scopes with regard to its territorial and sectoral dimension, the fact that institutional settings affect innovation behaviour and innovation output applies to all dimensions. Empirical studies about national, regional and sectoral innovation systems show that a bundle of different actors, actor groups and appropriate framework conditions have a pertinent function for the success of innovative efforts (Edquist, 2005).

As a matter of fact, most innovation processes are distributed and context-specific, i.e. they depend on the larger framework in which they take place (Singh, 2008; Coombs et al., 2003). The territorial (national or regional) systems of innovation approach emphasizes the relevance of localized framework conditions for the generation and diffusion of technologies and defines contingency with regard to a geographic perspective. One often emphasized aspect is the localized character of tacit, non-codified knowledge, which makes it necessary for firms which need to get access to this knowledge to closely locate to relevant knowledge sources (for example research labs or other creative enterprises) and by this to exploit the advantages of the 'local buzz' of learning and knowledge generating processes (Bathelt et al., 2004). Territorial embeddedness (Hess, 2004) of this kind is also an important aspect for MNEs. According to Cantwell and Piscitello (2002, p. 69-70), "the existing knowledge base of a region plays an important role in the decisions of the largest foreign-owned firms as to where to locate their technological activities…".

The sectoral innovation system, on the other hand, puts a specific focus on the framework conditions in a particular industry. It emphasizes that actors belonging to a certain sector have sector-specific knowledge and use sector-specific technologies, and that market relations, the institutional context, actors' behaviours, etc. are specific in these sectors. Sectoral innovation, however, is not spaceless, but rooted in a multi-territorial system in which different locations and their institutional fabric influence innovative activity in a specific manner. The coordination of processes within this complex system is mainly carried out by MNEs, the crucial actors of the global economy. Through internationalization, MNEs attempt to use their specific competences in several markets (Chandler, 1992). Within MNEs, polycentric R&D structures develop (Patel and Vega, 1999), and heterarchical organizational structures rely directly on various national competences (Sölvell and Zander, 1995). The activities of MNEs are therefore the main driving mechanism of the internationalisation of the transfer of knowledge and tech-

nologies (Dunning, 2000). On the other hand, nations and regions are not closed containers, whose economic strengths exist independently of its driving business actors which are deeply embedded in their inter-national environment (Bunnell and Coe, 2001). With the increasing internationalization in the business sector (as well as the policy arena), today's national and regional innovation systems are open, globally connected spaces, characterized by their integration in a number of transnational technological regimes (Carlsson, 2006; Koschatzky, 2005). Consequently, overlaps exist between sectoral innovation systems and geographically defined ones, due to the oftentimes localized character of sectoral innovation and production.

The interrelationship between localized and non-localized innovation leads to the fact that neither the sectoral nor the territorial innovation system approach can deliver satisfactory results when followed in isolation. What can be observed so far is that spatial studies emphasize the impact of geographical proximity on regional innovation (e.g. Davenport, 2005; Weterings and Boschma, 2009), while studies dealing with technological aspects of innovation focus on the sectoral and firm level without systematically taking the effects of geographical proximity into account (Caniels and Romijn, 2003). In recent contributions to this scientific debate, attempts are made to develop multi-level conceptual frameworks for the comprehensive analysis of sectoral and technological innovation and for bridging the different territorial scales in innovation policies. Markard and Truffer (2008) developed an integrated framework by relating the concepts of technological systems, defined by actors, networks and institutions, regimes, understood as a set of rules carried out by different social groups, and niches, which are constituted by actors, networks and supportive institutions, and pointing to the interactions between these two different spheres. With this framework it should be possible "…to account for emergent effects in innovation processes that occur beyond individual niches" (*ibid*, p. 613). Not only the concepts of national and regional systems of innovation display a strong governance orientation (Asheim and Gertler, 2005), but also the sectoral innovation approach (Malerba, 2002). Policy is thus one of the constitutive elements of the concepts of innovation systems (cf. table 1). In this respect, Fromhold-Eisebith (2007) links elements of national, regional and international systems of innovation in terms of an ideal type model for policy intervention purposes. She develops a 'national supersystem of innovation' (NSSI) approach in which national authorities act as 'masters of scales of innovation promotion' and in which the two scales (national and regional) fulfil different functions and tasks in order to link either to the regional or national scale and to the international scale. It is argued that "…an ideal type NSSI is not governed top-down but includes important bottom-up processes that emerge from regional initiatives and competences" (ibid, p. 229). What is interesting in this concept

is the finding that both national and regional systems can profit from each other and that both can profit from linking to the superior, i.e. international scale.

Related to the topic of the multidimensionality of sectoral innovation, it can be concluded that a view towards different niches, which could be interpreted as different regional or even national institutional settings, is essential in order to obtain a more comprehensive picture and understanding of actors, networks, and institutions that contribute to the overall technological and sectoral system. According to Markard and Truffer (2008) such a framework could offer a series of benefits, especially with regard to the explanation of technological transformations and transitions.

3 Conceptual framework and research questions

As already pointed out in section 2, regions and nation states are not containers of economic activity in a globalized world, but act as hubs in an international network of economic interactions and knowledge flows (cf. Bathelt et al., 2004). Very often, the nature of these international networks differs among technology fields, partially because of particular characteristics of the technology themselves, partially because of different communities of practice (Assimakopoulos 2007), and partially because of the structure of the global market or the international norms and standards enabling, limiting and shaping innovative activities of the sector. Regardless of their size, multinational enterprises fulfil and important role in these international networks, especially by bridging sectoral and territorial networks. They channel interregional knowledge flows in certain sectors and technology fields into a national or regional innovation system in the way that supra-national sectoral systems become territorialised.

Based on the preceding theoretical discussion, we formulate the following theses as guidelines for our empirical analysis:

1. Innovation systems are characterised by organisations and actors that span both regional and sectoral boundaries.
2. MNEs play an important role in the coordination process between sectoral and territorial innovation systems.
3. Only a combination of a territorial and a sectoral approach can provide both academics and policy makers with a satisfactory understanding of innovation systems.

