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When drivers of clusters shift scale from local towards global: What remains for regional innovation policy?

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Abstract:

Industries and regional economies evolve as a result of the interplay between local and non-local factors. Increasing globalization of both production- and innovation activities implies a shift in the relevant scales of interaction from the local towards the global level. This paper is concerned with the implications of such scale shifts for the role of the region and for cluster-related regional policies. It examines what is left of the role of regional settings in fostering economic development when extra-regional drivers of change increase in importance. We investigate this crucial question with two in-depth case studies of the medical technologies sector, in which such scale shifts have been particularly pronounced.

Our findings from empirical material collected in Scania/Sweden and Vienna/Austria illustrate the ways in which changes in national and supra-national regulatory frameworks have had a profound impact on the innovation activities of individual firms and the way to develop and launch new products, and subsequently on the regions in which they cluster. Such scale-shifts have on the one hand limited the potential for regional policy to shape the cluster's path through support for supply-side factors. Yet some critical assets remain local but are increasingly difficult to access. By addressing such barriers to access, regional policy can still strongly affect the opportunities for innovation. Furthermore, in an increasingly open industry system, we see an expanded role for regional policy in supporting firms to access critical assets and sources of innovation found external to the region.

Keywords: Regional industrial policy, innovation policy, cluster policy, scale shift, life science, globalization

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Introduction

Industries and regional economies evolve as a result of the interplay between local and non-local factors (Pitelis et al. 2006). The last decades have witnessed an increasing internationalization and globalization of both production- and innovation activities, which implies a shift in the relevant scales from the local towards the global level. This paper is mainly concerned with the implications of such scale shifts for the role of the region and of regional innovation policy in fostering economic development when key actors, regulations and networks shift to higher scales. We investigate this crucial question with two in-depth case studies of the medical technologies (med-tech) sector in Scania/Sweden and Vienna/Austria, in which scale shifts have been particularly pronounced.

The life science industry, a collective label for the pharmaceutical, biotechnology- and medical technology industries, has been a prime example of a knowledge-intensive activity in our economies for the past 15 years, and therefore subject of a large body of work on cluster development and the geography of innovation. Reasons cited for the continued concentration of the industry in regions such as Boston, Oxford, and Medicon Valley include the availability of knowledge and (venture-)capital (Gertler and Levitte 2005), and the presence of universities and medical schools that provide specialized qualified labour, as well as hospitals and patients for testing and use (Lawton-Smith 2004). On the other hand, a number of relevant institutions are found at the national and increasingly supranational scales, such as e.g. European funding for basic research and international regulations that shape the conditions for clinical research and market access (Cooke 2002, Grillitsch and Rekers 2016).

In this paper we consider the role of regional assets in light of strong European and global forces that have shaped the development of the medical technology industry over the past 15 years. Changes in supra-national regulatory frameworks that guide product development and market access have had a profound impact on the performance and innovation activities of individual firms and the way to develop and launch new products, and subsequently on the 'nodes' in which they cluster (Grillitsch and Rekers 2016). What are the implications of such scale-shifts for a cluster-oriented regional policy[1], and what remains of the role of regional factors and assets when

1 The paper is on policies aiming at strengthening knowledge-intensive sectors or clusters (such as med-tech) in regions of advanced economies. With this aim, it is mainly about innovation policy (with a cluster- and regional focus) and less about "industrial policy" that usually has a national sectoral focus.

the industry path is shaped by non-local drivers of change? Despite the strong attention placed on globalization and the multi-scalar nature of economic and institutional change, we argue that it remains necessary to understand the role of the region – in terms of resources, users and institutions – for the performance of firms and the development of clusters. This has relevance for policies that might be helpful to support this sector: local nodes in changing multi-scalar and global networks call for a new regional policy approach that takes account of these complex geographies.

Following a review of the literature that relates clusters to global networks and considers the evolution of clusters over time (section 2) we identify scale-shifts that have taken place in the med-tech industry over the past 15 years (section 3). Then we present our methodology (section 4) and findings (section 5) to illustrate what is left of the role of regional settings when drivers of change at extra-regional scales increase in importance. In section 6 we consider the implications of such scale-shifts for the role, potential and scope of cluster-related regional innovation policy. Section 7 concludes the paper.

