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Abstract

In recent years a move towards knowledge economies has been observed in many advanced countries. Knowledge based sectors and related activities have been expanding rapidly. However, the preconditions for developing such activities differ strongly between types of regions, depending on their location conditions, firm structure and institutional fabric. The regional innovation systems (RIS) approach captures such different settings in a useful way, allowing us to distinguish e.g. between well endowed and networked, fragmented and thin RIS. Using this approach we will study which conditions, potentials and barriers exist in different types of RIS for developing knowledge based industries and activities, and which routes and policy options might be adequate in different regional settings. We investigate these questions at first conceptually, drawing on the literature on RIS, and location and clustering of knowledge based sectors. Empirically we will present evidence on three regions in Austria (Vienna, Upper Austria and Salzburg) representing different types of RIS. Based on the conceptual findings we will compare these regions regarding their RIS characteristics, their preconditions for and strengths of knowledge based sectors focussing in particular on the ICT sector. Furthermore we will analyse routes and policy options for developing knowledge based sectors for such different types of regions.

1 Introduction

A move towards knowledge economies has been observed in recent years. Knowledge based sectors and related activities have been expanding rapidly in many countries and regions (OECD 2001, EC 2005, MERIT et al. 2008). There are expectations that knowledge based sectors bring a dynamic growth of jobs, in particular for the highly skilled labour force, career prospects and income possibilities. However, the preconditions for developing knowledge economies differ strongly between types of regions, depending on their location conditions, firm structure and institutional fabric. Studies of knowledge based sectors have shown that those sectors are often concentrated in particular locations and regions (Cooke 2002, Technopolis 2006, Cooke et al. 2007, Hollanders 2007) and that it is easier for some regions to develop such activities than for others. The regional innovation systems (RIS) approach captures such different settings in an appropriate way, allowing us to distinguish e.g. between well endowed and networked, fragmented and thin RIS.

Using this approach we will study which conditions and barriers exist in different types of RIS for developing knowledge based activities, and which routes and policy options might be appropriate in different regional settings. We investigate these questions at first conceptually, drawing on the literature on RIS, as well as on location and clustering of knowledge based sectors. Empirically we will present evidence on three regions in Austria (Vienna, Upper Austria and Salzburg) representing different types of RIS. Based on the conceptual findings we will compare these regions regarding their RIS characteristics, their preconditions for and strengths of knowledge based sectors focussing in particular on the ICT sector. Furthermore we will investigate routes and policy options for developing knowledge based sectors for such different types of regions.

Before we deal with these regional issues we have to point out that there are different views and approaches regarding the knowledge economy (Smith 2005). The first is a sectoral approach. Here, the knowledge economy is defined as those sectors whose products or services incorporate high shares of knowledge inputs. These may be in the form of R&D, or less codified forms of knowledge such as particular qualifications and competences. Such a sectoral approach was developed and followed in particular by the OECD (OECD 1996, 2001, Godin 2004a). knowledge based sectors usually comprise technology intensive manufacturing sectors as well as knowledge intensive services (Godin 2004b). Cooke (2002) characterises knowledge based industries more restrictive as those exploiting new knowledge in order to

create more new knowledge. They are selectively appropriating knowledge as a resource to be exploited. Examples are financial services, information technology, biotechnology and biosciences and cultural industries (Cooke 2002, p. 73).

Recently, this sectoral view has been criticised for being too simple. Smith (2000, p. 19) emphasises the importance of distributed knowledge networks, arguing that "the relevant knowledge base for many industries is not internal to the industry, but is distributed across a range of technologies, actors and industries". He gives the example of food industry which uses knowledge inputs from a variety of sectors and might to some extent be considered also as "knowledge based". This makes rankings such as those by the OECD of R&D intensive industries (high-tech versus low tech) more and more inadequate. Along this line it is argued that advanced new technologies and knowledge processes are no exclusive domain of high tech industries but also highly relevant for an upgrading of traditional sectors. This refers e.g. to the application of generic new technologies (such as ICT) in sectors such as food, tourism, machinery or services (Amara et al. 2008). Knowledge inputs, thus, are vital for innovation processes such as the improvement of products and the introduction of new products and processes in general, not only for particular sectors (Nonaka and Takeuchi 1995, Smith 2005). This includes the new combination of existing knowledge as it is typical in sectors operating on a synthetic knowledge base (Asheim and Gertler 2005, Tödtling et al. 2006). These kinds of innovations, including the application of generic new technologies, are closely related to the concept of the "learning economy" developed by Lundvall and Johnson (1994), Lundvall and Borràs (1999, 2005) and others. There are different learning processes involved such as learning by exploring and searching, learning by doing and using as well as learning by interacting.[1])

In the following sections 2 and 3 we will look at the conditions for developing knowledge based sectors in various types of regions by drawing on the regional innovation systems approach. In section 4 we will deal with policy implications and we will show that a broader perspective as has been discussed above is instructive for designing policy responses for weak RIS.

[1] Amara et al (2008) in a statistical analysis of more than 1000 established manufacturing SMEs in Canada find that learning by doing, training and by interacting had a high impact on the innovativeness of these firms.