Taking the heuristic approach of innovation systems as a conceptual framework of analysis, table 1 summarizes all elements which are classically considered to be important or constitutive of an innovation system (Edquist, 2005; Malerba, 2002) and which are subject to both territorial and sectoral influences. While some, such as the typical

form of competition, are easier acknowledged as a sectoral characteristic of an innovation system, they are also the result of the national or regional business culture. The impact of relevant policy measures, which for a long time has been rightly considered as mostly determined by the national and regional location, is increasingly complemented by the influence of transnational, sector-specific policy frameworks, e.g. in the European Union. While different policies are designed from both sectorally focused and cross-sectoral perspectives, it depends to a high degree on the regional institutional environment if sectoral or cross-sectoral policies play a more decisive role and at the level of policy making (transnational, national, regional) at which they are designed.

Table 1: A sectoral-territorial approach to the analysis of innovation systems

Innovation System			
Elements	**Territorial dimension**		**Sectoral dimension**
	regional	**national**	**sector / technology field**
Agents and organizations	regional governance bodies, regional education institutions	national governance bodies, national education institutions, national IPR administration	MNEs, international norming and standardisation bodies, international IPR administration, (international) branch associations
Interactions	local cross-sectoral networks	national cross-sectoral networks	international intra-MNE interactions, communities of practice
Knowledge base	localized tacit knowledge (specific, application related, cross-sectoral)	codified knowledge (general, basic research related, cross-sectoral)	codified knowledge, tacit knowledge in intra-MNE networks, tacit knowledge communities of practice
Human Capital	regional labour pool	national labour pool, mobility of labour force	specialised labour market, cross-sectoral mobility of labour force
Institutions	regional laws, regional governance	national laws and regulations, national governance	international treaties, international norms and standards
Policies	regional innovation policies, education policies	innovation policy, education policy	transnational ICT sector oriented policies and policies aiming at IT skills
Technologies and demand	regional laws on technology, regional acceptance of technology, regional buying power, regional demand caused by industry structure	national laws on technology, acceptance of technology in society, position to lead markets	factual trends in leading edge technology development

Innovation System			
Elements	**Territorial dimension**		**Sectoral dimension**
	regional	**national**	**sector / technology field**
Competition and selection	regional economic characteristics: presence of competitors in the field, spirit of competition, entrepreneurial spirit, foundation aptitude	national economic characteristics: anti-trust legislation, bankruptcy legislation	sectoral specificities, firm size, position in product/service life cycle, mobility of product/service, degree of specialisation

Source: own compilation based on Edquist (2005) and Malerba (2002)

For many other constitutive elements, such as agents and organisations, interactions, knowledge base, human capital, and institutions, the double importance of sectoral and territorial attribution of an innovation system under study becomes evident from the examples given in table 1 and does therefore not require additional argumentation.

A critical case, admittedly, remains the impact of technological trends which is often quoted as a key argument for the high(er) importance of the sectoral approach. We would argue, however, that even technological trends cannot be thought of independently of the location of the developing firm or institute. In the ICT sector, for example, the degree of development of the information society in a country or a region determines to what degree certain ICT products and processes can be developed with a realistic hope of market success.

Having pointed out to the double-dimensionality in the determination of innovation systems, it is important to take into account that much future research will still have to lay emphasis on one of the approaches. To be able to follow concise and relevant conceptual approaches, studies will thus either tend to focus on the different ways in which sectoral innovation systems are territorialised in certain places or to analyze how territorial innovation systems are determined by the different sectoral innovation systems that are locally anchored within their scope. In this paper, as pointed out above, we will follow the former approach and illustrate the impacts that territorial location can have on the development of sectoral innovative activity in certain places.

4 Sectoral Focus: Information and Communication Technologies

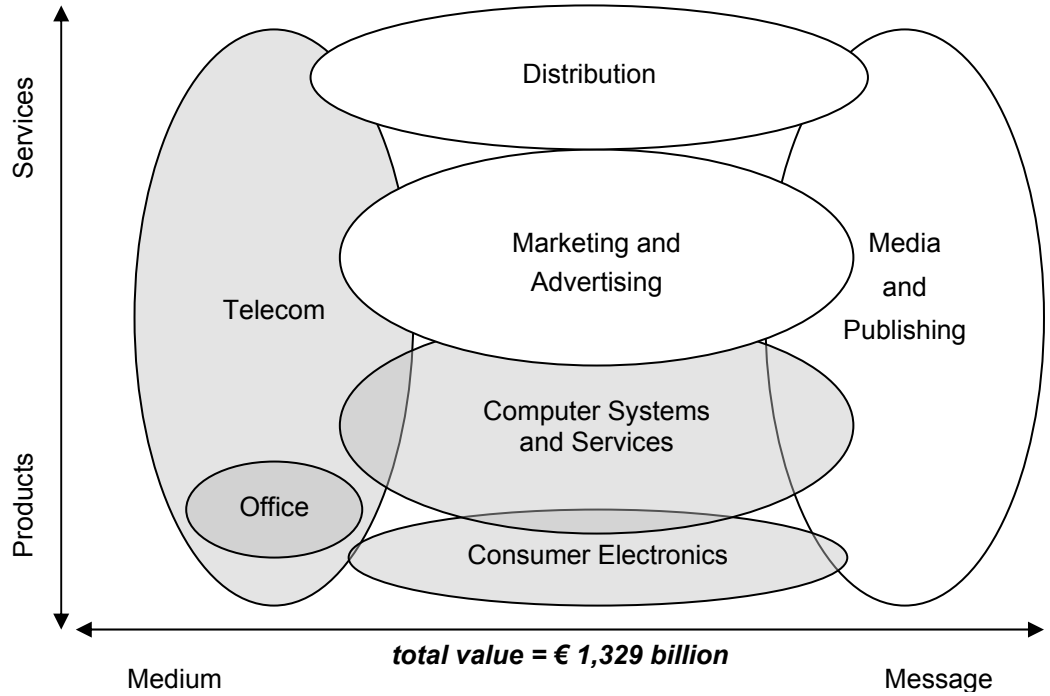
The R&D activity in the ICT sectors stands out as a very important factor boosting the development of knowledge-based competitiveness of European economy. ICT products and services are highly innovative general-purpose technologies, enabling many of the changes in business processes and innovation processes that help make other sectors more innovative (OECD, 2002).