1. Cluster policies in a changing environment

2.1 Local nodes in global networks

Cluster policies rest on the idea that external economies arising from co-located and interrelated firms enhance firms' competitiveness (Porter 2000). More than two decades ago, Scott (1988) summarized the localization thesis as a story of vertically disintegrated and locationally agglomerated production. A revived interest in agglomeration economies highlighted the transaction costs and untraded interdependencies between a multitude of production partners and networked sub-contractors, favoring close geographic proximity between firms and supporting organizations and creating conditions of "institutional thickness" (Amin and Thrift 1994).

Critics of this localization thesis, however, stressed the enduring and increasing power of global corporate networks, and the fact that industries increasingly operate on an integrated world scale, supported by advances in information and communication technologies. In their seminal contribution "Neo-Marshallian nodes in global networks", Amin and Thrift (1992) call for a more balanced approach to the local versus global debate, by recognizing that the importance of locality is necessarily within the context of globalizing markets and firms, and that "the majority of

localities may need to... accept the constraints laid down by the process of increasingly globally integrated industrial development" (585).

Acknowledging increasingly disaggregated production in space, the focus shifted to the role of the region for learning and innovation. Localized learning, according to Maskell and Malmberg (1999), has distinct advantages for the transfer of tacit knowledge because co-location facilitates face-to-face meetings and thereby interactive learning, and provides for a shared cultural and institutional context. Gertler (2003) showed that tacit knowledge is deeply embedded in local industrial cultures.

Comparable to Amin and Thrift's (1992) call for a more balanced approach to the debate on the geography of production, authors such as Malmberg and Maskell (2002), Bathelt et al. (2004) and Crevoisier and Jeannerat (2009) advanced a more differentiated discussion on the geography of innovation, where the complementarity of local and global innovation networks is emphasized. Accordingly, a strong local milieu facilitates access to global knowledge sources while new knowledge from global sources feed local learning dynamics (Bathelt et al. 2004). The anchoring of global networks in local milieus was thus, considered essential for successful regional clusters in the long-term (Crevoisier and Jeannerat 2009). Indeed, empirical studies are highly supportive of this differentiated perspective of knowledge networks (Tödtling and Grillitsch 2015).

These theoretical and empirical foundations resulted in a standard repertoire of cluster policies comprising measures to enhance local and global networks, strengthen the qualifications of the local labor force, and build a knowledge support infrastructure such as relevant educational facilities, research infrastructure, and technology parks.

2.2 Cluster evolution and policy responses

In recent years, the focus has shifted from understanding the functioning of developed clusters, towards questions of how clusters emerge and evolve over time (e.g. Bergman 2008, Menzel and Fornahl 2010, Isaksen 2011). In particular, there has been a call for cluster policies that are sensitive to such a temporal contextualisation (Fornahl and Hassink 2017). Accordingly, it is necessary to consider stylized development phases, which differ in important aspects such as the size of the cluster, the number of firms, the heterogeneity and variety of relevant knowledge, as well of firms and their networks (for a recent literature review, see Trippl et al. 2015). According

to Martin and Sunley (2011) cluster development is driven by either industry-related or firm-related factors. In early stages of industry evolution, production- and innovation activities are typically highly concentrated in space. With increasing standardisation and maturity, production – and even innovation activities – are moved to more peripheral and low-cost locations. This implies that cluster policies need to take the "industry life cycle" into consideration. Local dynamics are more important in early stages while the positioning of a cluster in global production networks (and potential for climbing the hierarchies in such networks) becomes increasingly important as industries mature.