2 Types of regional innovation systems and conditions for developing knowledge-economies

The sectoral view of the knowledge economy argues that a dynamic growth of knowledge based sectors usually requires specific location conditions such as excellent universities and research organisations, good educational institutions, a highly qualified labour force and a well developed ICT infrastructure (see Keeble and Wilkinson 2000). The generation of new firms and innovation, a high level of entrepreneurship, incubators, venture capital and a good networking of firms and knowledge organisations are needed for a dynamic growth and development of these sectors (Tödtling 1994, Swann et al. 1998, Cooke 2002, Cooke et al. 2007). Studies on successful high tech and knowledge intensive regions (Preer 1992, Castells and Hall 1994, Keeble and Wilkinson 2000, Kenney and Patton 2005) have demonstrated that these regions usually have strong subsystems of knowledge generation and –diffusion such as universities, research organisations, HEIs, and organisations of technology transfer. In addition, they also have many firms in high tech clusters, i.e. strong subsystems of knowledge application and –exploitation. Firms here are able to interact with the knowledge organisations and capable to apply and commercialise the knowledge generated. Knowledge can be accessed and exploited through various mechanisms such as the cooperation of regional firms with knowledge organisations (e.g. R&D cooperations), licensing, or the setting up of new companies e.g. in the form of spin-offs from existing firms or from academia.

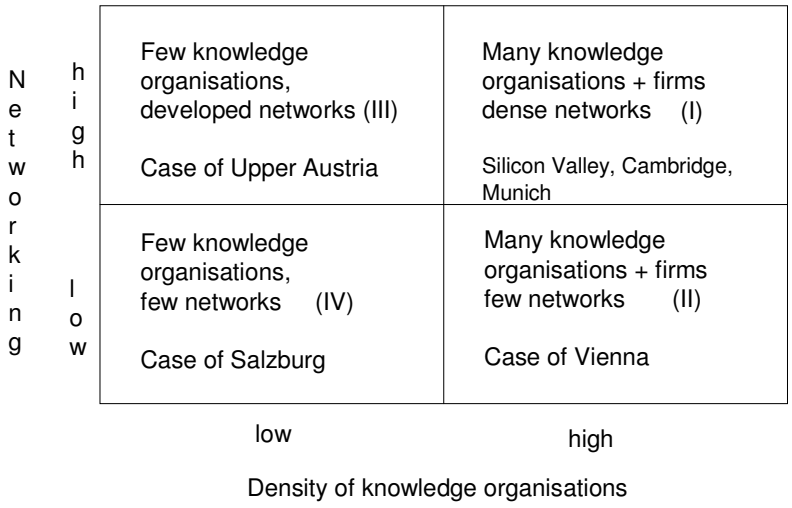
Preconditions for developing knowledge-based industries differ strongly between types of region and types of RIS depending on their location conditions, firm structure and institutional fabric. From a policy perspective it is easier for some regions to develop such sectors than for others. The regional innovation systems (RIS) approach captures such different settings in an appropriate way. Trippl and Tödtling (2007), for example, have drawn a distinction between "RIS with strong potentials for high technology industries" and "RIS with weak potentials for high technology industries", stressing that the development of high tech sectors in a region is strongly dependent on the strengths and the structuring of the respective RIS. Regions that already host successful high technology industries constitute a favourable environment also for the rise of new knowledge intensive clusters, even if the newly emerging sectors are different from those developed in the past. These areas are well endowed with generic factors such as excellent universities, knowledge mediating institutions,

venture capital organisations and highly skilled mobile labour. Other key features of such regions often include a culture of academic entrepreneurship and high risk taking, a propensity to cooperate and share knowledge and positive attitudes towards innovation and technological progress. In such "RIS with strong potentials for high technology industries" the emergence and growth of a new knowledge based sector might be a spontaneous phenomenon, as it can build on existing generic functions and expertise necessary for "seeding" high technology sectors. Due to the tradition of these areas as high technology centres, a considerable body of knowledge is available at the local scale.

In regions which have no tradition in promoting high technology industries, the rise of knowledge based sectors is likely to take a different route (Mayer, 2005; Rosson and McLarney, 2005). These areas often have a weak knowledge base (few universities and research organisations), little experience in commercialising scientific discoveries, a weak culture of risk taking, low levels of social capital, and frequently they lack crucial factors such as venture capital or a support structure specialised in promoting academic spin-offs. As a consequence there are few companies in knowledge based sectors, and often they are scattered rather than clustered. In such "RIS with weak potentials for high technology industries" the RIS must undergo a far reaching transformation for knowledge based sectors to emerge. Such RIS changes become manifest in the creation of a variety of new organisations, processes of institutional (un)learning and socio-cultural shifts. There are good reasons to assume that the state plays a stronger role in such regional settings to promote high technology clusters (Rosson and McLarney, 2005).

Inspired by the concept of "institutional thickness" (Amin and Thrift 1994) and literature on RIS (Cooke et al. 2000, 2004, Doloreux 2002), we apply the two dimensions "density of relevant organisations" and "degree of networking" to differentiate between well endowed and thin, as well as fragmented and networked RIS (see fig. 1).

Figure 1: **Types of Regional innovation systems**



Much of the literature on high tech regions refers to the "Silicon Valley" reference model (I): here we find a high density and quality of knowledge generating organisations (universities, research organisations, R&D performing firms) as well as a high degree of networking among firms and those organisations (Preer 1992, Saxenian 1994, Lee et al. 2000). A similar situation we find in the Greater Boston region (Tödtling 1994, Bathelt 2001), in Cambridge / UK (Keeble et al. 1999, Garnsey and Heffernan 2005), and in Munich (Sternberg and Tamasy 1999). The growth, innovation performance and networking of knowledge and technology intensive firms in this type of region have been frequently studied in the literature (Saxenian 1994, Swann et al. 1998, Keeble and Wilkinson 2000, Fleming an Frenken 2006) and we do not repeat the arguments and findings here. More relevant for our paper are in fact the other types of regions or RIS where there are either few knowledge organisations, support institutions or firms ("organisationally thinness"), or where there is a lack of networking among the actors ("fragmentation"). In the following we will describe and analyse these latter types of regions or RIS as regards their location conditions for knowledge based sectors, their potential for developing such activities, the specific barriers that exist in this respect and potential policy options and routes for developing knowledge based sectors.