While the economic downturn following the burst of the IT bubble in 2001 had severe consequences for ICT manufacturing, telecommunications services and information technology services continued to grow (OECD, 2004). Currently growth in the ICT sectors is concentrated on new and niche goods and services and to emerging markets (OECD, 2006). However, beyond the industrial sectors classically associated with ICT production, an "information society industry" is created by the convergence of IT, communications and content sectors. According to the i2010 Annual Report this industry currently generates 8% of Europe's GDP and employs about 6% of its workforce. It is among the most productive sectors of the economy, contributing over 25% of productivity growth (European Commission, 2007). Moreover, the ICT sector accounts for a 26% share of business R&D spending in 2003 (European Commission, 2007). The business ICT R&D model is one of "open innovation" where firms are tapping international talents and excellence, spreading R&D costs and technological risks and participating in broader international technology networks (Kogut and Metiu, 2001).

Typically, the ICT sectors are defined by the 2002 OECD definition (OECD, 2002). For manufacturing industries, the products of a candidate industry must thus be intended to fulfil the function of information processing and communication including transmission and display and/or use electronic processing to detect, measure and/or record physical phenomena or control a physical process. For services industries, the products of a candidate industry must be intended to enable the function of information processing and communication by electronic means.

As pointed out above, however, a process of convergence between formerly separate industries can be witnessed that would need to include a somewhat broader set of branches relevant for the "information society industries" (cf. figure 1). Beyond computer systems and services as well as telecommunications, those include office machinery, electrical engineering, consumer electronics, media/publishing, marketing/advertising and the distribution of ICT goods (EITO, 2007). While much of this broader field is indeed covered by the OECD definition, there may be particular framework conditions under which a lot of ICT relevant activities cannot really be captured through NACE attribution.

Figure 1: Information Society Industries



Note: Grey shading: ICT sector by OECD definition
Source: EITO (2007, p. 43)

Given this basic understanding of the ICT sector as a broad and delimited field, it is important to point out that the composition of the ICT industries varies considerably across countries. From a sectoral perspective, in fact, few countries are specialised in the parts of the ICT sector that are characterised by very rapid technological progress, e.g. semiconductor or computer production. While some specialise in the manufacturing of communication equipment, others have experienced a growing weight of computer services. In Denmark, France, Italy, the Netherlands, Norway, and the United Kingdom, for example, computer services now account for over 30% of total ICT production (OECD, 2002).

Moreover, it is important to point out that ownership and control of the ICT industry varies considerably across countries. Finland and Sweden have built up competitive advantage by expanding their domestic communication equipment sector. On the other hand, the relative specialisation of some countries in ICT production depends strongly on the presence of foreign affiliates – such as in Ireland and Hungary.

Within the European context, the three largest economies, i.e. Germany, France and the United Kingdom contribute more than 60% of total (known) value added and more than 60% of total (known) BERD of the EU ICT sectors. They constitute the nexus of all ICT activity in Europe providing both lead markets and the most substantial and best

networked capacities for ICT R&D. The growth of many smaller national ICT sectors, in contrast, is still to a large degree dominated by catching up effects rather than necessarily by innovativeness.

Among the medium-sized economies, characteristics differ strongly. Countries with innovation-oriented ICT sectors such as Austria, Belgium and Denmark display a lot of similarities to the larger countries at a smaller scale whereas some countries like Finland and the Netherlands have highly innovative, specialised ICT sectors with an output far beyond the absorptive capacities of their home markets. The success of these countries is unambiguously based on their ICT R&D capacities. Other countries, like Italy and Poland, have not developed an active ICT innovation system despite having a relatively large ICT market. The ICT innovation systems of these countries appear to be quite heterogeneous, fragmented and far from forming efficient and capable systems. The level of interaction among the actors is relatively low. Finally, there are a number of European countries with catching-up ICT sectors whose growth is based on comparatively low wages and assembly oriented production. Most notable among those are Hungary, but also Ireland, which may be on the way to develop a highly innovative medium-sized ICT sector, but for the moment remains centred on export processing. Although there is no direct connection between economic success and size, there is a considerable group of countries with ICT micro sectors that seem to lack critical mass for any substantial ICT R&D development. Despite their often fast growing ICT sectors and partially sizeable foreign direct investments, foreign financing of ICT R&D in those countries remains low even compared to that in some high-growth catching-up sectors. One of the major problems for these countries is that their ICT R&D sectors are often dominated by a few highly innovative foreign-owned companies which import knowledge and new technologies from abroad without necessarily initiating any spillover effects to the local ICT business or research sector.

MNEs as Central Players in National Innovation Systems in the ICT Sectors

In the European ICT sectors, multinational companies play a defining role. The statement that those countries which are home to the largest ICT corporations have the strongest ICT sectors is simplifying, yet holds some validity. The German ICT sector, for example, is strongly influenced by the contributions of Siemens, Infineon Technologies, Deutsche Telekom and SAP as is the French by Alcatel, ST Microelectronics and France Telecom. It also seems noteworthy that those smaller economies known for their strong performance in the ICT sector are typically home to one or more large MNEs, like Philips and ASML in the Netherlands, Nokia in Finland as well as Ericsson and TeliaSonera in Sweden. Remarkably, however, there are exceptions to the rule. Even though the United Kingdom is home to the third largest ICT sector in Europe,

there are few internationally dominant large-size MNEs beyond the national telecommunications providers BT and Vodafone. On the one hand this can be attributed to intra-sectoral specialisation on computer services (and thus lower average firm size) and on the other hand to an ownership pattern that is particular for the UK (high degree of U.S. influence). This example already points to the interrelationships and contingencies between national and sectoral contexts which constitute the complex nexus of a local innovation framework and which will in the following be further explored.

At the end of this section, however, it is important to sum up that an identification of the key players in the business sector is indispensable to understand national innovation systems in the ICT sector (cf. table 2). If sectoral research and development are concentrated to the degree observed in this field, all actors in the respective innovation system have to be understood in relation to those central players, their motivations and actions. For this reason we will in the following not only apply our theoretical concept on a broad scale, but also give concrete case studies to illustrate in what ways the different national as well as sub-sectoral innovation systems can be differentiated.