As clusters may develop differently in the same industry and institutional context, firm-related factors also play a role. In this regard heterogeneity of knowledge (Menzel and Fornahl 2010) and network structures (Ter Wal and Boschma 2011) are highlighted. Cluster emergence is associated with the development of a shared knowledge base in relation to an industry or technology across a critical mass of firms and organisations. This produces the agglomeration economies that facilitate faster growth of knowledge and capabilities in the respective industrial specialisation. In this phase, the call for cluster policy lies in supporting the development of cutting-edge knowledge and capabilities in the focal field. In contrast, when clusters mature or decline, the key rationale for policy intervention is to support the discovery and exploitation of new growth opportunities (Barca et al. 2009). This is constrained by a homogeneous knowledge base and therefore the policy intervention should aim at enhancing variety and firm heterogeneity. In a similar vein, Ter Wal and Boschma (2011) argue that networks become more structured and hierarchical as clusters develop. While this process contributes to growth in early stages of cluster development, it may impede renewal when clusters mature or decline. Consequently, standard cluster policies such as strengthening networks between collocated firms may become impediments.

2.3 Multiple scales and scale shifts

Having established the need for a dynamic perspective of cluster policies, this section moves a step further and argues for a spatial-temporal sensitivity taking account of context specific aspects of scale-shifts e.g. in production, innovation, sales and regulation of clusters. Concretely, the propagated spatial-temporal sensitivity concerns scale shifts as regards actor-networks and institutional configurations, which have been identified as a key challenge for further research (Trippl et al. 2015). For conceptual purposes we use the local – global dichotomy to capture

differences in scales. Which scales are relevant depends on the concrete sectoral and empirical context and may include, for instance, local, regional, national, European, and global scales.

Changes in scales can relate either to actor-network-, or institutional configurations. The former can be differentiated in production and innovation networks. As already discussed above, these networks co-evolve with industry lifecycles. The stylized trajectory suggests an increasing globalization of networks as industries mature. However, other global factors also exist. For example, technological progress (such as new information and communication technologies, transport technologies, etc.) has generally reduced transaction costs, and facilitated global production- and innovation networks also in early phases of cluster development (Dicken 2015). Recent technological developments in robotics, automation, and artificial intelligence, however, make production less reliant on labour cost allowing other factors such as the qualification of the labour force to become relatively more important. As regards institutions, we have seen for a long time an increasing liberalisation of trade and investment policies. Recently, however, protectionist forces have been propagating more restrictive trade policies. Thus, the nature of technological and institutional change has a major impact on the spatiality of actor-network configurations, potentially causing scale shifts.

Turning to institutional configurations, clusters are embedded in multi-scalar architectures of institutions (Gertler 2010, Hassink 2010). Grillitsch (2015) conceptualises this through multiple interconnected institutional layers. Some layers are spatially bound such as local cultures, national laws, or EU regulations while others are defined non-spatially by for instance industries or professions. Clusters are characterised by unique institutional configurations producing variations between clusters, as institutions specific to a locality intersect with industry- and profession-related institutions (Asheim and Gertler 2005). The relative importance of such local, regional, national, and international institutional layers may change over time. For instance, increasing harmonisation of laws and regulations at the level of the European Union shifts importance from the national to the supranational level, as is also the case in the med-tech sector (see below). Some authors argue consequently for the emergence of European innovation systems (Fromhold-Eisebith 2007). A number of nationalist and regionalist movements such as the Brexit and vote for independence in Cataluña are wakening calls, however, that scale shifts may also point in the opposite direction.

Cluster research is still largely silent on the implications of such scale shifts of actor-network and institutional configurations for policy. In essence, cluster policy needs to identify and potentially intervene in relation to those factors that make a difference for the innovation- and economic performance of firms. It is an empirical question, however, where the sources of competitive advantage are located. In the context of industrial clusters, a key question thus is which local factors contribute to the innovativeness, survival and growth of firms and which extra-regional factors need to be taken into account. As policy intervention takes time to produce effects, foresight or expectations about how technological and institutional changes influence the spatiality of competitive factors also needs to be considered. We illustrate these important aspects for cluster policy based on developments in the medical technology industry, which displays important scale shifts both as regards actor-networks and institutional configurations.