Organisationally and institutionally thick but fragmented (metropolitan) RIS

Metropolitan regions are often regarded as locations for knowledge intensive sectors (Cooke et al. 2007) as well as centres of innovation (Audretsch 1998, Simmie 2003), benefiting from knowledge externalities and agglomeration economies. Leading research organisations and universities, business services, as well as headquarters of international firms and high-tech companies are often concentrated in metropolitan areas (Keeble and Wilkinson, 1999; Moulaert and Tödtling, 1995, Simmie et al. 2006). As a consequence, knowledge intensive sectors such as ICT, in particular KIBS, as well as innovative activities, such as R&D and patenting are usually above average (Brower et al., 1999; Feldman and Audretsch, 1999; Gehrke and Legler, 2001; Simmie, 2003). Well known locations for such industries are Stockholm, Helsinki, Munich or Paris (van Winden 2004, Sternberg and Tamasy 1999). Andersson et al. (2005) in a study on commercial patents in Sweden find that "…the results document the importance of agglomeration and spatial factors in influencing creativity: patent activity is increased in larger and more dense labour markets …" (p.445). Similar results we find for Norway (Onsegar et al. 2007). However, not all metropolitan regions are centres of innovation. Some are lacking dynamic clusters of innovative firms, despite the fact that individual technology companies, R&D activities and research organisations may exist. These areas often have a highly developed organisational infrastructure of public research and educational institutions and a dense supply of (often commercialised) knowledge transfer services. However, the problem of fragmentation, i.e. the lack of networks and interactive learning seems to represent an important innovation barrier. The two RIS subsystems of knowledge generation and application tend to operate separately, as university-firm links are often at a low level. Also, innovation networking among local companies may be weak (Fritsch, 2003), even if market links among firms exist. As a consequence, the development of new technologies and the formation of new knowledge intensive firms are often below expectations. Examples here could be agglomerations such as Frankfurt (Schamp, 2001) or the region of South East Brabant in Holland (Eindhoven: Cooke et al., 2000) which show some of the stated features. Schamp (2001) provides an interesting case study for Frankfurt showing that weak regional networking and a continuing erosion of innovative functions could be observed in particular for the more established and internationalised industries chemicals and automobiles, while better developed innovation networks could be identified for the new sectors biotechnology and financial services.

From our cases Vienna might fall into this category (Tödtling 2002, Tödtling and Trippl 2005). Whereas firms in Vienna do well in patenting (Fischer et al. 2001), the degree of networking still has to be empirically explored. So far we have contradictory evidence for Vienna in this respect. A low degree of innovative networking was found in a European comparative study (ERIS: Fritsch 2004), whereas a considerable local networking among firms has been observed for the Vienna ICT and software sector (Trippl et al. 2007). A study on the Vienna biotech sector has provided mixed results in this respect: There were extensive networks of biotech firms, but more often at a global level than on the regional one (Tödtling and Trippl 2007). Local partners for Viennese Biotech firms were mainly universities, to a smaller extent firms. Policy support for networking exists in the form of cluster policies both for biotech and for ICT, but so far these have been not very comprehensive. In particular there was weak institutional networking, i.e. among the various policy actors, in the Vienna ICT sector.

Organisationally thin RIS

A different situation we find in regions which have few knowledge organisations and a lower density of knowledge intensive sectors. A main characteristic of such regions is that important RIS prerequisites are weakly developed as there is a lack of knowledge based sectors and of knowledge organisations ("organisational thinness"). High tech firms, radical innovations, patenting, and spin-offs are often at a lower level in comparison to metropolitan regions (Tödtling, 1992, Feldman, 1994; Fritsch, 2000, European Commission, 2003). There exist innovative companies in such regions, but often the critical mass for technology clusters is not reached (e.g. Isaksen, 2006 for the Arendal region in Norway). If there are clusters they are often in traditional industries with little R&D and less radical innovation. The emphasis is on incremental innovation and on process innovations instead (Cooke et al., 2000). The low level of agglomeration implies also a "thin" and less specialised structure of knowledge organisations and educational institutions. Although low and medium level qualifications may be readily available, the more specialised qualifications are rare.

Regarding the network features we can distinguish between two types of organisationally "thin" RIS. Belonging to the first type are regions with well developed networks among firms, knowledge providers and policy makers. Here, we often find cluster policies and networks of

technology centres and transfer agencies. From our case study the region of Upper Austria would represent this case. In the second type, networks are rather weakly developed among firms, knowledge organisations and policy makers (Landabaso and Mouton, 2003). Policies in this respect (e.g. cluster policies or the stimulation of networks) have been weaker or not effective. Technology centres or transfer organisations may have been set up in the past in order to improve the situation, but they did not reach a critical mass for stimulating innovation and networks (Asheim et al., 2003; Hassink, 1996; Lagendijk, 2000; Landabaso and Mouton, 2003). From our cases Salzburg seems to fall into this category. The fact that such regions do not have strong knowledge based sectors does not rule out that they may be quite successful in low or medium technology sectors or in services such as tourism

3 Comparing the innovation systems of Vienna, Upper Austria and Salzburg regarding the strength of knowledge based sectors (ICT)

In the following we characterise and compare three regions of Austria regarding strength and weaknesses of their RIS for developing knowledge based activities. The three regions represent different types of RIS as discussed above. We focus in particular on the ICT sector as one important sub-sector of knowledge based sectors, looking on RIS preconditions, strengths, and weaknesses regarding this ICT sector in the three regions mentioned. We will look at knowledge organisations, firms and relevant policy support in this respect. Key indicators characterising the three regional innovation systems are presented in tables 1-4 in the annex.