Table 2: Multinational Enterprises in the ICT sectors in European Economies

				R&D Investment	Employees	R&D/ Employee	Net Sales
Rank	**Company**	**Country**	**NACE**	**2005**	**2005**	**2005**	**2005**
				€m	**#**	**€K**	**€m**
1	Siemens	D	3162	5,155	439,400	11.7	75,445
2	Nokia	SF	3220	3,978	56,896	69.9	34,191
3	Ericsson	S	3220	2,730	54,195	50.4	16,172
4	Philips Electronics	NL	3230	2,337	137,799	17.0	30,395
5	Alcatel	F	3220	1,792	57,699	31.1	13,135
6	STMicroelectronics	CH (F)	3210	1,317	50,000	26.3	7,525
7	Infineon Technologies	D	3210	1,243	36,158	34.4	6,759
8	SAP	D	7221	1,089	34,550	31.5	8,512
9	BT	GB	6420	1,058	103,000	10.3	28,401
10	France Telecom	F	6420	716	196,452	3.6	49,038
11	Telefonica	E	6420	544	195,086	2.8	37,882
12	Deutsche Telekom	D	6420	433	244,026	1.8	59,604
13	ASML	NL	3210	329	5,055	65.1	2,529
14	TeliaSonera	S	6420	306	27,403	11.2	9,338
15	Vodafone	GB	6420	300	61,672	4.9	53,291

Source: European Commission (2006)

5 Case studies

We selected three regional case studies reflecting different territorial settings in order to not only include three different regions, but three different types of regional governance competences and thus regulatory regimes. In all three cases the ICT sector and thus MNEs operating in this sector play a prominent role.

- Vienna serves as an example for a metropolitan innovation system. Its enterprise structure in the ICT sector is dominated by a large number of SMEs, many of which provide business services. The demand for ICTs and related services relies heavily on large ICT enterprises and university labs, or alternatively comes from outside the Vienna region, even from outside Austria. The R&D performance of the ICT sector is hampered by structural deficiencies.
- Baden-Württemberg serves as an example for a large and thriving regional innovation system. Its sectoral innovation system is characterized by a strong regional demand for ICTs, which is generated by MNEs and SMEs from sectors such as the automotive industry and mechanical engineering for example. Economic success of the region relies partly on a successful integration of ICT in the business activity of traditional industries.
- Finland serves as an example for a national innovation system of a small nation state. The development of the Finish innovation system was mainly founded on successful commercialization in the field of ICT and the pioneering role of Nokia. The whole development was achieved by a close interaction and coordination between policy, industry and science. However, it was not the result of a planning approach; instead a decentralized decision-making and bottom-up approach can be identified.

The case studies are centred around the structure and interceptions of regional and sectoral innovation systems and will be analyzed according to the elements highlighted in table 1. Due to the orientation on constitutive elements of innovation systems as analytical framework, aspects of path-dependency and evolving dynamics within the system are not prominently described and structural characteristics prevail in the discussion.

5.1 Vienna

General characteristics: Vienna as the capital of Austria can serve as an example of a metropolitan innovation system. The ICT sector plays an important role within Austria but also within the larger Vienna region itself. Approximately 5,300 enterprises of different size add up to 8 % of the regional enterprise population. The ICT sector accounts for 10 % of the employment and 15 % of the total value added in Vienna. On the one hand this is clearly above average compared to the overall Austrian economy in

which the ICT sector ac-counts for only 8 % of the total value added. On the other hand the total value added of the ICT sector in Vienna exceeds that of tourism by the factor 6.5, which is of significance in a country that relies heavily on tourism as a driving economic determinant. The enterprise structure of the ICT sector is dominated by a large number of SMEs, especially single-person enterprises. Altogether 56 % of the enterprises belong to the latter group. Most of the enterprises provide ICT oriented business services for regional customers in the field of server and network administration, programming, database management, software development, and homepage design. A technology concentration within the ICT sector can be found in medical informatics, IT-security or embedded systems technology and other niches (KMU Forschung Austria and Fraunhofer ISI, 2007).

Agents and organizations: Important actors in the field of ICT oriented R&D are enterprises, public and private R&D institutions including universities and universities of applied sciences. With its many higher education institutes, research institutions and technology centres, the larger metropolitan area of Vienna is the centre for R&D in the ICT sector in Austria. However, R&D cooperation is also particularly needed since R&D teams in enterprises are often very small, counting less than five employees, which might constitute a deficit in the innovation system.

Interactions: International intra-MNE interactions clearly dominate this sector. According to the TrendChart database and the 2006 EU Industrial R&D Investment Scoreboard nearly all the key business actors in the Austrian ICT sector have their headquarters and/or at least premises in Vienna. As in many sections of the Austrian economy, economic success in the Austrian ICT sector depends on export and internationalization since 1980 (Krumpak, 2007). Philips and Infineon are even characterized by an export rate of 100 % (*ibid.*) and a tendency to attract and integrate competency from abroad into their Austrian subsidiaries. In order to produce for the world market they exploit the locational advantages Vienna is able to offer in combination with leading edge knowledge from abroad.

Knowledge base: ICT oriented enterprises often rely on external knowledge in the innovation process, with customers, competitors and suppliers as the most important knowledge sources. Knowledge sources from within the region are perceived as particularly crucial due to the fast and easy knowledge exchange, informal modes of communication and lower transaction costs (Trippl et al., 2007).

Human capital: The Viennese ICT sector is characterized by a sufficient supply of highly qualified ICT skilled workers, which makes the location attractive not only for indigenous enterprises but also for MNEs. The existence of many universities contrib-

utes positively to the locational factors (Trippl et al., 2007). Universities, universities of applied sciences and other higher education institutions offer a large range of IT and ICT relevant degree programmes as well as advanced training modules to ensure further qualification of the Viennese workforce. Comparatively moderate wages (when compared to other European ICT locations like Munich) made Vienna attractive. The city now provides a bridging function for many internationally oriented enterprises that plan to expand eastward.

