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Knowledge bases, innovation and multi-scalar relationships – Which kind of territorial boundedness of industrial clusters?

by

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Abstract

Innovation is nowadays a highly interdependent process where firms rely on distributed knowledge sources at various spatial scales. It has been argued that innovation interactions are shifting increasingly from local/regional towards global scales and that the region as a space for supporting innovation and competitiveness of firms is losing in importance. We suggest, however, that firms and clusters rely on various kinds of knowledge bases and factors for their development that differ in their geographical mobility and territorial boundedness. Whereas codified knowledge as well as many kinds of goods and services, investment capital, and people have become mobile at a global scale due to improvements of transport- and communication technologies and a lowering of trade barriers, we find other factors that are still territorially bound, such as tacit knowledge that is exchanged in local and social networks, and certain kinds institutions and regulations that are territorially confined. We investigate therefore for different types of industries to what extent and which kind of driving factors for cluster development and innovation have become non-local or foot-lose, or remain territorially bound to regions or countries. This also has relevance for regional and innovation policies that try to enhance the competitiveness of clusters and regional economies.

1) Introduction

It has been frequently stated that innovation is nowadays a highly interdependent process where firms rely on distributed knowledge sources at various spatial scales (Bunnel and Coe 2001, Smith 2002, Asheim et al. 2011, Tödtling et al. 2013). There is also the argument that innovation interactions of firms and clusters are shifting from local/regional towards global scales (Bunnel and Coe 2001, Binz and Truffer 2017), and that the region as a space for innovation and competitiveness of companies is losing in importance (Cairncross 1997, Friedman 2006, Crevoisier and Jeannerat 2009). However, we suggest that this is not a general process, since firms and clusters rely on different kinds of knowledge bases (Asheim and Gertler 2005, Asheim and Coenen 2006, Cooke et al, 2007) and factors for their development (Menzel and Fornahl 2009, Belussi and Hervas-Oliver 2017, Fornahl and Hassink 2017) that differ in their geographical mobility and territorial „stickiness". Whereas codified knowledge as well as many kinds of goods and services, investment capital, and people have become mobile at a global scale due to improvements of transport and communication technologies and a lowering of trade barriers, we find other factors that are still territorially bound (Gertler and Wolfe 2006, Tödtling et al. 2017). These are not just the tacit knowledge that is tied to people and organisations and that is exchanged in geographically proximate and social networks (Carincazeaux 2002, Gertler 2003, Morgan 2004). It are also certain formal and informal institutions and regulations (Storper 1997, Doloreux and Parto 2005, Wolfe 2009, Wolfe and Nelles 2009) that are bound to regions, nations or supranational communities such the EU, NAFTA or MERCOSUR (Dicken 2015). Furthermore, in the past few years we can observe a slowing down of the globalisation process due to environmental and social concerns, as the recent resistance to CETA, TTIP and other such agreements has demonstrated (Tödtling et al. 2017). So the question arises, to what extent driving factors for cluster development and innovation have become non-local or footlose or remain territorially bound to regions or countries.

The innovation- and knowledge aspect of this argument has been pointed out in the knowledge base theory (Asheim and Gertler 2005, Asheim and Coenen 2006, Cooke et al. 2007) arguing that companies rely on different kinds of knowledge (tacit, codified: Nonaka and Takeuchi 1995, Johnson 2002) and knowledge bases (synthetic, analytical and symbolic: SAS), or combinations thereof (Maniche 2012, Strambach and Clement 2012, Tödtling and Grillitsch 2015). Whereas codified and analytical knowledge can easily be transmitted due to modern communication technologies and is therefore highly mobile, tacit and symbolic knowledge is more geographically bound (Ibert and Kujaht 2011). However, these patterns are not to be seen as deterministic since e.g. tacit knowledge can also be exchanged in conferences, fairs and temporary projects at a global scale (Grabher 2001, Amin and Cohendet 2004, Maskell et al. 2006), and codified / analytical knowledge can also be tied to local communities and informal networks (Tödtling and Trippl 2007, Trippl et al. 2009). In addition these patterns are in constant flux due to organizational (e.g. global firms and alliances), technological (communication technologies, internet, social networks, etc.), and regulatory changes (WTO, and other regulatory institutions). In many cases, we have seen a shift towards higher spatial scales (e.g. from regional to supra-national and global scales), but this is not a general pattern, as we have argued. There are e.g. differences between sectors and industries with some staying more tied to local and regional markets, clusters and knowledge bases, whereas others are strongly extending their markets, knowledge links and innovation interactions towards higher spatial scales.

In the present paper we are going to investigate for three local clusters of Austria (Medical Technologies and New Media in Vienna, and Environmental Technologies in Upper Austria) the following research questions:

- To what extent do companies in those clusters rely on regional, national and international knowledge relations and other support factors in their innovation- and development process?
- To what extent can we observe shifts in those clusters towards higher spatial scales of interactions and supporting factors?

2) Conceptual Background

Relevant theories for investigating these research questions are the cluster concept and its life cycle theory, and the knowledge base approach among other literatures. One of the most popular approaches to the development of clusters was provided by Michael Porter (2008). He focused on the factors that help to explain why firms in clusters are more competitive than those in non-clustered situations, or why some clusters perform better than others. Factors referred to in his "Diamond-model" are factor conditions such as the quality of inputs (e.g. qualified labour, R&D, risk capital), demand conditions (sophisticated customers), related firms and supporting organizations, and the context for firm strategy and rivalry. Although there is a role for policy in cluster development and for cooperation among actors, the emphasis is placed on the propelling force of competition among cluster firms. Porter's approach is illustrative for framing the competitiveness position and key development factors of clusters, but it lacks a systematic dynamic perspective of cluster emergence, growth and transformation.

Bergman (2008), Karlsson (2008) and Menzel and Fornahl (2009) and have provided a more systematic perspective for cluster change using a cluster life cycle approach (CLC). Clusters are considered to move through stages (emergence, growth, sustaining, decline, rejuvenation) that show differences in technologies, learning- and innovation capabilities of firms. Key elements are actors, networks and institutions inside or outside the cluster, industry and region. Among the actors are firms, support organisations and policy actors. Networks are defined by the density and quality of interactions, whereas institutions include the regulatory setting, and formal and informal rules shaping actor behaviour. Driving factors vary by stage, i.e. factors relevant for cluster emergence differ from those in the growth and maturity stage. The emergence stage is characterized by start-ups, spin-offs, and technologically diverse companies, as well as a need for finance and a supportive science- and skills base. In the growth stage we find an increasing number of new and specialised firms in the cluster. But also a shake-out of companies may occur, with knowledge becoming more homogeneous leading to a dominant design. There is a growing density of companies and institutions, and the cluster offers possibilities for intensified customer-supplier relations and innovation networks. The stage of sustainment is characterized by relatively stable state and dense networks. Too rigid networks and knowledge relationships, however, may lead to a "lock-in" (Hassink, 2007), where the cluster then lags behind other clusters in the same sector. Under certain conditions clusters might transform and renew themselves as their companies are restructuring and applying new knowledge and technologies (Trippl and Tödtling, 2008).