3.1 ICT activities in the metropolitan RIS of Vienna

Vienna has a relatively strong RIS in an Austrian and European comparison. As many other metropolitan regions it has an excellent knowledge infrastructure, reflecting its role as scientific centre of Austria (table 1). The region hosts nine 9 universities and 900 other public and private research organisations. It also holds a large knowledge based sector, in particular in various KIBS subsectors (table 2). Both public and business R&D expenses (as % of GDP) are clearly above the Austrian and the EU averages (table 3) indicating that Vienna is a key centre of R&D in Austria.

Looking specifically at ICT we found that the RIS Vienna is very well endowed with knowledge generating organisations in the field of ICT. Academic key actors include

- Technical University of Vienna (faculty of electrical engineering and information technology),
- University of Vienna (faculty of computer sciences), and
- Medical University of Vienna (Section of Medical Computer Vision, and excellence centre telemedicine).

Among the non-academic research institutes we find the Austrian Research Institute for Artificial Intelligence (OFAI) of the Austrian Society for Cybernetic Studies (OSGK) and Seibersdorf Research (medical informatics). Furthermore, there are several co-operative research institutes located in Vienna. In the field of ICT not fewer than four CD Labs and four competence centres could be found in the region (see table1).

Vienna is also a key educational centre within Austria. There are nine public universities holding about 127.000 students and producing more then 11.000 graduates a year. Vienna also hosts several technical colleges (i.e. "Fachhochschulen"), which have about 7.500 students and 1.400 graduates a year. The technical colleges present in the region offer about 60 degree programmes, exhibiting a strong specialisation on the disciplines engineering and business. In the fields of software and informatics there are 10 degree programmes including biomedical engineering sciences, embedded systems, informatics/computer science, information and communication services; information management and computer security, information technologies and telecommunication, multimedia and software development among others. In the areas of electronics, communication systems, and automation seven degree programmes are offered, such as applied electronics, electronic engineering, industrial electronics, mechatronics / robotics (2 programmes); and telecommunication and internet technologies

In 2003 the academic spin-off centre "Inits" has been founded. Its aim is to support technology-oriented spin-offs from the university sector by offering counselling and assistance to scientists in the process of turning a good idea into a viable business. There is a variety of other organisations such as technology liaison offices at the universities and eight technology centres. Two of them, i.e. the Business and Research Center Höchststädtplatz (BRC) and the Tech Gate Vienna have a focus on ICT. In June 2006 it hosted 13 start-up companies. Also a technical college (Technikum Wien) as well as the cluster management unit VITE are located there. Tech Gate Vienna hosts all four Viennese ICT competence centres and firms with a focus on ICT. To summarise, the region's ICT research capacity and

its capabilities to transfer knowledge and to provide highly qualified workers and talent and are rather strong.

Regarding the business subsystem our analysis showed that Vienna is the core location of ICT companies in Austria. Using data from the firm census we find that about 6000 ICT plants were located in Vienna in 2001, representing more than 30 % of all Austrian ICT plants, well above of Vienna´s share of the manufacturing sector as whole. There are about 80.000 employees in this sector (25 % of the Austrian total). The most important subsectors are telecommunications and software consultancy and supply. Using employment data from the firm census we calculated location quotients (LQs) for all ICT subsectors. The results support the findings that Vienna is Austria's most important centre for commercialising ICT knowledge. It holds LQs greater than 1 for 15 of 19 subsectors, indicating a very strong concentration of different ICT activities in Vienna (see table 4).

As regards innovation networking there are no clear results so far. Some earlier studies have shown that innovation networking in Vienna was generally rather weak in comparison to other European regions (Fritsch 2001, Tödtling 2002). More recent studies of the Vienna ICT sector have shown considerable innovation networking at the regional level, in particular as regards knowledge exchange among firms (Tödtling et al. 2007, Trippl et al. 2008). However, there were still few links between companies and research organisations.

3.2 ICT activities in the networked RIS of Upper Austria

Compared to Vienna, Upper Austria does not have a strong knowledge infrastructure (table 1) and, as a consequence, it has few public R&D expenses (table 3). Furthermore, it has relatively small high tech and KIBS sectors (table 2 and 3). Due to some larger plants in industries such as vehicles (BMW, MAN-Steyr and KTM) and engineering (VOEST) the medium-high tech sector is relatively large, and Upper Austria´s patenting activity is clearly above the EU average (table 3).

Regarding knowledge organisations, there are two small universities, several technical colleges and a relatively large number of technology centres. In the field of ICT only a few knowledge generating organisations exist. The main scientific actor with ICT related research competence is Johannes Kepler University. Several university institutes carrying out ICT

research have been located in the Software Park Hagenberg. Then, there is the Johann Radon Institute for Computational and Applied Mathematics (Austrian Academy of Sciences) in the capital city Linz. Profactor in Steyr is active in basic and applied research and technology transfer in areas such as intelligent software systems, process design & automation, etc. The region also hosts two CD Labs and two competence centres (see table1), one of them is dealing with mechatronics (bringing together mechanics, electronics and IT). Another important actor is Upper Austrian Research (fully owned by the regional development agency TMG), which has a focus on medical informatics, sensor technology, biomedical nanotechnology, and plastics technology.