Institutions: Major national public bodies and institutions with responsibilities related to R&D in ICT are the federal chancellery which coordinates the national ICT strategy, the BMVIT (Federal Ministry of Transport, Innovation and Technology) which is responsible for ICT and R&D, innovation and the telecommunication infrastructure, the BMWA (Federal Ministry of Economic Affairs and Labour) which organises ICT-related innovation and the BMBWK (Federal Ministry of Education, Science and Culture) which ensures the acquisition of ICT skills during the education process and therefore a well qualified labour pool. BMVIT launched the FIT-IT programme which promotes collaborative R&D projects between enterprises and research institutes with the overall goal of achieving radical innovations and therefore spur dynamics of the ICT sector. Besides BMVIT, the Austria Research Promotion Agency (FFG) is one of the key actors in the national innovation system. It implements and manages the major measures of the Austrian research, innovation and technology policy. Approximately 100 ICT projects are annually funded by the programmes of the FFG in Vienna. Other key functions for the promotion of the ICT sector in Vienna remain with regional actors. The central player is the city of Vienna itself, especially its Magistratsabteilung 27 which is responsible for the development of the EU strategy and economic development of the city. It is surrounded by further regional actors like the Wiener Wirtschaftsförderungsfonds (WWFF), the Zentrum für Innovation und Technologie (ZIT) and the Wiener Wissenschafts- und Technologiefonds (WWTF). Central for the development of the ICT sector is the VITE (Vienna IT enterprises) network. It supports IT enterprises with regard to project management and various consulting activities. Calls, innovation support, the establishment of competence centres and excellence initiatives belong to the local promotion portfolio of the ICT sector. Additionally, the Viennese ICT sector profits from the sectoral associations and institutions which maintain offices in the Austrian capital. They foster the dialogue between enterprises and the political actors and institutions and integrate external knowledge and techno-logical trends relatively early in the communication channels of the metropolitan region.

Policies: The development of the ICT sector in Vienna is influenced by a multi-level governance system. Programmes and measures from European, national and regional policy institutions provide support functions for local R&D activities. Particularly, the

research framework programme from the EU has been implemented comprehensively making the ICT sector in Vienna an example for the integration of EU policy measures in a metropolitan policy framework. The ICT oriented IST-programme within the 6th research framework programme was very important for Austrian and especially Viennese institutions and enterprises. Altogether 18 project coordinators for projects from the IST-programme came from Vienna.

Technologies and demand: The demand side of the Viennese ICT sector is characterized by demand coming from the ICT sector itself, or from the public sector, especially university labs. Additional demand comes from outside the Vienna region, even from outside Austria. Large, regional customers from high-technology or ICT-intensive industries (like automotive, electronics etc.) are missing. This is a hampering factor for the sectoral development.

Competition and selection: The ICT sector in Vienna is characterized by a high number of firm foundations. Younger enterprises in the Viennese ICT sector tend to be more innovative than established ones and therefore spur sectoral dynamics. A critical mass of players in R&D relevant ICT sub-sectors is missing which results in a diversification of the sector but at the same time in a lack of visibility in the international context.

Summary: Vienna is one of Europe's leading ICT locations and systemic features can be identified. A large number of enterprises of different size and from different subsectors form the economic structure of the sector. MNEs integrate knowledge and competences from abroad in the system and thereby spur sectoral advancement. At the same time they profit from locational advantages like a highly skilled workforce, and the proximity to east Europe as potential market. The policy mix is well diversified across several levels, although integration is sometimes missing. Nevertheless, the ICT innovation system in the Vienna region reveals a number of weaknesses, especially with regard to the regional demand structure. Key customers for local ICT enterprises are underrepresented in the region so that Viennese ICT enterprises often have to rely on external customers and knowledge in the innovation process. While the internalisation of foreign knowledge is sufficiently ensured through contacts to foreign customers and headquarters and subsidies of MNEs abroad, local enterprises cannot leverage the specific advantages they would enjoy if there was local demand from key technological sectors. These structural gaps in the local ICT innovation system hampers knowledge exchange among regional actors and to a degree the innovation dynamics in the overall regional innovation system which relies on knowledge exchange and interactive processes.

5.2 Baden-Württemberg

General characteristics: The systemic nature of the regional innovation system of Baden-Württemberg has been mentioned repeatedly (Heidenreich and Krauss, 1997; Heidenreich and Krauss, 2004; Asheim and Gertler, 2005). Very often, these analyses focus on the strong position of the production system, which generates its strengths from the traditionally strong sectors such as automotive, mechanical and electrical engineering. The R&D performance of Baden-Württemberg is exceptionally high when compared to the German average. According to Eurostat figures, total intramural R&D expenditures amounted to 3.88 % of GDP in Baden-Württemberg in 2008 while the German average was 2.52 %. The contribution from the business enterprise sector is also very high, accounting for 3.08 %. Likewise, Baden-Württemberg revealed outstanding numbers in terms of total R&D personnel as percentage of total employment which reached 2.64 % in 2003. In the same year, the German average amounted to only 1.85 %, hardly more than the contribution of the business sector in Baden-Württemberg (1.66 %, compared to a German average of 0.93 %).

Agents and organizations: Business R&D in Baden-Württemberg is complemented by a wide range of research institutes that specialize in ICT research, such as two large Fraunhofer institutes that concentrate on applied research in ICT. Altogether 15 universities, 41 universities of applied sciences, eight colleges for fine arts and six colleges of education contribute to a highly skilled workforce, as does the vocational training scheme which is a pillar in the German education system. The federal state promotes enterprises that qualify and support older employees in order to maintain and generate skills.

Interactions: The ICT sector is characterized by network activities which are fostered by European, national and federal programmes or emerge from regional activities. A good example for a long existing network is bwcon (Baden-Württemberg connected), which is promoted by the national initiative of "kompetenznetze.de". It acts as networking unit in order to connect ICT providers and users as well as enterprises and research institutes. The networking activities are not only oriented to better connect actors within the sector itself, but also aim to establish contacts to other high-tech clusters. This is done to strengthen the already important cross-sectoral function of the ICT sector. Since Baden-Württemberg has a strong health sector and the established borders between the ICT and health sector become successively blurred, bwcon fosters for example contacts between actors of the health and the ICT sector.