Furthermore, the knowledge base approach helps to understand how specific types of industries are innovating using different kinds of knowledge and respective sources (Asheim and Gertler 2005, Cooke et al. 2007). Knowledge and innovation are regarded as key factors for cluster performance, whereby innovation processes are seen to differ between knowledge bases and sectors (SAS: Synthetic, Analytic and Symbolic Knowledge Base). Sectors based on analytical knowledge (such as Biotech and Medical technologies) are said to rely more on scientific knowledge, frequently of codified nature, interacting with universities and research organisations. Sectors based on synthetic knowledge (such as Environmental Technologies) more often recombine existing knowledge, using both codified and tacit forms thereof and interact more with other firms along the value chain. Sectors based on symbolic knowledge (such as New Media) use also symbols and cultural artefacts in their innovation process, drawing on both local and global sources and networks. Factors shaping cluster evolution and innovation from this perspective are, thus, sector-specific knowledge bases, multi-scalar knowledge networks, and conditions for innovation within the region and beyond. More recently, it has been pointed out that often combinations of knowledge bases matter for innovation and that firms and industries are often positioned along a continuum between different types of knowledge bases (Maniche 2012, Strambach und Klement 2012, Tödtling and Grillitsch 2015).

Which geographical scale of driving factors and knowledge relations?

The "scale"-dimension of driving factors for cluster development has often remained implicit and used in an unclear way in the presented approaches. Porter for example refers to clusters as localised phenomena that benefit from colocation, including advantages regarding factor inputs, sophisticated demand, supporting industries, and knowledge flows and innovation. However, this and related approaches (Sölvell 2008, Ketels 2015) are unclear on the geographical scale of business environments and on what „local" actually means (Boschma 2005). In this cluster literature relevant spatial levels reach from local labour markets and metropolitan areas to regions, provinces and states depending on the perspective and the study approach. However, not just the spatial scales remain unclear, also a dynamic view is often lacking in this regard.

Concerning the spatial scale of cluster interactions the knowledge base approach provides some useful insights. Moodysson et al. (2008) e.g. emphasize local-global patterns of knowledge interactions in industrial clusters along the lines of "local buzz and global pipelines" (Bathelt et al., 2004). It has been pointed out that different knowledge bases (SAS) have particular geographies of knowledge relationships (Martin and Moodysson 2013). Companies reliant upon an analytical knowledge base predominantly exchange codified knowledge and are more globally oriented (see e.g. Belussi et al. 2010, and Plum and Hassink 2011 for the life science industry), whereas companies relying on symbolic and synthetic knowledge bases more often use and exchange local tacit knowledge (Asheim and Coenen 2006). For the synthetic knowledge base (relevant e.g. for engineering, machinery, and automotives) we find contradictory views: Moodysson et al. (2008) as well as Gertler and Wolfe (2006) identify a strong role for local learning and informal (tacit) knowledge exchange with local suppliers and clients, whereas Tödtling et al. (2012) and Plum and Hassink (2013) find that knowledge exchange in such sectors often takes place along the value chain (e.g. with suppliers, supporting services, clients) at national and international spatial scales. Several empirical studies have used the knowledge base approach in a multi-scalar and comparative perspective for analysing knowledge relations in different types of clusters (for example the

`Constructing Regional Advantage´ project: Asheim et al. 2011, Tödtling et al. 2013). This research has demonstrated that knowledge sources of firms tend to be distributed at several spatial scales, including regional, national, European and global, and that these patterns seem to be shaped by respective knowledge bases as well as regional contexts. Despite these important insights regarding the scales of cluster interactions there is a lack of studies comparing sectors relying on different kinds of knowledge bases, and of studies investigating changes of interaction spaces in the course of cluster development in a more systematic way. Exactly these aspects will be the focus of the present study.

Based on these considerations we argue that geographies of driving factors for cluster development and innovation can reach from local to global scales, depending on the nature of the industry and the underlying knowledge base, and that they will shift in their relevance from early to late stages. Often they are not rooted in particular predefined levels or territories, but along a continuum from local to global interactions, such as relations to markets, suppliers and clients, or knowledge- and innovation networks of firms (Bunnel and Coe, 2001). However, predefined territorial levels *do* matter as well, since the institutional- and the policy dimension is tied to territories such as regions (provinces), countries (national states) and the European Union. In the empirical section below we use therefore these territorial levels to analyse the spatial dimension and respective shifts of driving factors for cluster evolution.

From this brief literature review we derive the following observations for a framework of cluster development and innovation, and their driving factors:

- Driving factors, knowledge sources and innovation relations, and their spatial scales, differ between types of industries and knowledge bases (Asheim et al. 2011). Whereas firms in industries based on synthetic knowledge such as Environmental Technologies are expected to rely upon suppliers, clients, and service firms as knowledge sources for innovation at various spatial scales, companies in “symbolic industries” such as New Media are expected to rely more on local skills, qualifications and informal networks in their activities and innovations. However, due to their reliance on modern ICTs and the Internet, global virtual communities and -relationships matter to an increasing extent also in such “symbolic” sectors. Industries relying on analytical knowledge such as Biotech, global knowledge and innovation relations seem to be of key importance, whereas more user-driven sectors such as Med-Tech might rely both on global scientific knowledge as well as applied and practical knowledge of doctors and hospitals at local levels.

- Furthermore, driving factors and knowledge sources are expected to change in their importance as the cluster evolves, as the cluster life cycle model and evolutionary approaches have emphasised (Bergman 2008, Belussi and Sedita 2009, Menzel and Fornahl 2009). In the emergence phase companies are said to rely partly on knowledge from related industries or from research organisations for developing new business models and products, and they use their personal and social networks in order to overcome problems and barriers for start-up processes and company development. The region is an important interaction-space during this phase, since start-ups and spin offs are often geographically close to originating sectors, firms and organisations (Frenken and Boschma 2007). During the growth phase the conditions for acquiring key inputs such as qualified labour, (risk-) capital and necessary infrastructure, the access to markets and sophisticated customers, and the

availability of related firms and services become more important. For some of these factors such as a qualified workforce and tacit knowledge exchange, the region is important, for others such as markets, related firms (suppliers, clients) and formal innovation relationships higher spatial scales (national, European and global) seem to matter more. Although there is a tendency for the cluster space and driving factors to expand towards higher spatial scales, such an expansion is not of general nature. The cluster co-depends upon the region for the qualified workforce and skills, and for the exchange of tacit knowledge and informal networking. These latter factors, however, depend also on sectorial and institutional contexts.

3) Empirical setting and background

This section focusses on the background factors that have supported the emergence and development of the investigated clusters in regions of Austria. It is based on a review of relevant literature and of documents to those clusters, 10 qualitative interviews with industry- and policy experts in these investigated fields as well as on information from the firm interviews in those clusters (see section 4.1 for the methodology).

3.1 Medical Technologies in Vienna

The medical technology industry (MT) in Vienna is part of the broader life sciences cluster there that includes also the pharma-biotechnology industry. In general, these sectors are said to use both analytical and synthetic knowledge in their innovation process, although the medical technologies are more user-led (by doctors and hospitals) and less research driven than the pharma-biotech sector. Vienna is the main centre for these life sciences and medical sectors in Austria and possesses competencies in areas such as biotech, prosthetics and imaging (LISA Vienna, 2014; Hochgatterer et al., 2014). The medical devices industry is based on a long tradition in medical research as well as precision mechanics in this region, and about one third of all Austrian medical devices firms are located here (33 out of 98 firm; LISA Vienna, 2014). The R&D performing firms are specialised in software for medicine, telemedicine and e-health, electromechanical medical devices, dental technology, diagnostic and therapeutic radiation technologies, and surgical instruments. More than half of the firms in this industry have been set up in the last 10 to 15 years, and the average age of the companies is 18 years (Tödtling et al. 2016). The cluster has both, growing and maturing segments. Growth is particularly in areas where IT capabilities are used and accumulated. In contrast to biotechnology, medical devices have shorter product development cycles and a lower development risk, generating on average four times the revenue invested in R&D. The firms are mainly small, employing less than 10 people, and highly specialised (LISA Vienna, 2014).