The Johannes Kepler University is the main institution in the field of tertiary education present in the region of Upper Austria. It is one of the smaller and younger Austrian universities, having about 13.000 students and 1.100 graduates a year. Another important player in the region are the technical colleges offering 32 degree programmes in the cities of Wels, Hagenberg, Steyr, and Linz. They hold about 3.800 students and have 800 graduates a year. With 21 degree programs there is a strong focus on engineering. In the fields of software and informatics, we find 11 degree programmes located in the software Hagenberg. These include bioinformatics, computer and media security, digital media, embedded systems design, hardware/software systems engineering, media technique and design, mobile computing, secure information systems, and software engineering. In the areas of electronics, communication systems, and automation there are degree programmes for automation technique and mechatronics.

There are 22 technology centres active in the field of knowledge transfer in Upper Austria. Of key importance is the “Software Park Hagenberg”, combining business, scientific and educational competences in the area of software. About 1000 persons are employed in the firms, research and education institutes located in the software park, and almost 1300 students are enrolled in different degree programmes offered there. The Park hosts

- about 40 companies,
- four institutes of the University Linz (RISC - Research Institute for Symbolic Computation, FAW - Institute for Applied Knowledge Processing, FLLL - Fuzzy Logic Laboratorium - Department of Knowledge-Based Mathematical Systems, and RIPE - Research Institute for Pervasive Computing)

- other research organisations (co-operative research institute Competence Centre Hagenberg, department for Medicine Informatics (Upper Austrian Research),
- and Hagenberg Technical College (Upper Austria University of Applied Sciences), offering about 10 degree programmes and carrying out research (Research Center Hagenberg)

Overall, we might conclude that the region's capacity to produce and transmit ICT knowledge and talent is not very strong. There are, however, some interesting research activities in specific areas, such as "mechatronics" or software.

Our analysis of the business dimension showed that the ICT sector is not very strongly developed in the region. There are about 2000 plants (15 % of the Austrian total), employing about 18.000 workers (table 4). LQs greater than 1 can only be found in 3 ICT subsectors, indicating that ICT firm activities are only weakly concentrated in Upper Austria. Putting these finding together, we can conclude that the region has with a few exceptions such as Hagenberg and FAZAT only a weak capacity to apply and exploit ICT knowledge

We have considered Upper Austria as a "networked RIS" because it has a pronounced cluster policy approach since a few years. There are cluster management organisations active in the fields of automotive, plastics and mechatronics (Ohler et al 2001). Overall, these cluster approaches are regarded as "good practice" examples of such policies in Austria.

3.3 ICT activities in the organisationally thin RIS of Salzburg

From the three case study regions, Salzburg has clearly the weakest RIS. It has few knowledge organisations (table 1) and a small high tech and KIBS sector (table 2). As a consequence, public and in particular business R&D are very low in European comparison (table 3).

As regards knowledge organisations the region hosts three universities (University of Salzburg, Paracelsus medical private university, Mozarteum University), a few other research organisations (as, for example, Salzburg Research), and the technical colleges (Fachhochschule Salzburg). In the field of ICT, a key actor is the University of Salzburg (faculties of natural sciences, law, cultural and social sciences), which is, however, rather

small. The university has some research capacity in this field. It hosts the “Zentrum für Geo-Informatik” (Centre for Geoinformatics). Salzburg Research represents another important knowledge generating institution in the region. It is a non-profit research organisation founded in 1996 and owned by the Land. Its focus is on applied research in the fields of ICT and new media. Core activities include the development of software prototypes, design of software architectures, analyses of ICT trends and markets and consultancy. Salzburg Research employs about 50 researchers. Furthermore, there are the Institute for Geographical Information Systems (“GIScience”) of the Austrian Academy of Sciences and the “Research Studio iSpace” which has been established in 2003 by the Austrian Research Centers (Seibersdorf). Salzburg also hosts two competence centers (K-ind-Zentren) which are run by Salzburg Research. These include “anet Salzburg” which focuses on the development of new software applications for the tourism sector and “Salzburg NewMediaLab” which deals with new methods and technologies for the design and development of digital content. Furthermore, in 2007 a CD Lab for “Embedded Software Systems” has been established at the University of Salzburg.

Salzburg’s education system is made up of two public universities, both situated in the city of Salzburg and a number of technical colleges spread across the region. The University of Salzburg is one of the smaller Austrian universities and has about 11.600 students and about 1.500 graduates a year (table 1). Fachhochschule Salzburg offers 14 degree programmes in different disciplines and has about 1.900 students and 300 graduates a year. In the areas of electronics, communication systems, and automation we find a degree programme for “information technology and system management” (since 2007). Among the other degree programmes we find “digital television (since 2006) and “MultiMediaArt” (since 2006), which are all offered in the city of Hallein.

Examining the region’s endowment with technology centres and knowledge transfer agencies we could identify different actors. The RIS Salzburg hosts an academic spin-off centre. In 2005 the „Business Creation Center Salzburg“ (BCCS) has been established to support new firm formation by researchers by offering financial support and coaching activities. There are also seven technology centers present in the region of Salzburg. “Techno-Z Salzburg” is specialised in ICT, computer technology and software. Three others centers, including “Techno-Z Mariapfarr” (information economy, services in the field of ICT), “Techno-Z Zell

am See" (geographical information systems), and "Techno-Z Pfarrwerfen" (information systems for tourism) also have some focus on ICT related topics.

Salzburg does not host a strong ICT sector, it seems to lack critical mass. About 1200 ICT plants could be found in the region, representing a share of only 7 % of the Austrian total. Software consultancy and supply (NACE 7220) and data processing (NACE 7230) represent important ICT subsectors. Not more than 5 % (a total of about 8.500) of all Austrian ICT employees could be found in Salzburg, signalling a rather weak concentration (table 4). The analysis of LQs showed that there is some specialisation in the manufacture of office machinery (NACE 3001) and hardware consultancy (NACE 7210). LQs > 1 can also be observed in the manufacture of computers etc. (NACE 3002), and database activities (NACE 7240).