Human capital/Knowledge base: Qualification measures target the whole workforce which contributes to locational advantages given the fact that Baden-Württemberg also

has to deal with an ageing workforce. Additionally, close interactions between enterprises and higher education institutes ensure a continuous knowledge transfer from universities to enterprises. Especially large enterprises like SAP try to interact with local universities like the University of Mannheim and the University of Karlsruhe (now part of the KIT research organisation), which are close by and characterised by an economic or technological focus.

Policies/Institutions: Innovation policy measures for Baden-Württemberg are designed and implemented at different levels, namely the European level (research and structural programmes), the national level (federal RTDI policy) and the regional level. Additionally, the city of Karlsruhe has been selected as a model for new federal-regional cooperation in research realised through the formation of the KIT research organisation from a (federal) institute for basic research and a (regionally funded) university. Innovation policy measures at the regional level aim at the further qualification of the (potential) workforce, support (outstanding) research, promote research and teaching in universities of applied sciences, established 47 collaborative research centres as well as the provide structural and innovation funds to acquire and hold excellent researchers at universities. Another pillar of innovation policy of Baden-Württemberg is the strengthening of entrepreneurial innovation and the creation and growth of innovative enterprises. The measures include consulting, provision of capital and the promotion of cooperation (Wirtschaftsministerium Baden-Württemberg, 2007). Although these measures do not target the ICT sector specifically, they are often relevant for local ICT firms as the sector is dominated by SMEs which are the intended beneficiaries of many of these policy instruments. Another important regional policy measure in Baden-Württemberg has been the support of technology transfer. Steinbeis Foundation, TTI GmbH, and especially the Medien- und Filmgesellschaft and the Landesstiftung Baden-Württemberg (that acts as a coordinator of various projects that aim at the promotion of activities in the cultural, educational, academic or economic sectors with future innovation potential) can serve as prominent examples for targeted regional support of the ICT sector.

Technologies and demand: The presence of the traditional industries is pivotal for the recent development of the ICT sector. It is an important component of the economic structure in Baden-Württemberg today (Döbler, 2005) and profits from the favourable demand from traditional industries. The knowledge intensive ICT services sector reveals the highest average annual economic growth rate (8.6 %) among the economic sectors in Baden-Württemberg, followed by the R&D intensive ICT sub-sector of electrical engineering (6.6 %) (Statistisches Landesamt Baden-Württemberg, 2007). Despite of the increased globalisation of markets, Baden-Württemberg itself remains the key market for products and services from ICT firms in Baden-Württemberg (Bertschek et al., 2006).

Competition and selection: The ICT sector in Baden-Württemberg comprises 25,600 enterprises with approximately 274,000 employees. The sector has reached an annual turnover of € 45 billion in the year 2004 and accounts for 7 % the total value added. It is characterised by a large number of relatively small enterprises which predominantly belong to the computer service sub-sector (NACE 72), with SAP as a prominent exception. This can be explained by the strong presence of data processing and software engineering enterprises. On the contrary, the ICT manufacturing sector is dominated by large, multinational enterprises like HP and IBM Germany. Within Baden-Württemberg sub-regional concentrations of ICT enterprises are found in the Stuttgart area, in the Rhine-Neckar region, Karlsruhe and Freiburg (MFG, 2007).

Summary: For the regional economy the ICT sector is very important in two respects: firstly, it is a highly dynamic and innovative sector and secondly, it contributes to productivity growth in a lot of other sectors of the regional economy. While large ICT enterprises contribute to the innovation performance of the sector itself, traditional industries profit from the adoption of ICTs to improve their products, processes and services (Häring et al., 2007). For the regional ICT innovation system in Baden-Württemberg it is therefore important that the existing cross-sectoral interaction and demand structures are strengthened and further developed. Partly this can be achieved through collaboration in regional networks and initiatives, while the further development of the regional labour market with its large, highly qualified labour force ensures the mutual understanding across disciplines and sectors.

5.3 Finland

General characteristics: Finland's economy is heavily specialised in ICT. In fact, Finland is the country with the strongest sectoral specialisation in ICT of all countries worldwide. Finland has been the forerunner in nearly every respect: R&D spending, broadband, setting standards, growth, dynamics, services, structural change, coordinated policy, etc. A set of cultural, societal, economic, and political factors has resulted in the success story of Finland. The large relative share of the ICT sector also explains the high amount of BERD in ICT accounting more than two thirds of all business related R&D in Finland. The ICT share grew from 56.5% in 1998 to 62.9% in 2005, which reflects the continuous concentration process in Finland. Finland has already shown a dynamic development in the last few years. Apart from the high investments in R&D (expenses), Finland also shows strength related to the more output-oriented measures such as patents and scientific publication. Even though the latter measures the performance of all R&D performing actors (universities, enterprises, etc.), they neverthe-

less give an indication of the scientific strength of the ICT innovation system and the huge potential for transferring scientific findings into products.

Agents and organizations: The Finnish R&D dynamics is particularly driven by sub-sector 32 (Manufacture of radio, television and communication equipment) with the major player Nokia. Nokia and its close cooperation with suppliers, customers and research institutes as well as the related leverage effects in the past are important drivers for the development of R&D dynamics in Finland. In 2004 Nokia has spent about € 3.7 billion in R&D (12.8% of its net sales), whereby about 65% of Nokia's R&D is still conducted in Finland (Oinas, 2005). Besides Nokia two firms, namely TietoEnator and Vaisala are key actors in the Finnish innovation system (cf. Table 3). Both companies are listed within the R&D Scoreboard of the most R&D intensive European firms. Both companies compete on the global market. TietoEnator is one of the leading IT service firms in Europe specialised in soft-ware development for business process for various industries such as media, banking, health and logistics. About 50% of the sales are made in Finland, about one third in Sweden. With about 1,000 employees Vaisala is specialised in the development of measurement systems and equipment for meteorology, environmental sciences, traffic safety and manufacturing industries. In addition to the large MNEs, a large number of newly founded Finnish ICT firms operate in small niches for a specific application, which, however, might become larger markets in the future.