The Vienna city region has also the highest concentration of specialised and teaching hospitals in Austria, and hosts some of the main medical and technical university centres in the country. The city is location of the largest hospital in Europe (the Allgemeines Krankenhaus or AKH) which is engaged in teaching and research, in addition to a number of smaller and specialised hospitals in the city and its surroundings. Vienna also has a medical university and a technical university, both of which are

important for training medical practitioners, scientists and engineers in Austria. These health organisations act both as powerful clients and as providers of various kinds of knowledge for the medical devices sector (Tödtling et al. 2016). The social, economic and cultural proximities of Austria to the German and Swiss markets (also known as the "DACH" region) are significant for R&D and production channels also for this sector. The largest R&D performing firm in this sector in the Vienna region is a (German) R&D subsidiary of the global Otto Bock Healthcare Products, specialised in prosthetics. Moreover, since the early 2000s, the life sciences sectors have been a central pillar of Vienna's science, technology and innovation (STI) policy (Stadt Wien, 2004; ZIT, 2013; w.wiendenktzukunft.at, www.wienwin.at) and a major focus of large-scale funding programmes. In addition to direct economic benefits for employment, sales, firm formation and economic growth, the Vienna medical cluster has substantial direct importance for the local population in meeting changing healthcare requirements of the elderly and increasing complexity of diseases that such demographic changes bring about.

3.2 Creative industries and New Media in Vienna

New Media is part of the wider group of creative industries that have been studied internationally for at least two decades not least because of their increasing role for growth and competitiveness in advanced economies (see e.g. Lazzeretti 2012; for Austria ZEW 2008, for Vienna Ratzenböck et al. 2004). As regards the definition of this industry we follow Lazzeretti et al. (2008) differentiating between "traditional creative industries" (for example, printing and reproduction of recorded media, motion picture, video, television, architectural and engineering activities, creative arts, entertainment and museums) and "non-traditional creative industries" (such as software and computer services, scientific research and development, advertising and market research) the latter including New Media products and services (Sinozic and Tödtling, 2014).

Creative industries including New Media tend to rely more on symbolic as well synthetic knowledge than the Medical and Environmental Technologies sectors, and they develop and sell products and services by organising in temporary projects that cross organisational boundaries and include free lancers from different communities (Grabher, 2001:354, Lorenzen and Frederiksen, 2008). Uncertain markets and demand make more stable structures expensive and risky. Skills (human capital), work relationships (social capital), and trust built up in latent networks are of key importance for participating in such projects (Sedita 2008, Bettiol and Belussi 2011, 2013). Projects are oriented towards client needs, and these influence the work organisation and interactions among creative firms. An important driver of networks is the search for technological diversity. For example in advertising, client needs may not only refer to advertising but also to marketing and communication strategies. Projects tend to be based upon social relations, and over time they create and interrelate with communities of practice and latent networks in the region and beyond (Sydow and Staber 2002, Bettiol and Belussi 2011, 2013).

New Media (NM) are a relatively small segment of Vienna's broader creative industries. These have a long tradition, as Resch (2008) has demonstrated using Austrian national census statistics from 1910, 1951 and 2001. In 1910, the creative industries in Vienna (composed at that time of traditional creative industries, such as architecture, audio-visuals, arts, print and publishing, music, museums and libraries) employed around 200500 persons. Between 1910 and 1951 Vienna lost its imperial role

and political position in Europe, causing a decline in sectors such as graphics, fashion, design, museums and libraries. During the same period, driven by new technology and growing demand, the audio-visuals and music sectors grew. In the period from 1951 to 2001 some creative sectors went through dramatic growth phases (especially architecture, museums, libraries, advertising, and audio-visuals, whereas graphics, fashion, design, print, publishing and music declined. In this period the global ICT industry emerged, starting off New Media. Between 2000 and 2010, the New Media cluster in Vienna (including film and video, advertising, software applications, gaming and computer services) has grown by approximately 40%, the most dramatic growth of all Creative Industries during that last period. These sectors have become a major focus of government support in Vienna in the recent period.

3.3 Environmental Technologies in Upper Austria

Environmental Technologies can be traced back to the early 1970s when pollution problems from basic industries spurred the creation of end-of-pipe products for their abatement (OECD, 1999; Weber 2005). In the 1980s and 1990s the use of information technologies (IT) allowed environmental technology industries to shift towards more integrated, and process-oriented clean technologies and products. In the 2000s an integration of diverse technology areas such as IT, biotechnology, nanotechnology, and materials science into process-based environmental technologies could be observed, aiming at resource- and energy-efficiency and pollution reduction within the production process itself. These have been called 'sustainable' technologies (Weber, 2005). These processes were reflected in a convergence of environmental and high-tech industries, and the emergence of 'cleantech' clusters notably in Germany and in the US (Cooke, 2008). Innovations in these industries are often the result of a recombination of existing knowledge and solutions in the different subareas and technological fields (Cooke 2012). The synthetic knowledge base, thus, seems to be predominant, although analytical knowledge can also play a role in fields where research inputs are needed.

The origins of Upper Austrian Environmental Technology firms (ET) are predominantly in materials, engineering, machineries and instruments sectors. Some of these firms, based on their technical competencies, have diversified into environmental technologies. Relying predominantly on a synthetic knowledge base, firms have integrated environmental solutions into their product range to gain competitive advantages (De Marchi, 2012). The strongest areas in Upper Austria are renewable energy, energy efficiency, water and waste. Similar to the ´Ruhrgebiet´ in Germany (Hilbert et al., 2004), the emergence and growth has been triggered by pollution problems caused by manufacturing industries in the 1960s and 1970s. Contamination of air, water and soil by heavy industries prompted local activism for its reduction and control. Societal protests pushed the local industry towards the reduction of emissions and wastewater. Regulations and policies for pollution control in manufacturing were further factors gaining momentum during this period (Pirgmaier, 2011). Such regulations were implemented at national and EU levels, setting incentives for searching new solutions to reduce pollution. Existing technological capabilities, supplying firms, and sophisticated local buyers (such as steel and engineering firms and public demand) were thus essential factors for the emergence and growth of these new products and technology areas. In addition, two cluster initiatives and policy organisations were set up to support companies in this field since the 2000s (Tödtling et al., 2014).

4) Multiscale factors underlying cluster development and innovation

This section investigates and compares the driving factors for cluster development, as well as the knowledge sources and innovation relations that are predominant in these three different types of industries. It focuses in particular on the respective geographical scales and on scale shifts with regard to these factors in order to find out to what extent these different types of industries stay territorially bound to regions and countries, or become linked to higher European or global scales in their driving factors and innovation relations. Although knowledge sources and innovation relations are in the centre of the analysis we also give attention to other factors that might be relevant for cluster development such as demand, finance, regulations and policy support.