There are several firms with competence in the field of geographical information systems. Some of these companies and local research institutes, including the University Salzburg, Salzburg Research, Research Studio iSpace formed a network ("GIScluster Salzburg") to reap synergy effects and to establish cooperations between firms and research organisations. In the recent past, however, this network seems to have undergone a process of stagnation and erosion.

Comparing the cases

What do we conclude from this description of the case regions? The analysis of the three cases shows that in all regions there is some potential of developing knowledge-based and ICT-related activities, although there are large differences between them. Vienna has clearly the largest density of research organisations and firms. From our preliminary investigation there is knowledge exchange among firms in the ICT and software sector, but there are few relationships between firms and the science sector. There are few spin offs, few R&D cooperations with science, and rather incremental innovations. From the three regions, Salzburg has the lowest potential for developing knowledge based sectors. There is a thin infrastructure of relevant knowledge organisations and educational institutions and – despite some small cluster initiatives - very few firms in knowledge based sectors including ICT. Upper Austria is in an intermediate position. It holds a number of firms in medium technology sectors (steel, chemicals, plastics, vehicles), but it is also weak as regards knowledge based

sectors and ICT. Although it holds a successful software park in Hagenberg, it lacks relevant research organisations for developing knowledge based sectors in a broader sense. Upper Austria, however, differs from Salzburg, since it has undertaken a relatively successful cluster policy approach in several fields (Automotive, Plastics, Mechatromics). There seems to be a better networking of relevant firms, knowledge organisations and policy actors.

4 Strategies for developing regional knowledge economies in different settings

As we have pointed out in the introduction, the development of regional knowledge economies may comprise different aspects and routes. It may imply (1) the increase of knowledge based sectors such as ICT, biotech or KIBS in a regional economy largely unrelated to existing activities (diversifying into knowledge intensive sectors). It might relate (2) to a strengthening of existing knowledge based sectors through cluster building and networking. And/or it might aim (3) at intensification of knowledge processes and innovation in existing sectors. Whereas the first two strategies follow the more narrow sectoral view of the knowledge economy, the latter is based on the broader concept of a knowledge and learning economy following Lundvall and Borràs (1999, 2005), Smith (2002(and Asheim et al. (2003).

1) Diversifying into knowledge intensive sectors

The strategy aims to bring knowledge based sectors with strong growth and innovation potential to the region. These may be unrelated or related to existing industries (Frenken et al. 2007). The concept builds also on the idea of Jacobs (1969) and Glaeser et al. (1993) that such a diversification away from traditional sectors helps the region to broaden its economic base, to grow, and to stimulate knowledge spill-overs. The growth- and the knowledge spill-over-effects of diversified regional economies, are debated, however. There is contradictory empirical evidence in this respect (Frenken et al 2007). Potential instruments to achieve such a diversification into knowledge intensive industries are the attraction of high tech companies or research organisations to a low or medium tech region or setting up of technology centers and research parks. There are a number of questions arising, however, such as the following: Which industries should be selected? Which companies can be attracted? How can new firms be established? And how can links and knowledge flows to regional firms be stimulated? In

particular regions characterised by a "thin" RIS often do not have the location, economic and institutional requirements to attract firms in knowledge based sectors and to develop links to existing firms.

2) Developing and strengthening knowledge based clusters:
This route is based on existing strengths such as firms and knowledge organisations in specific knowledge based sectors or technology areas. Such clusters, then, focus on particular sectoral or technological niches and try to develop unique advantages in these fields. Key issues and problems often are to identify strengths and critical mass of firms and knowledge organisations in such fields. Another problem is mobilizing regional actors to engage in such a cluster policy. Often, there is a lack of trust to build up networks and to share a joint strategy.

3) Enhancing knowledge processes and innovation in traditional sectors
One way to do this is to apply generic new technologies such as ICT in traditional sectors. The argument is that not just the generation of knowledge but also the application and use of generic new technologies such as ICT stimulates innovation in such sectors. Whereas knowledge based clusters often aim at the generation of new knowledge and on radical innovations through university-firm links and spin-offs, the idea of this approach is to stimulate innovation in traditional sectors by exposing them to generic new technologies such as ICT. The stimulation of knowledge links to sectors related to the existing ones as well as "platform policies" (Cooke et al. 2007) might support such knowledge flows across sector.

Policy issues and strategies for different types of regions

As was shown above, different types of regions and RIS face specific problem and challenges. We argue, therefore, that specific routes and strategies might be more appropriate for particular regions to move towards knowledge economies than others. We will illustrate such routes and related challenges with our case study regions.

1) Fragmented metropolitan RIS

Metropolitan regions, such as Vienna, often have many knowledge organisations and firms in knowledge based sectors; in particular in KIBS less so in manufacturing. The problem is often

a lack of profile and visible focus, as well as a lacking perspective for the industry, as is the case in the Vienna ICT sector. A cluster approach might be a useful strategy under such conditions. An important policy question is which segments of knowledge based sectors might serve as a focus of a globally competitive cluster. Further questions and challenges are:

- How can networks among firms and knowledge organisations be stimulated? Which kind of networks should be stimulated (e.g. local – global networks and their interdependence)?
- How can networking between policy actors and support institutions be improved and some level of coordination introduced?
- How can a common perspective and strategy for the cluster be developed?