2. Medical technology industry

3.1 Innovation in the medical technology industry

The life science industries include three distinct branches that are commonly referred to in unison by industry organizations and policy-makers – pharmaceuticals, biotechnology and medical technology (med-tech) – despite their significant differences in type of products, industrial structure and firm resources, and mode of innovation. Whereas the pharmaceutical industry typically focuses on drug development for medication and biotechnology on the application of biological processes to the improvement of materials and organisms, firms in the med-tech industry may be offering one or few of a range of products, including low-tech products such as plasters, assistive devices, as well as high-tech diagnostic kits and medical devices such as dialysis equipment and stent implants, all with the aim to contribute to improving and extending people's health and quality of life. In terms of industrial structure, pharmaceutical firms are often large and multi-national, whereas it is estimated that in Europe, 95% of the med-tech companies are SME's, the majority of which employing fewer than 50 people (MedTech Europe 2018). The European market for medical technologies was estimated at €110 billion in 2016, and there is a global trend towards industry consolidation through mergers and acquisition (MedTech Europe 2018, Ernst and Young 2017). Large firms acquire the technologies, products, patents, research and/or people of small firms to seek dominance in a therapeutic area or to increase the diversity of their portfolio of products. In so doing, large firms have built organizational capabilities to streamline the process

of gaining regulatory approval and initial market access, negotiating reimbursement and other payment plans, and penetrating export markets.

In terms of their mode of innovation, the med-tech sector is characterized by a strong need for interaction between firms and physicians, patients and hospitals (Shaw 1985, Von Hippel 1976, Lettl et al 2006, Chatterji and Fabrizio 2013). Advantages of user-involvement range from identifying needs, building and testing prototypes, to serving as a reference for future sales. Firms, in other words, have incentives to invest in developing collaborative relations with physicians, patients and hospitals, and these are often localized in order to reduce search- and transaction costs. This sector, thus, is part of a wider Health Innovation System (Consoli and Mina 2009, Gelijns and Rosenberg 1994), in which innovation is driven by the interaction and mutual dependence between a large number of organizations, including firms, universities and medical schools, hospitals and other care facilities, professional associations, patient groups, authorities and regulators, and payers in health care systems. In order for new products to be developed, tested, approved and utilized, these organizations must increasingly work together to ensure timely and equal access to new treatment options. Medical innovation is therefore considered as ‘‘an emergent, nondeterministic process generated from complex interactions across heterogeneous knowledge bases’’ (Consoli and Mina 2009). The context of the health innovation system is highly regulated, professionalized and dynamic and involves a wide range of stakeholders at regional, national and global scales. In other words, the need for localized learning is especially great, but the range of institutions pressing on this relationship is diverse and in flux – probably more so than in other industries.

3.2 Present challenges and scale shifts

Present challenges have to do with increasing societal demands for the health system due to aging societies and a mounting medical demand, the need to provide access to quality health care for all societal groups, and an advancement of medical standards, often implying increasing costs. The European Commission (2017) in this context states that “the medical devices sector faces challenges at national, European and international levels such as … find(ing) a balance between patient’s needs and financial sustainability, (challenges of) innovation in particular for SMEs regarding R&D and emerging technologies, and issues related to the EU’s trade- and regulatory cooperation globally“. In order to meet these challenges, the med-tech industry association

MedTech Europe (2018)[2] proposes for the industry to aim for cost-effectiveness as well as societal benefits for patients, payers and policymakers, to invest in knowledge transfer from healthcare professionals and organisations, and to provide medical technology innovations with socioeconomic value and sustainability. Policymakers and payers should foster access to new technology and funding models. These policy statements by actors on the European level indicate the ongoing pressures and scale shifts as well as the complexity of stakeholders involved in the MedTech sector.