4.1 Methodology

This section investigates and compares factors for clusters development and innovation from the perspective of surveyed firms. Driving factors and the importance of particular spatial scales have been evaluated based on (1) qualitative interviews with experts and policy actors and (2) semi-standardised interviews with firms, where we analysed factors for companies to locate and stay in the region, and multi-scale factors for company- and cluster development in different points in time. Empirically it is based on 80 semi-standardised company interviews and other sources. The interview guideline was based on the conceptual framework of the CLC project[1], and a combination of theoretical and statistical sampling was used to select the firms. In the smallest cluster, the Medical technologies in Vienna (MT), we interviewed almost the whole population (30 firms from 33). In the present analysis we kept those 25 companies that were more than "sales outlets", i.e. companies that had some operative functions including production, services, and R&D at the Vienna location. It was more difficult to statistically define the New Media sector because it is rapidly changing and NACE codes are not always up to date. We relied therefore on previous studies to this topic such as Lazzeretti et al (2008), and included the following NACE categories: advertising (7311), film and video production (5911), selected ICTs (7311; 6209), publishing (1812). Based on these criteria, the New Media cluster in Vienna (NM) included 480 firms in 2013, from which we interviewed a sample of 25 firms that appeared to be active also in innovation. In the environmental technology cluster in Upper Austria (ET) a sample of 30 innovation-active companies was drawn from the populations of the two cluster initiatives in the region, the eco-energy cluster (164 firms and organisations) and the environmental technology cluster (136). Firm interviews were carried out face-to-face with general managers or R&D leaders, and lasted between one and two hours.

4.2 Factors relevant for locating and for staying in the region

Since we were interested in driving forces for cluster development and their spatial shifts we investigated at first the factors that were regarded as relevant by the companies both for locating and for staying in the region. We asked them to evaluate the respective importance of those factors

[1] CLC („Cluster Life Cycles") was a cooperative European research project from 2011 to 2014 coordinated by the University of Kiel (Prof. Robert Hassink) and supported by the European Science Foundation and the Austrian Science Fund (FWF, see Acknowledgements).

by using a five point Likert scale. Figure 1 shows that the *location of companies in the region* is dominated by personal factors in all three clusters. This is basically in line with other studies on firm establishment that have shown similar results (Sternberg 2007, Tödtling et al. 2009). For Medical Technologies (MT) and New Media (NM), in addition, skills and qualifications were seen as highly important for locating in Vienna. Obviously, these two industries rely more on human capital and skills than the Environmental Technologies firms (ET). Local demand was more relevant for firms of the Medical Technology sector in comparison, showing their strong regional market focus in the initial years. Furthermore the existence of other firms in the cluster as potential business partners was considered important for locating by firms in Environmental and Medical Technologies. Obviously, these firms draw on local suppliers of various kinds of inputs in the initial years. For Medical Technologies due to its higher reliance on analytical knowledge also the access to universities and research hospitals was highly relevant, both for locating and for staying in the region of Vienna. Supporting policies and regulations were considered as less relevant for locating and for staying in the region. It seems that this is not a location factor, but as we will see in section 4.3, a factor that gains importance for firm growth and development.

Fig 1) **Factors for locating in the region** (MT: n=25, NM: n=25; ET: n=30)

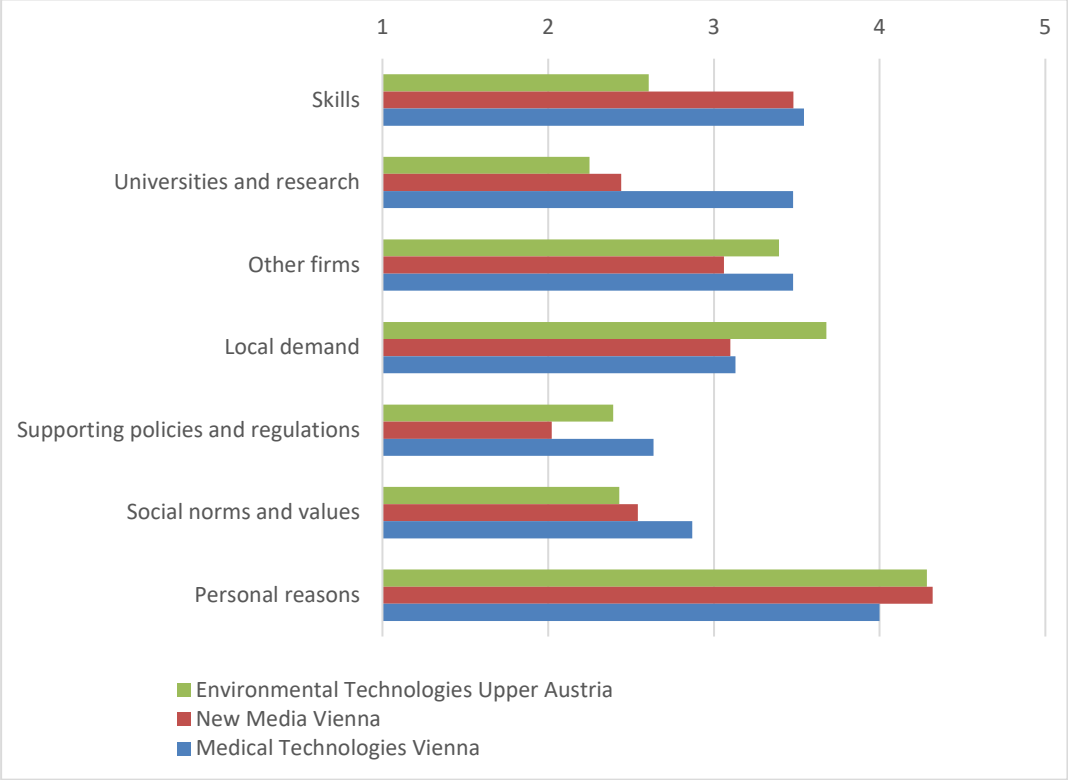
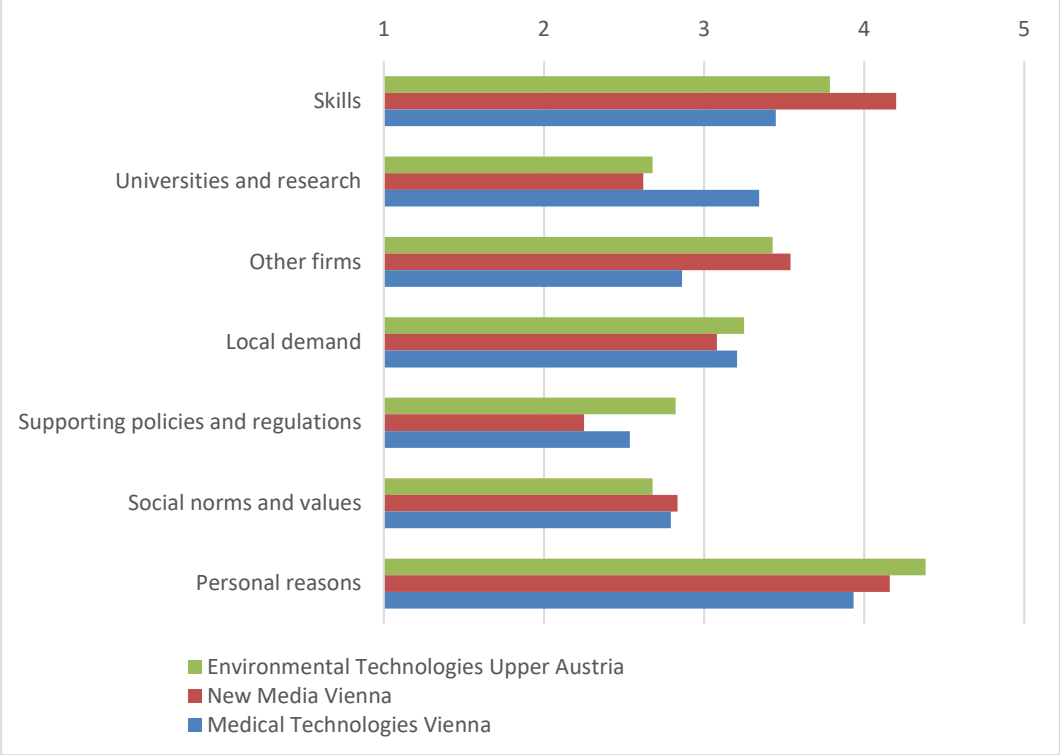