Both the Vienna biotech sector and the ICT sector currently are facing some of these challenges, although in different constellations, as two recent studies have demonstrated. Whereas the Vienna biotech cluster has a specific technology focus and well developed university-firm links, and networks both at local and global levels exist, the cluster is still rather small and vulnerable (Tödtling and Trippl 2006). The Vienna ICT sector on the other hand is large and heterogenous but seems to lack a particular focus or profile. It has well developed relationships with clients but few links to universities and rather few radical innovations (Trippl et al. 2007). There is a weak institutional networking (i.e. between policy actors and support organisations at regional and national levels) and no strategy for the cluster.

2) Organisationally "thin" but networked RIS

These regions, such as Upper Austria, are often focussed on traditional and medium technology sectors, and they are rather weak in knowledge based sectors. They often also have only few relevant knowledge organisations (universities, R&D organisations) since such organisations tend to be concentrated in larger cities. Such regions, however, may have well functioning clusters, networks and policy support organisations in a variety of sectors as is the case in Upper Austria. They can use, thus, their well developed institutional structure and their policy framework in order to shift the region more towards a knowledge economy. They have several options:

- Increasing knowledge intensive activities in existing sectors. This refers e.g. to the use and inclusion of generic technologies such as ICT and of new knowledge in existing production and business processes, products and services.
- Strengthen related variety among sectors and knowledge bases: This refers to the stimulation of knowledge intensive activities related to the existing industries and to strengthening knowledge bases which are complementary to the existing ones.
- Finally, they may use existing nuclei of knowledge based sectors to develop knowledge based clusters.

The case of the "Mechatronics" initiative in Upper Austria is an illustration for a combination of options 1 and 2, i.e. introducing information technologies in machinery and engineering sectors and strengthening related variety in the region. The software park Hagenberg is an example for option 3. The effectiveness of those instruments has still to be investigated for Upper Austria, but, given the large size of sectors with a synthetic knowledge base (engineering, machinery, vehicles), the "Mechatronics" initiative might have a broader impact in the region than the software park.

3) Organisationally "thin" RIS / few networks

Like the type described above, these regions have few or small universities and research organisations, and few technology- and knowledge intensive companies. Their economies are dominated by traditional sectors and services, such as wood products, machinery or tourism. These companies are not high tech but they may be quite innovative modifying their products (incremental innovation), using new technologies such as ICT, or introducing new forms of organisation in their production or business processes. Since there is a lack of critical mass in many sectors there are few networks and clusters, and the companies tend to improve their competitive situation through individual strategies and actions.

Policies to raise the knowledge intensity of firms are relevant for this type of region as well, in order to improve their innovative performance. Lacking critical mass for developing high tech or knowledge intensive clusters, the main strategy should be to improve the adoption of new technologies and knowledge in existing firms. This could be done through specialised innovation centers and TTOs, educational programs, and through a stimulation of networks within the region and beyond. Since there may be too few specialised partners for establishing

regional networks, it is more important to link companies to knowledge providers located at the national and international level.

We can use the case of Salzburg to illustrate policy options for this type of region:

- In Salzburg there were severe problems of developing clusters in new media and in GIS, mainly due to a lack of RIS preconditions and of critical mass in those sectors.
- There is some potential, however to upgrade existing sectors such as tourism or wood products through introducing ICT in those sectors. Examples may be the introduction of electronic booking systems in tourism which is one of the dominant sectors, or the introduction of CAD / CAM techniques in the wood sector. There is a role for innovation centres like Techno-Z in order to support this process.
- Finally, it has to be recognised that an "institutionally thin" region like Salzburg has to develop and strengthen knowledge links to firms and organisations outside the region. This concerns links to knowledge organisations within the Austrian innovation system as well as at an international level. This also may concern relationships to neighbouring regions such as Upper Austria and Bavaria in Germany.

5 Summary and Conclusions

Strengthening the knowledge economy seems to be relevant for various types of regions. It is useful to apply a broad understanding of a knowledge economy. "Knowledge economy" does not only refer to an increase of knowledge based sectors in a region, but it implies also growing interactions between science and industry, as well as an enhancement of knowledge inputs and –processes in existing sectors in order to make them more innovative and competitive. However, there is no single best way in this respect. Different routes and strategies seem to be appropriate for specific types of regions and situations. Potential routes are sectoral diversification (e.g. attracting FDI in knowledge based sectors or setting up of technology incubators), the building up of clusters, and the advancement of generic new technologies such as ICT in traditional sectors. In our case study regions we have observed quite different conditions, strengths and barriers for developing knowledge economies.

Vienna has an excellent KG subsystem and it has a number of firms in knowledge based sectors and ICT. It is rather diversified but seems to lack an internationally visible focus in this sector. The strengthening of specialised sub-clusters within ICT might be a possible route.

This includes the stimulation of relevant networks, also those between firms and universities. We have to take into account, however, that the character and policy challenges of NW may differ between knowledge intensive sectors and even ICT sub-sectors. Whereas the software sector has shown many local links, the ICT hardware sector was much more globally oriented. The Vienna Biotech sector, on the other hand has successfully combined local networking with global links. Such findings have to be taken into account for designing policies for supporting the development of clusters and of networks.

Upper Austria, in comparison, has fewer universities and knowledge organisations and fewer firms in knowledge based sectors. However, it can use its experiences of cluster policies and networking to make the traditional sectors such as steel, vehicles, machinery, and engineering more knowledge intensive. It can build on related variety and link those sectors to new generic technologies such as ICT and new materials.