Traditionally the med-tech sector was solidly rooted in local and regional economies since its major clients were local hospitals, doctors and other health organisations. Med-tech innovations were also largely locally driven, since users and appliers of those technologies (such as doctors and hospitals) are often an important source of innovation, and these sites also offer possibilities for testing newly developed products (Lettl et al. 2006). However, due to the high overall cost (e.g. of hospitals and diagnostic and therapeutic products) and the coordination needs of various actors in the health sector, organisational structures and processes (such as procurement) became more centralised and formalised within and between hospitals and financing organisations. For medical technology firms this has implied e.g. the need to replace personal relations to particular doctors by the participation in formal tender procedures for contracts (Grillitsch and Rekers 2016). It has also created an increasing pressure to stay cost-competitive and to achieve economies of scale in production by serving larger and often international markets (Ernst and Young 2017).

As a consequence, in the past few years some marked changes could be observed in the governance-setting of the medical sector: The network of actors involved became more complex due to the involvement of public, semi-public (social-security organisations), and private sources of finance at regional, national and international scales (Ernst and Young 2017). Regulations and standards were set increasingly by European and international organisations, in addition to those at the national scale (Grillitsch and Rekers 2016). Fragmented regulatory systems at country level, thus, are more and more replaced by regulations at European and partly global level in order to increase safety for patients and to allow economies of scale in production.

[2] MedTech Europe is a European trade association representing more than 26,000 medical technology companies (i.e. diagnostics and medical devices manufacturers) in Europe, of which 95% are SMEs.

At the European level, MedTech Europe engages with regulators, policy-makers and other officials from the institutions of the European Union (EU) and Member States in the process of drafting legislation on med-tech. The two most important regulations for the med-tech sector in the EU are the Medical Devices Regulation (MDR) and the In Vitro Diagnostic Medical Devices Regulation (IVDR), which are currently in the implementation phase (MedTech Europe 2018). Furthermore, bodies like the Global Harmonization Task Force (GHTF) have helped to harmonize standards between Europe, the US and Japan in areas such as post market surveillance, device types and principles of clinical trials (European Commission 2017). Such regulatory changes often have benefits for patients and users like more safety of or better access to devices, but frequently they imply higher cost for the firms, and a centralisation of the tender- and procurement process, thus putting SMEs in a disadvantaged position.

Besides these shifts to a European scale of parts of production and delivery, sales, regulation and policy measures we find also tendencies of globalization that have reinforced some of the opportunities and pressures stated above for the med-tech sector. These include the global harmonization of standards, an increasing role of global firms (such as Otto Bock in Vienna and Novo Nordisk in the Medicon Valley), knowledge- and innovation relations at a global scale, a shift of markets not just to the European but also to the global scale (e.g. an increasing importance of Asian markets), and a growing role of emerging economies as production spaces such as Pakistan for surgical instruments (Nadvi 2002, Nadvi and Halder 2005), or Asian countries for IT supported med-tech devices. This may include the relocation of productions (e.g. surgical instruments from the German Tutlingen to Sialkot in Pakistan) or the emergence of indigenous medical firms in those countries.

There are certainly large differences in the challenges and potential responses between large and small med-tech firms. Whereas large firms often try to influence policy and regulatory change supporting their interests, small firms have a more passive role in this regard and are confronted with the outcomes of such changes. Large firms also tend to have specialized legal skills in-house, as well as the organizational capabilities and financial resources that are needed to navigate the regulatory landscape, which small firms do not. And whereas large firms have the option of going global in terms of production, innovation and sales, small firms are more dependent on the institutional settings of respective regions and countries.

Overall, these studies and materials, thus, have pointed to the (increasingly) multi-scalar nature of markets, production, innovation and regulations of the life sciences and med-tech sectors. For firms in advanced countries such as Austria and Sweden these changes imply a shift from a previously dominant regional and national scale upward to a European, international and even global scale in these dimensions. For Vienna, most of the interviewed medtech companies have reported an increasing importance of the international (i.e. European and global) scale for relations to clients, suppliers and cooperation partners, as well as for specific regulations in areas where the European level has become more relevant recently. These international factors mattered in particular for the more technology intensive and R&D performing companies, less for the low tech and the service firms (Tödtling et al 2016). For Scania, most of the interviewed firms have sought to build relations with non-local suppliers, distributers and clients, and some firms have also accessed European funding to finance the long research and extended testing periods that are now needed in order to collect the evidence needed to demonstrate product safety to European regulatory agencies. Moreover, many (though not all) of the small firms have the ambition to get acquired by a large, non-local firm that is better equipped to navigate the formal regulatory landscape at the European and international level. This then further contributes to the strength of extra-local decision makers on the localized activities, as was demonstrated in 2018 by the decision of Baxter (US) to move production jobs from Lund to Italy, after acquiring the Lund-based firm Gambro (dialysis equipment) in 2015.