Fig 2) **Factors for staying in the region** (MT: n=25; NM: n=25; ET: n=30)



Factors for staying in the region were evaluated generally as more important in all three clusters compared to the factors for location (figure 2). Environmental Technology (ET) and New Media firms (NM) have become more reliant on their region in particular for the recruitment of skilled and qualified labour. This finding might be due to a growing sophistication of production and business processes, such as an increasing role of marketing, management, innovation and R&D. There is a higher relevance of supporting policies and regulations in particular in the Environmental Technologies in Upper Austria (ET) indicating an increasing role of the local cluster policies there. For New Media "other firms" along the value chain have grown in importance, such as suppliers and clients, indicating a process of cluster formation in the region of Vienna. Medical Technology firms, in contrast, reported no major changes and with regard to "other firms" even a decrease in importance. This indicates an orientation towards higher spatial scales and a dislocation of the value chain at a relatively early stage of firm development.

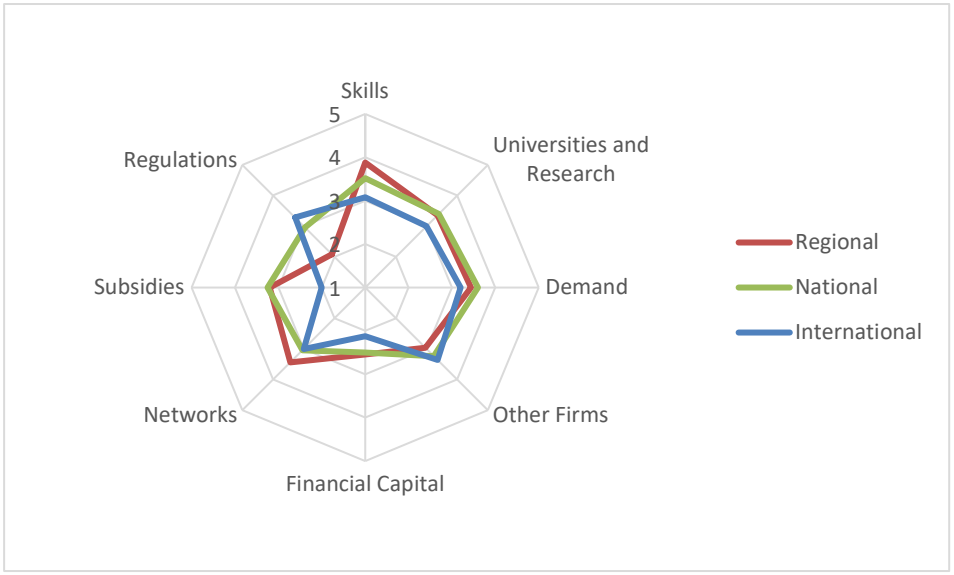
4.3 Multi-scalar factors for company- and cluster development

The survey focused also on factors that were regarded as important for the further development of the companies and the respective cluster. The respondents were asked to evaluate these factors according to their relevance on different spatial scales (regional, national and international) and according to temporal changes. They were studied both for the past (three to five years ago depending on the start-up date) and at present, using a five point Likert-scale. For the development of companies, "skills" (such as qualified personnel) were evaluated as most important for all three industries and at both points in time (figures 3-5). As to be expected, these skills are highly localized.

Firms rely on the respective regional labour market and recruit qualified labour also from the Austrian labour market. The Medical Technologies- and New Media firms in Vienna in addition draw talent from abroad.

Fig 3) Factors relevant for company development in Medical Technologies Vienna

Factors **previously** relevant (n=25)



Factors **presently** relevant (n=25)

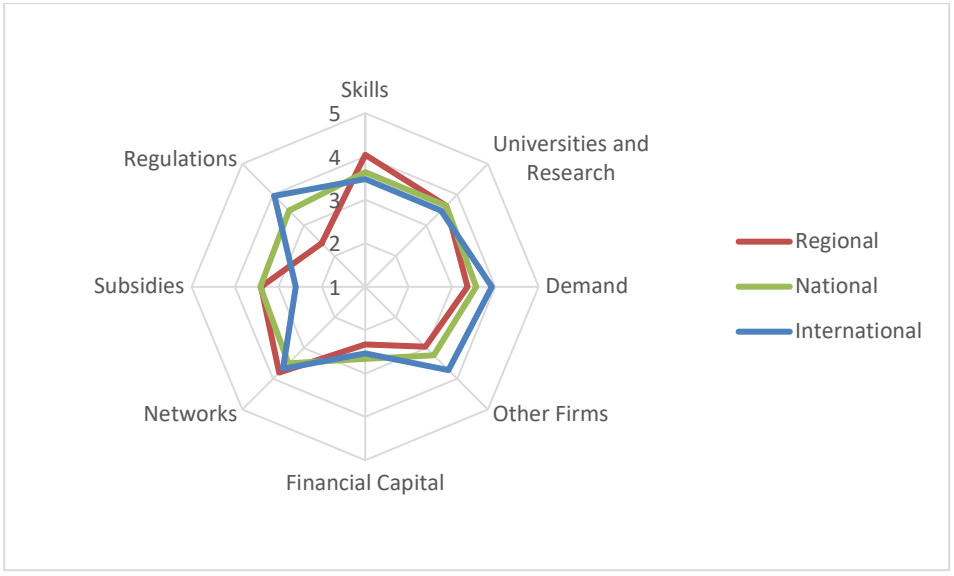
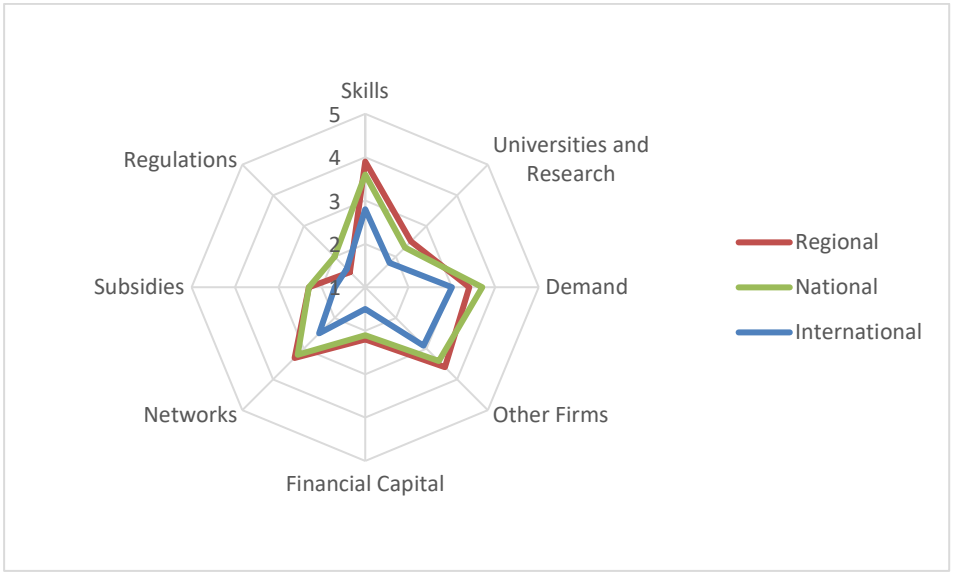