Table 3: Structural statistics of the most important MNEs in the Finnish ICT sector

			R&D Investments (million €)	Employees	R&D/ Employees (thousand €)	Net Sales (million €)	R&D/Net Sales ratio (%)
Rank	**Company**	**Sub-sector**	**2005**	**2005**	**2005**	**2005**	**2005**
2	Nokia	Telecommunications equipment	3,978	56,896	69.9	34,191	11.6
45	TietoEnator	Computer services	58	14,236	4.1	1,682	3.5
94	Vaisala	Electronic equipment	20	1,062	18.6	198	10.0

Source: European Commission (2006)

Interactions: The Finnish MNEs – above all Nokia – played an important role in the establishment and coordination process of the national (ICT) innovation system. Dense R&D networks between universities, polytechnics, research organisation and industrial firms are a common feature of the Finnish ICT innovation system. Nokia played an important role insofar as it enabled the emergence of a network of suppliers in the past century. The development was achieved by a close interaction and coordination be-

tween policy, industry and science, which, from the theoretical perspective, can be described well with the triple helix approach (Etzkowitz and Leydesdorff, 2000). Nokia as well as a few other MNEs have constantly been playing all the time an active role in the national debate on innovation. However, the orchestrated development was not the result of a planning approach; instead a decentralised decision-making and bottom-up approach can be identified.

Human capital/Knowledge base: It is worthwhile to note the intensive collaboration between ICT related education at master's level and ICT industry. Many ICT firms and development centres are around those universities that provide Master of Engineering in ICT programmes whereby about 90% of the master theses are carried out in cooperation with local ICT companies, which is a specific asset compared to other countries. This is an important element of knowledge transfer and the development of human capital which supports up-to-date education, training and research on both sides, academy and industry.

Institutions: The high level of coordination of the RTDI policy is another feature which fostered the "network culture". In particular, TEKES (oriented towards applied research and industry research) and the Academy of Finland (oriented towards basic research and universities) have started in 2000 to define common research topics and programmes in the field of ICT. Moreover, within the university sector between 2000 und 2005 26 new Centres of Excellence have been defined by the Academy of Finland based on a call, whereby many of them are associated with ICT issues.

Policies: To become one of the world’s leading countries specialised on information technology - Finland can be labelled as the prototype of an information society, Finland focused on close interaction between economy, policy, society and science. This coordination can clearly be seen as unique national competitive advantage. The innovation and technology policy which focuses on ICT has consequently been further developed in recent years and it focuses on the coordination between the different actors, science-industry relationships, the formation of new firms and the promotion of new ICT applications, assisted by participative foresight processes.

Competition and selection: With Nokia, Finland has specialised in mobile telecommunication, which once used to be a niche but has since developed as large global market. The growth of Nokia has clearly facilitated the development of suppliers and partners who as well have to follow an innovation strategy and which have, in turn, increasingly invested in R&D, too. Moreover, Nokia has also enabled these firms to enter global markets. The company formulated a new strategy in the 1980s towards consumer electronics, communication technologies and personal computers even though it was at the

end only successful in mobile communication technologies. From a multi-branch conglomerate, Nokia has been transformed into a purely ICT company, it focused its activities and acquired a number of electronic firms.

Summary: There is no single explanation for the success story of Nokia or the Finnish ICT cluster. It is the interplay between various technological and economic factors that contributed to the birth and growth of the sector. Despite the prominent role of the telecommunications equipment industry, experience also shows that network operations played a very important role for enabling the economic development, probably more important than equipment manufacturing. Moreover, Finland was one of the first countries to deregulate the telecommunication market, although the legacy system prior to this deregulation had not been characterised by a pure state-owned monopoly as in most European countries (Andersson-Skog, 2000). Finally, Finland heavily invested in the digitalization of the telecommunication infrastructure. Finland's strengths in ICT and the success of Nokia are the major threat and, at the same time, the main weakness of the system. The dependence on Nokia with its cyclical development also embraces its about 300 suppliers and the whole ICT cluster with its 6,000 firms. Moreover, the Finnish ICT industry also lacks multisectoral cooperation and there is a particular demand for new horizontal business clusters. In general, smallness and specialisation increase the sensitivity to external shocks. With social security programmes and a high level of informal networking, Finland has thus recently set up new policies to be prepared for the future.

5.4 Synopsis of the case studies

In the following table 4 we will structure the information compiled from the three above case studies by assigning it to the different cells of the table developed for the conceptual section (cf. table 1). We will thus try to illustrate how the characteristics of innovative activities in a certain sector in a certain region depend on both the nature of the activity (ICT sub-sector) and the framework conditions in the region in which they are located. Undoubtedly, the provided information is not complete in the sense that all conceptually possible diversity in each and every one of the cells of the table has been corroborated by examples from the case studies. After all, all three cases are taken from well developed European countries so that it is not surprising to find certain framework conditions similar among them. Likewise, our case studies do not cover the full spectrum of ICT sub-sectors so that diversity of sectoral requirements could not be fully covered. However, the fact that we found such significant diversity with regard to the majority of relevant determining elements of an innovation system despite the comparatively similar background of the regions or nation states proves our point. If diversi-

ties are already so significant in the European context they would be even more so under truly different territorial and sectoral framework conditions such as for example in Asia.