The scale shifts imply that clusters' success in part depends on the conditions they provide for building and managing a broad variety of channels to knowledge and resources from around the globe mixing local and global knowledge flows in an effective way (Grillitsch and Trippl 2014, Tödtling and Grillitsch 2015), very much in line with the multi-scalar perspective advocated for in section 2.3. The changes in regulatory frameworks at national and supra-national scale have placed demands on firms that require legal skills, financial resources and organizational capabilities that are not found in every cluster, thereby driving firms to build networks outside of the region. Partly, these scale-shifts can be attributed to industry lifecycles where standardised production, often organised in large multi-national co-operations, is relocated to low-cost locations. Partly, however, they are not causally related to industry lifecycles but due to other factors such as raising cost pressures in the health system. Most importantly, however, knowledge intensive clusters continue to produce med-tech innovations that are often brought forward by SMEs, but eventually are acquired by large firms, standardised and scaled-up. The performance of

firms in such clusters thus does not depend on cost advantages in production but on their capability to create new products, which is therefore the focus of the subsequent analysis.

3. Medical technology in the study regions and methodology

4.1 Background to the study regions: Scania/Sweden and Vienna/Austria

This paper combines the findings from two in-depth case studies (the med-tech industry in Scania and the med-tech industry in Vienna) carried out within a common research framework developed under the European multi-collaborative project "Cluster Life Cycles" (2012-2016)[3]. Both case studies, thus, were focussing on the same research questions: How and why do clusters change over time, and to what extent do relevant actors, networks and institutions shift from local to global scales? Despite their difference in population size and position in the (national) urban hierarchy, (the Scania region of 1,3 million, with Malmö (340 000) being the third largest city in Sweden; and Vienna (1,8 million) being a large European city region and the capital of Austria) the regions are similar in several respects with regards to their med-tech industries. Firstly, both regions are home to a sizable number of med-tech firms, 135 in Scania and 220 in Vienna, and as this industry is highly concentrated in only a few places, med-tech is a regional specialization and area of strength for both regions. Vienna is a major hub of the broader life sciences sector in Austria: the region holds about 430 life science firms with about 22100 employees in 2014 (and 35700 including other organisations), which corresponds to 53% of Austrian life science firms and 43% of the respective workforce (LISAvienna, 2016). About 220 of these firms with about 8200 employees were in the med-tech sector. However only 36 firms of these had also local production and R&D. More than 40% of the companies are older than 20 years, and a few are dating back almost 100 years. But there is also a vivid start up scene, with 25% of companies being younger than 5 years (LISAvienna 2016). The region of Scania in southern Sweden is known for Medicon Valley, a life-science cluster of global standing employing 41300, of which ca. 6000 in the med-tech industry. In both regions, the med-tech industry is diverse, including firms specialised in software for medicine, electromechanical medical devices, prosthetics, digital imaging, and diagnostic and therapeutic devices. Secondly, although most of the med-tech firms are small, both

[3] 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, Grant number I 582-G11).

regions have a few prominent medium-sized firms that operate globally, such as Gambro (dialysis equipment) and ArjoHuntley (assistive devices) in Scania, and units belonging to Otto Bock (prosthetics) in Vienna. Thirdly, both regions have strong supporting infrastructure in the form of (university-)hospitals, medical schools and research organisations that are important for anchoring the med-tech industry in the region. In Vienna, these include the Medical University, the research hospitals (e.g. the General Hospital AKH, one of the largest research hospitals in Europe), and the AIT (Austrian Institute of Technology) a non-government research organisation. In Scania these include Lund University, the BioMedicalCentre, and the science-park IDEON.