Fig 4) **Factors relevant for company development in New Media Vienna**

Factors **previously** relevant (n=25)



Factors **presently** relevant (n=25)

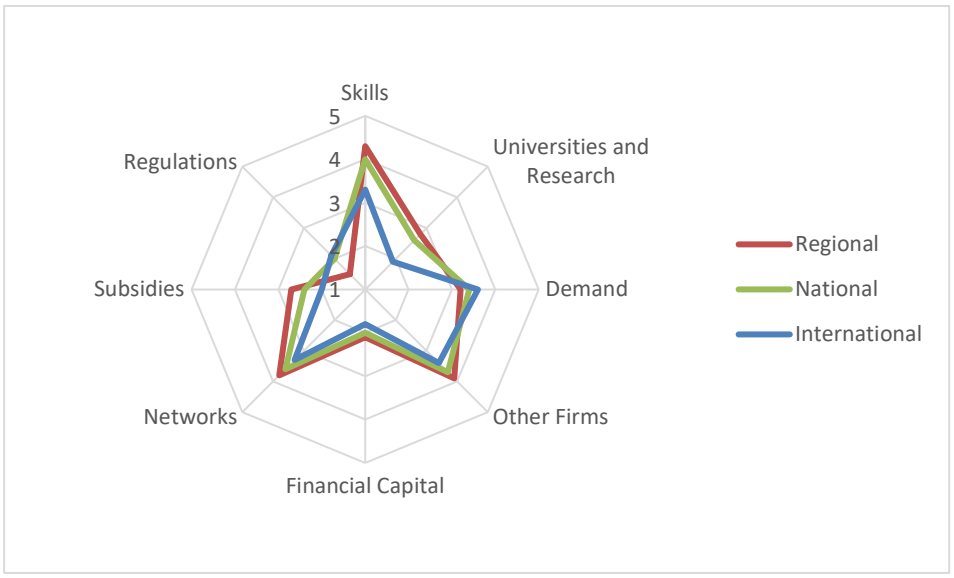
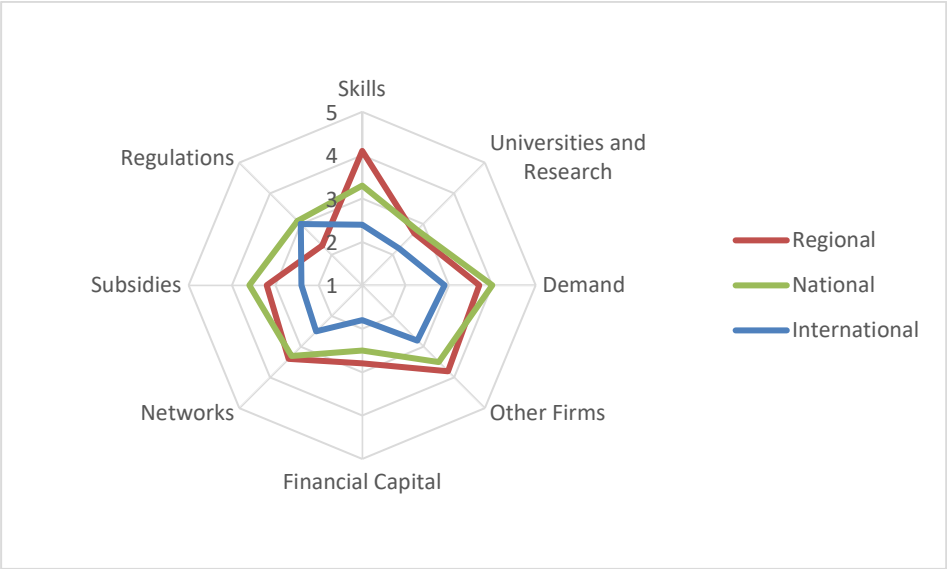
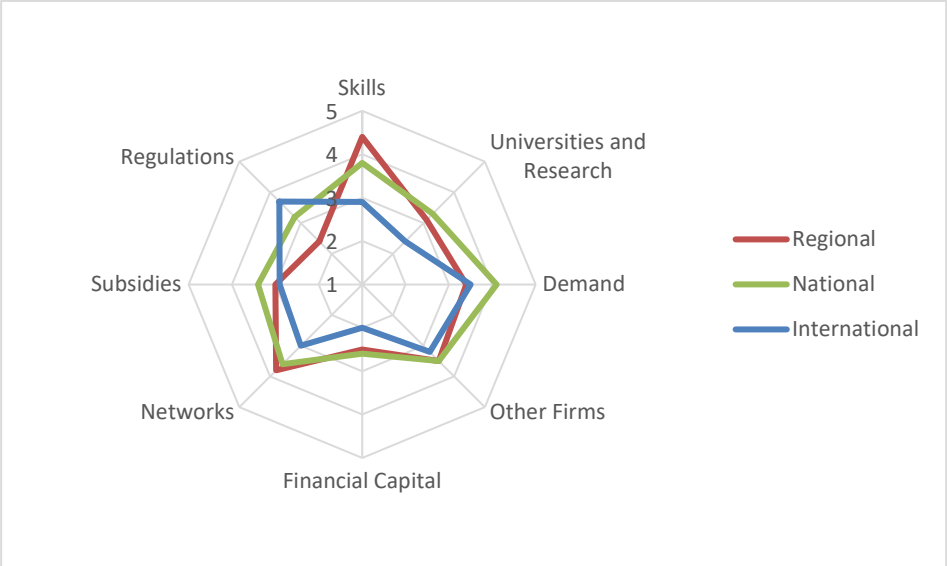


Fig 5) **Factors relevant for company development in Environmental Technologies Upper Austria**

Factors **previously** relevant (n=30)



Factors **presently** relevant



The factor “demand” also has a high relevance for all three sectors. It seems to be more important for Environmental Technology- and for Medical Technology firms than for New Media companies. Environmental Technology firms are strongly oriented to the national market, although we see also a certain role of the regional and a shift to international markets. This is in line with findings from an earlier study based on a broader data set that also showed a clear shift towards international markets for Upper Austria Environmental Technology firms (Tödtling et al. 2014). In Medical Technologies and New Media we see despite a continuing strong role of the regional and national markets a certain shift to the international market in recent years.

With regard to “networks” (i.e. more durable relations to other firms and organisations) we can observe a high importance of proximate links (regional, national) initially, that increase in importance over time. For all three industries, it obviously takes time to build up such relationships and trust and we see rather more than less embedding into the region and the country in the course of cluster evolution. In addition, links to international partners have become more important over time, indicating an extension towards multi-scalar networks in particular.

Related firms from the sector and cluster (“other firms”) were also rated as important for the development of the companies indicating a supportive role of suppliers and services in the region and in Austria. Related firms from the region are more important for the New Media cluster than for the other two sectors. This finding might be due to the frequent exchange of services and knowledge with other cluster firms as well as the high level of division of labour and collaboration in a sector that is widely dominated by small firms. Over time, we not only find such related firms to gain importance in the region and in Austria for New Media firms but also for their Environmental Technologies sector counterparts. For firms in both of these sectors geographical proximity to potential business partners is supportive for their development. This differs for Medical Technology firms which are clearly more tied into international links with related firms. This might be due to the more specialised products and also some international firms in the sector.

Subsidies are more relevant for firms in the Environmental Technology sector where previously regional and national programs have played a role. This has changed in the past years to a multi-scale pattern of support where all three levels matter. This might be due to the relatively high priority this sector receives at present within regional, national and EU promotion schemes. Interestingly regulations and directives were reported as having no relevance for the New Media. They clearly had a higher and increasing importance for the Environmental Technology- and the Medical Technology sectors. As regards the geographical scales of regulations we can observe a certain shift in both sectors from the national level to the international one in recent years. This reflects the increasing role that the EU takes in such regulations in order to harmonize respective rules. For the companies this implies more need to monitor all those regulations very closely before they can introduce new products or services.