Salzburg is even weaker in knowledge based sectors in comparison to Upper Austria, and there is a lack of critical mass regarding knowledge organisations and firms. Like Upper Austria it might try to enhance the knowledge intensity of its traditional sectors such as tourism by applying new generic technologies such as ICT. But more important for a "thin" RIS like Salzburg might be the link of its main sectors to relevant knowledge providers and firms beyond the region. This might be sector specific links to Austrian, European and global organisations and firms, but also include relationships to neighbouring regions such as Upper Austria and Bavaria.

Summing up we find that particular types of strategies cannot be assigned to particular types of regions in a clear cut way. Most regions follow several routes and a combination of instruments in order to move towards the knowledge economy. Nevertheless our analysis has shown that certain strategies might work better for particular types of regions. Cluster strategies for knowledge based sectors (route 2 above) most probably works better for regions with a certain density of knowledge based firms and relevant organizations (under conditions of institutional "thickness" as in RIS types I and II in figure 1). For regions with a lower density of knowledge based firms and knowledge organisations such as it is the case in Upper Austria and Salzburg (RIS types III and IV) a diversification strategy (route 1) as well as the enhancement of knowledge processes and innovation in traditional sectors (route 3) might be more effective ways towards the knowledge economy.

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Table 1: **Organisations of knowledge generation and –diffusion** (selected)

	Vienna	**Upper Austria**	**Salzburg**
Universities	9	2	2
Students (2006/07)	127.448	12.991	12.979
Graduates (2005/06)	11.232	1.251	1.722
Technical Colleges			
Degree programmes	61	31	14
Students (2006/07)	7.517	3.742	1.876
Graduates (2005/06)	1.366	804	311
Competence Centres (ICT related)	-Kplus Advanced Computer Vision -Kplus FTW -Kplus VRVIS -Kind EC3	-Software Competence Center Hagenberg -Linz Center of Competence in Mechatronics	-NewMediaLab
CD Labs (ICT related)	-Compilation Techniques for Embedded Processors Design Methodology of Signal Processing Algorithms Spatial Data from Laser Scanning and Remote Sensing Technologie-CAD in der Mikroelektronik	-Automated Software Engineering -Integrated Radar Sensores	Embedded Software Systems

Table 2: **Employment by sector groups** (2006 – NUTS 2 level)

Sector (NACE codes)	**Austria** No.	%	**Vienna** No.	%	**Upper Austria** No.	%	**Salzburg** No.	%
Agriculture, hunting, forestry, fishing mining and quarrying (A-C) (01-14)	**222.529**	**5,7**	**7.229**	**1**	**47.977**	**7**	**14.259**	**5,5**
Manufacturing (D)	**740.938**	**18,9**	**90.285**	**11,9**	**168.056**	**24,63**	**42.475**	**16,3**
High tech manufacturing	53.444	1,4	11.872	1,6	7.858	1,2	2.897	1,1
. Medium high tech manufacturing	219.349	5,6	30.564	4	55.512	8,1	9.371	3,6
. Low and medium low tech manufacturing	468.145	11,9	47.850	6,3	104.686	15,3	30.207	11,6
Electricity, gas, water supply & construction (E,F)	**354.779**	**9,1**	**61.258**	**8,1**	**59.015**	**8,7**	**23.562**	**9**
Services (G to Q = 50 to 99)	**2602.172**	**66,4**	**600.556**	**79,1**	**407.339**	**59,7**	**180.660**	**69,2**
Knowledge intensive services	1193.515	30,4	322.028	42,4	179.970	26,4	73.866	28,3
Knowledge intensive high tech services	107.836	2,8	37.996	5	15.449	2,3	5.150	2
Knowledge intensive market services	312.001	8	102.416	13,5	38.753	5,7	19.622	7,5
Knowledge intensive financial services	132.990	3,4	31.554	4,2	17.718	2,6	8.159	3,1
Other knowledge intensive services	640.689	16,3	150.063	19,8	108.050	15,8	40.953	15,7
Less knowledge intensive services	1408.657	35,9	278.528	36,7	227.369	33,3	106.794	40,9
Total employment	**3920.419**	**100**	**759.328**	**100**	**682.387**	**100**	**260.956**	**100**

Source: Eurostat

Table 3: **Innovation Indicators 2006** (EU = 100)

	Austria	Vienna	Upper Austria	Salzburg
Human Resources in Science and Technology – Core (% of population)	67	95	56	73
Participation in life-long learning (% of 25 – 64 years age class)	110	139	114	110
Employment in medium-high and high-tech manufacturing (% of total workforce)	97	97	121	72
Employment in high-tech services (% of total workforce)	91	195	69	67
Public R&D expenditures (GERD-BERD) (% of GDP)	97	201	30	54
Business expenditures on R&D (BERD) (% of GDP)	97	154	96	26
EPO patent applications (per million population)	118	102	154	105

Source: Hollanders (2007)

Table 4: **Plants and employment in the ICT sector 1991 and 2001**

	Austria	Vienna	Upper Austria	Salzburg
ICT plants (no.)				
1991	7223	2735	991	576
2001	17674	5928	2271	1173
Change (%)	145	117	129	104
ICT plants (%)				
1991	2,3	3,9	2,1	2,3
2001	4,5	6,8	3,9	3,8
ICT employees (no.)				
1991	113868	60654	12404	5758
2001	164572	79296	17713	8459
Change (%)	45	31	43	47
ICT employees (%)				
1991	3,9	8,1	2,4	2,8
2001	4,8	9,7	3,0	3,5
ICT- Subsectors with location quotients > 1		3220; 3230; 3330; 5143; 5184; 5185; 6420; 7133; 7210; 7220; 7230; 7240; 7250; 7260	3001; 3002; 7250	3001; 3002; 5143; 7210; 7240

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