Table 4: Specification of innovation system elements derived from the case studies

Innovation System			
Elements	**Territorial dimension**		**Sectoral dimension**
	Regional	**National**	**Sector / technology field**
Agents and organizations	– dominated by a large number of MNEs – dominated by SMEs, even single person enterprises – presence of technology transfer agencies – mix of higher education institutes, public and private research organisations	– dominant MNEs – nationally specific regulation agency – dominant centralised technology transfer agency – decentralised technology transfer agency – research promotion agencies – universities dominant actor, little public research	– driven by a few large MNEs, – driven by a mix of SMEs and MNEs – (international) branch associations in proximity to political decision makers
Interactions	– collaboration as a means of overcoming small R&D structures – polycentric networks – cross-sectoral cooperation with key-customers – instrumentalisation of networks to bridge gap between providers and users	– dense R&D networks between universities, polytechnics, research organisation and industrial firms – dense network between leading firm and its suppliers – concentration on the national level – polycentric networks	– international sourcing (inward and outward in MNEs)
Knowledge base	– local networks which spur exchange – good absorptive capacity	– high scientific strength of the ICT innovation system	– international sourcing, incorporation of external knowledge through MNEs, universities, branch associations
Human Capital	– highly skilled workforce, with IT-skills, MNEs engage in higher education institutes to ensure future labour supply	– intensive collaboration between ICT related education at master's level and ICT industry	– international sourcing, but national focus
Institutions		– long-established deregulation of the telecommunication market	– existence of EU laws and regulations concerning single subsectors (e.g. broadband) – internationalisation and harmonisation and standardisation of ICT appliances and products

Innovation System			
Elements	**Territorial dimension**		**Sectoral dimension**
	Regional	**National**	**Sector / technology field**
Policies	– regional innovation policy, education policies, bottom-up programmes with focus on ICT sectors	– national innovation and technology policy focuses on ICT – heavy investment in the digitalization of the telecommunication infrastructure	– sectoral focus of international programmes, international collaborative projects
Technologies and demand	– demand from ICT sector (large enterprises) – demand from public sector (university labs) – demand from ICT-intensive traditional industries	– close interaction between economy, policy, society and science, "prototype of information society" – cross-sectoral interaction drives technology forward	– cyclical development of the mobile communication sector – small firm size and small development teams in the computer services sector – broad focus, focus on companies that interact with other sectors – no specific technological trends of outstanding sectoral relevance can be identified – important global technological trends can be identified: embedded systems, software engineering at the interface of ICT sector and further branches
Competition and selection	– high number of new firm formations which contribute to sectoral dynamics – critical mass of actors in ICT-subsectors is missing – concentration of internationally active key players in metropolitan region	– sector dominated by one large domestic MNE and its suppliers; – dominated by a large number of SMEs and some, often non-domestic MNEs – export and internationalisation as key drivers for economic success	– global oligopoly market for mobile phones and semiconductors – liberalisation of the telecommunication market

Source: own compilation by Fraunhofer ISI

6 Conclusion

In this concluding section we come back to the three theses we formulated in section 3 and link them with the findings from the case studies.

1. Innovation systems are characterised by organisations and actors that span both regional and sectoral boundaries:

   The case of Baden-Württemberg provides a good example for the importance of cross-sectoral interaction on a regional basis which itself is closely linked to the global market. Only through this interconnectedness and the proximity to key customers from neighbouring sectors (e.g. the automotive sector) the ICT sector has been able to develop the way it has. The same applies, to a certain degree, to

Finland where Nokia has been actively shaping a local network of suppliers and customers, while of course its impact reaches far beyond Finland. In Vienna, finally, the sector develops in the presence of only few key customers, posing particular challenges to both research performers and policy makers.

2. MNEs play an important role in the coordination process between sectoral and territorial innovation systems:

   In all cases even smaller multinational enterprises are the key players that anchor transnational sectoral innovation systems in a territorial context. In interaction with local cross-sectoral actors (e.g. policy makers or universities) they translate the requirements of the international sectoral networks they are embedded in into innovative activities in the respective region. In the individual local business units international knowledge from sectoral communities of practice is complemented with local tacit knowledge about market requirements, and human capital of different origin comes together. Only enterprises that actually span national borders can actively shape this process of translation, whereas purely domestic firms remain subject to it as an external factor.

3. Only a combination of a territorial and a sectoral approach can provide both academics and policy makers with a satisfactory understanding of innovation systems:

   Comparing the case studies it can be concluded that all three support the notion that both sectoral and territorial specificities are important for the local development of innovative activities in the ICT sector. Undeniably, there are certain territorial systems in which the impact of a single sector is higher than in others what in turn gives innovative activities in this sector a different scope to evolve in the local context. The Finnish case, for example, demonstrates that a whole national innovation system including its governance structures can become subject to the specific needs of a few key players in an ICT sub-sector which is particularly important for national competitiveness. The other cases show quite clearly that in systems in which there is no clear sectoral focus, or the sector in question is less relevant for overall regional or national competitiveness, general territorial characteristics have a more defining influence on the nature of innovative activities than elsewhere. The influence of technological characteristics and the structure of the global market for products and services, however, play an important role in those regions, too. On the other hand, it appears that local systems of innovation always respond to the character of the activities of all actors within them. Even in Finland, we find 'characteristically Finnish' approaches to e.g. university-industry networking which are as such not specifically tailored towards the needs of the abovementioned dominant ICT actors. So, while there are cases of "sector determines region" and "region determines sector" – the case studies demonstrate that the average case will be found on the continuum in between.

A final remark is related to the policy implications of the regional/national and sectoral interfaces. All three cases demonstrate that the situation could hardly be more complex. Transnational sectoral policy has been emerging as a new and important factor at the European arena, especially within the context of the European Research Area. Through this concept, financial and human resources in research and development should be pooled and cross-national critical masses be generated. This policy approach is of different relevance for the three analyzed case studies. In Vienna it is intensively adopted while in Finland it is far less important than national measures. Additionally, we find that even if the design of national and regional measures is not always an interactive process, the impacts of any such policy can only be understood when taking into account the offers made at all levels. Another issue of importance is the question at which level the actors of the local ICT sector are able to shape policy making. In Finland, for example, a central role at national level is evident and an important one at the European level more than likely. In Baden-Württemberg, policy is strongly influenced by the government of this federal state, and certain additional relevance of the federal level is likely, given the key importance of Baden-Württemberg for the national ICT sector. In Austria, in contrast, the ICT sector is not a particularly driving force at the national level. As, however, the sector is of relevant importance for the capital city itself, it has been decided to implement specific support measures at the regional level and engage in the offers coming from EU sectoral policies, to complement the limited number of support policies at the national level. Referring to the 'national supersystem of innovation' (NSSI) approach developed by Fromhold-Eisebith (2007), these findings show that sector specific requirements force regions and nations to create and further develop policy links to the international scale. Through these sectoral links, not only national systems can profit from regional specializations, and vice versa, but also both have the opportunities to create added value from the sectoral linkages to the international scale.

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