4.4 Innovation, core competencies and networks

In the present research we were interested in particular in the question to what extent the firms in these three clusters rely on regional, national and international knowledge relations and support factors in their innovation- and development process in addition to their internal competencies. From figure 6 we can observe that in all three sectors the firms are quite innovative since more than ¾ of them (from 77% to 88%) had some kind of innovation. Basically this reflects the sampling strategy to focus on innovation-active firms. Technological innovations were more frequent in general, with 73% to 80% having introduced new products and 73-76% new processes, components or materials. The Medical technologies firms were the most active in the introduction of new products (80% of companies), whereas process innovations and new materials were of about equal high importance in all three clusters (73-76%). The findings are in line with the suggestion that the medical devices firms are technology-driven and leaning towards the analytical knowledge base (Moodysson, et al. 2008). In contrast, the New Media firms are more often relying on changes of

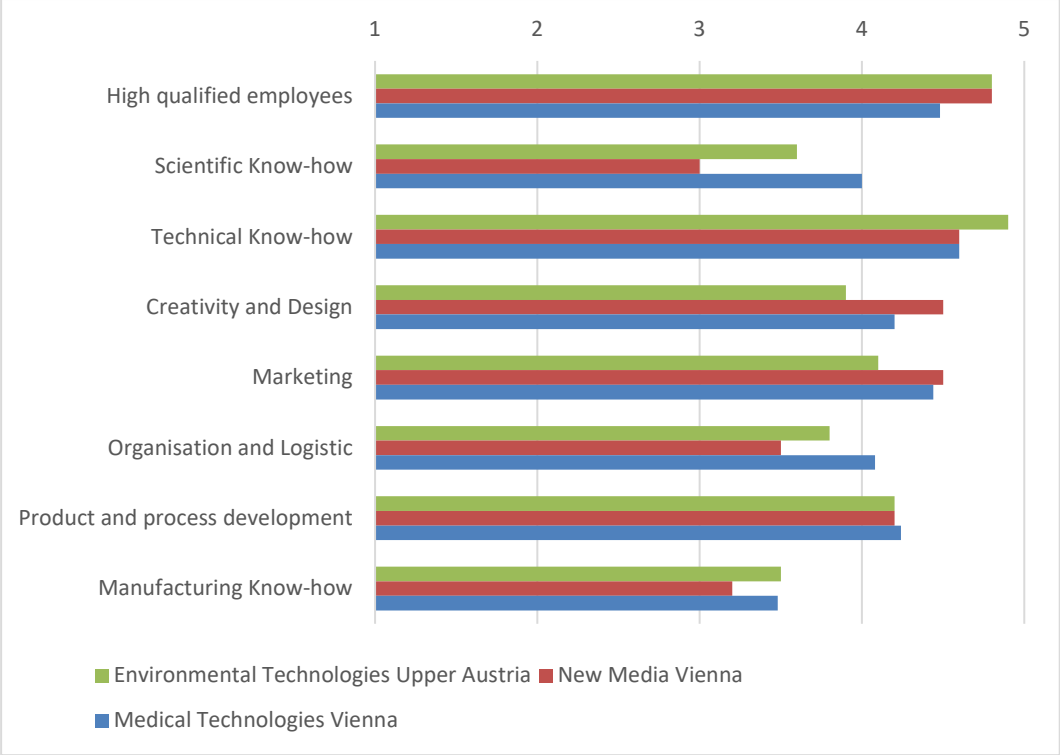
strategies (56%) or organisational structures (56%) compared to the other two sectors. This may have to do with the fact that flexible and temporary forms such as project organisations and virtual networks have a higher relevance here (Grabher 2002).

Tab 1) **Type of innovation** (MT: n=25; NM: n=25; ET: n=30)

Type of innovation	MT companies (% of sample firms)	NM companies (% of sample firms)	ET companies (% of sample firms)
Introduction or improvement on products and services	80	88	77
Introduction of new product to the market	80	60	73
Use of new or improved process, component or material	76	76	73
Use of new or improved strategy	52	64	50
Use of new or improved organisational structure	40	56	20
Introduction of a new or improved marketing concept	64	40	40

On which internal competencies were the companies relying and which kinds of external partners did they use in their innovation- and development process? The findings about the core competencies are in line with their innovation activities and the knowledge base approach (figure 6): The most important internal competences, as stated by the companies, for NM and ET are the highly qualified employees (4.8 on a 5 point Likert scale), and for ET their accumulated technical know-how of both tacit and codified nature (4.9). For MT these two internal sources are also highly relevant, but due to its more analytical knowledge base also the scientific Know-How ranks high for these firms (4.0). In comparison, scientific know-how is less relevant for the "symbolic" NM sector (3), where in line with expectations creativity and design and marketing skills rank high (4.5).

Fig 6) **Core competencies presently** (MT: n=25; NM: n=25; ET: n=30)



In addition to those internal competencies and Know How the firms rely on external innovation partners at various spatial scales (tables 2-4). These networks are shaped by the respective knowledge base and sector characteristics. The Medical Technologies sector (MT: table 2) is characterised by a stronger role of analytical knowledge that is generated in medical research in hospitals and universities. Accordingly, MT firms have most frequently partners from such organisations (35%). Confirming other research on such university collaborations, we find a strong role of geographical proximity for a smooth knowledge exchange since 46% of them are within the region and another 30% within Austria. But different from other "analytical" sectors such as e.g. pharma and biotech, the MT sector is also characterised by strong interactions with the clients, i.e. doctors, hospitals, and other health organisations. Such partners are used by 38% of MT firms. In line with their sales markets, these innovation interactions are more wide spread, i.e. often on the national and European scales.

Innovation partners of firms in Environmental Technologies (table 4) clearly differ from this pattern. The most frequent type are public agencies which are often technology transfer-, cluster- and other support organisations relevant for this industry. These might be particularly relevant for the process innovations that are high in this sector, and they are almost exclusively on the national (50%) and regional scales (43%) where these support organisation are mainly located. Universities and technical colleges also matter as innovation partners for this sector for 26% of the companies. Most probably these have to do with applied research rather than basic research. These relations are almost exclusively within the region (45%) and in the rest of Austria (50%). In line with expectations for the synthetic knowledge base, we find also suppliers and clients as innovation partners. However, these are less frequent than the public agencies and the colleges.

Tab 2) **Innovation relevant network partners of Medical Technologies companies in Vienna** (n=25)

	Regional	National	EU	Global	Total	% of total
Supplier	4	1	7	3	15	14,4
Client	9	17	10	4	40	38,5
Competitor	0	1	1	2	4	3,6
Firm of same sector	1	2	1	1	5	4,8
Firm of different sector	0	1	0	0	1	1,0
University	16	11	6	3	36	34,6
Public agency	2	0	0	1	3	2,9
Total	32	33	25	14	104	100
% of total	30,8	31,7	24,0	13,5	100	-

Tab. 3**) Innovation relevant network partners of New Media companies in Vienna** (n=25)

Type of partner	Regional	National	EU	Global	Total	% of total
Supplier	0	0	0	3	3	3,5
Client	3	2	7	2	14	16,3
Competitor	0	0	0	0	0	0
Firm in same sector	11	6	3	19	39	45,3
Firm in different sector	2	0	0	0	2	2,3
University	11	4	2	0	17	19,8
Public agency	7	2	0	2	11	12,8
Total	34	14	12	26	86	100
% of total	39,5	16,3	14	30,2	-	-

Tab. 4) **Innovation relevant network partners of Environmental Technologies companies in Upper Austria** (n=30)

	Regional.	National	EU	Global	Total	% of total
Suppliers	8	5	6	2	21	15,9
Client	5	9	3	3	20	15,2
Competitor	0	0	0	0	0	0
Firm of same sector	1	5	-	2	8	6,1
Firm of different sector	6	-	1	-	7	5,3
University	15	17	1	1	34	25,8
Public agency	18	21	1	2	42	31,8
Total	53	57	12	10	132	100
% of Total	40,2	43,2	9,1	7,6	-	-

New Media companies (table 3) are most often partnering with other firms of the same sector in their innovation process (45%). And surprisingly, almost half of these are on a global scale (i.e. outside Europe). This global innovation partnering often has to do with drawing knowledge and technologies in the fields of IT and software, and applying these to the respective media-products and -services. This opens up new markets that are rapidly growing. But 1/3 of New Media firms also

have innovation partners within the region, and these are again firms from the same sector as well as universities. The sector firms seem to be partners e.g. for project consortia, whereas the universities often serve as sources for technological- and software knowledge.

Summarizing the geography of innovation networks of the investigated clusters we find that the Environmental Technologies sector is most strongly confined to the region (40%) and the rest of Austria (43%). This has to do with the strong role of public and semi-public organisations for this industry as client, for providing support, and for knowledge and technology transfer. Most probably this is not just typical for Upper Austria, but more broadly for the sector in general. The Medical Technologies firms in Vienna have a regional, national and European reach in comparison. Within the region we find the university- and research relations, and at the national and EU scale the clients and regulators. Overall there are 85% of the innovation relations within this European area. The New Media sector differs from the other two due to its distinct local-global pattern of innovation relations, with 40% of those relations within the region of Vienna and 30% at the global scale.

When we compare our findings with expectations in the literature, we find some deviations. Contrary to the expectations we find our "analytical" Medical Technologies sector very little global in its innovation networks. We can explain this difference by the strong role of regional, national and EU health organisations as clients and also by the high importance of the relevant regulatory settings (in Austria and EU). And contrary to the expectations from the literature we find that our symbolic sector (New Media) is not confined to the region in its innovation relations but shows this specific local-global pattern described above. The deviation is due to the need for these companies to link up with global technology- and knowledge providers in the IT field that is a major source for innovations in this sector.

5) Conclusions

The aim of this paper was to investigate to what extent driving factors for cluster development and innovation relations are different in their spatial scales and territorial rootedness between industries and how these patterns change over time in the course of cluster evolution. For this purpose sectors relying presumably on different kinds of knowledge bases were compared. We studied the Medical Technologies (relative more analytical knowledge) and the New Media clusters (more symbolic knowledge) in Vienna, as well as the Environmental Technologies cluster (more synthetic knowledge) in Upper Austria. Driving factors and innovation relations were investigated mainly from a firm perspective by interviewing samples of companies in the three clusters indicating their evaluation of the relevance, spatial scales and shifts of importance of those factors and relationships.

We found that the three clusters clearly differ in this respect. Whereas companies in the Environmental Technologies cluster in Upper Austria are more dependent on public demand as well as on the regulatory setting and subsidies at the Austrian level, the New Media cluster of Vienna relies more on the demand from other businesses located in the region and in Austria. Other key factors for company- and cluster development in New Media are qualifications and skills available in regional and Austrian labour markets, and the possibility to interact with other firms in Vienna and at a global scale. The Medical Technologies firms in Vienna depend much more on the demand and user-led innovations driven by hospitals and doctors at regional and national levels in comparison, as

well as on research findings from universities. Since the sector strongly depends on the regulations and the finance from the public health system it stays strongly tied to the regional and national scales in the driving factors and innovation relations.

Partly, the spatial pattern of driving factors is related to differences in the knowledge bases and innovation processes as we have shown in this and other research. The Medical Technologies cluster in Vienna has the strongest links to universities and research hospitals reflecting its stronger role of analytical knowledge. However, different from e.g. the pharma-biotech sector it is more often the user knowledge of doctors and hospitals that matters, as well as access to patients for testing and certifying new products, rather than results from research. This and the importance of the regional and national health system and regulations keeps the sector tied to the region and the national level, although we can observe shifts to the European and international scales more recently for regulations, demand and related firms. Environmental Technology firms in Upper Austria, in comparison, rely more often on applied knowledge from technical colleges and on transfer agencies, as well as on public demand and subsidies, leading also to a strong rootedness in the regional and national economies and innovation systems (Tödtling et al. 2014). Different from the other two sectors New Media firms in Vienna mainly interact with other cluster and sector firms in a local-global pattern (Sinozic and Tödtling 2014). Due to the importance of temporary projects (Grabher 2001) these companies are relying both on personal interactions in the region and the country, and on IT related inputs and internet based communities at a global scale.

The second interest of this paper was to investigate to what extent factors relevant for company- and cluster evolution change over time, as the CLC concept and evolutionary approaches suggest. Indeed, such shifts are partly similar and partly different in the three clusters. In all cases we find a strong role of personal factors and social relationships within the region in the initial years of company foundation. Also, in all clusters demand from the region and the country, as well as qualifications and skills on the labour market matter most in the early stages. This is basically in line with studies on company location that usually stress the role of personal factors as well as with the view that Marshallian labour market externalities matter in this phase. Different from other cluster studies we find that relationships to other firms in the region (supporting firms and services) as well as networks do not seem to be of highest importance initially, but become more relevant later on.

In recent years, companies clearly have reached beyond the region and the country in several dimensions. As to be expected in an era of European integration and of globalisation for companies in all three clusters international (often European) markets and clients get more relevance, as well as relationships to other firms from the sector and along the value chain. Networks of knowledge sourcing and innovation also become extended in geographical space and increasingly include European and global partners. However, despite much talk on “globalisation” in the literature, we do not find a replacement or hollowing out of the region or the country as interaction spaces since these territories keep their importance in various respects. Instead, we observe a shift towards multi-scalar factors and –interactions. There are some marked differences between the investigated clusters in this process of spatial extension. The Medical Technologies firms in Vienna show the strongest shift to an international (mainly European) scale with regard to regulations, markets and related firms. For Environmental Technologies firms in Upper Austria and we observe as well that international (mainly European) regulations have become a key factor recently, whereas for New Media firms in Vienna it is the demand and networks on an international scale that matter more strongly in recent years.

Overall, our findings let us reject on the one hand the Porterian view, that cluster competitiveness and growth are mainly based on local and regional factors. We find that clusters to some extent always depend also on national and international factors, although the regional setting indeed matters more in the early stages. On the other hand, our findings also let us reject an overstated globalisation argument that industries and clusters predominantly depend on global markets and technologies, accompanied by an erosion of local, regional and national business- and innovation environments as interaction spaces. Also the view that industries move towards a schematic local - global paradigm where firms and clusters are embedded in their region with social and informal ties, and where they compete, trade and collaborate mainly at a global scale is not supported by our data. From our study it appears that, indeed, international factors *do* matter to an increasing extent, but "international" in our cases is more often "European" than truly global, and both the regional and the national business environments keep their relevance regarding many factors for cluster development and innovation. What we observe is a shift towards multi-scalar driving- and innovation factors that depend on type of industry and knowledge base in their more specific configurations.

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