4.2 Methodology

The material presented below combines and compares findings from two case studies, which were carried out under the same overarching research framework. Both case studies employed a mixed-methods approach, including desktop research, and quantitative and qualitative methods including interviews. In this paper, we combine the findings from these two case studies, which we consider to be both comparable and complementary given their overarching framework. This comparative case study design strengthens the validity of our results. In both cases, the material collected during desktop research included industry reports and statements by regional, national and European industry organizations as well as by consultancy firms. Both cases also used firm-level data on the number and size of establishments, employment levels and patents, in order to present a regional industry profile. This formed the bases from which to sample firms for interviews.

In total, our findings draw on 38 interviews of which 20 in Vienna and 18 in Scania. There were certain differences in the approach to the interviews. In Vienna the quantitative presentation of data was more emphasized while in Scania the approach was more qualitative, i.e. based on text interpretation of responses[4]. In Vienna the interviewed firms were selected using the AURELIA Database, a comprehensive firm database for Austria, as well as the LISAvienna data, a detailed listing of general firm characteristics on the medical devices sector in Vienna. Interviews were undertaken with general managers or similar competent persons based on a semi-standardised

4 Although the two case studies have applied the same overarching research frame of the CLC project, there was a certain flexibility regarding the more concrete research procedures in order to take account of particularities of investigated cases. In the Vienna case there was a higher number of med-tech firms compared to Lund, therefore the data gathering and analysis in Vienna was more standardized in comparison to the Lund case where fewer firms were interviewed in a more qualitative way.

questionnaire. For the present study mere trading firms were excluded and 20 firms kept for the analysis (see Appendix, table 1). In Scania, original data was collected using 10 semi-structured interviews with senior managers in firms, with additional interviews with leaders of supporting organizations such as industry associations and regional authorities (5), and leaders in hospital administration (3). The firms were selected from industry mappings carried out by regional authorities and industry associations, with the aim to cover a diversity of technological areas (assistive devices, diagnostics, IT, medical devices). Interviews in Vienna and Scania lasted on average about one hour.

The interview guide used in the two case studies was very similar and focused on gathering information on (1) general firm characteristics, (2) the history and development of the firm and the Med-tech cluster in the region, (3) innovation activities, (4) important partnerships and their geography, (5) financing, (6) the role of policy, and (7) perceived challenges for the regional industry in the near future.

4. Regional factors of cluster development

Although the med-tech sector is diverse in terms of technologies and products, firms share a dependence on skilled labour and supporting infrastructure such as the hospitals, technical schools and universities, science park incubators, investors and industry organizations. Despite the scale shifts in regulatory frameworks identified in section 3, our combined findings suggest that the region seems to have kept its importance in these aspects, and as a space for various kinds of interactions. In particular skilled labour and supporting infrastructure found in the region have remained important to firms as sources of innovation, as well as the location of regional partners during product development, and as initial markets (see tables 1 to 4 in the Appendix). In this section we summarize which regional assets are still of relevance for med-tech firms, and how this has changed in light of the scale shifts identified in section 3.

Hospitals and universities

The strongest and most obvious finding from our interviews is that medical universities and hospitals are key assets in the two regions. In Vienna, 15 out of 20 companies identified the regional presence of universities, medical schools and hospitals as important resources (see table 1 in the appendix), and in Scania firms highlighted the benefit of having these organizations in very

close proximity to one another: “If you put these together; the hospital, university, technical university and the industry, you get a very good combination and you know, the distance here is 500 meters or something like that” (Medical Device 3, Lund). Given the nature of medical innovation reviewed in section 3, this is not a surprising finding as hospitals are a source of ideas and knowledge, development partner and test market for many new products coming from the industry (see table 4 in the appendix for interview material illustrating these points). Although knowledge relations with hospitals and medical schools are not exclusively within the region (see tables 2 and 3 in the Appendix), we find that many firms still work with such regional partners. This can be explained by the presence and quality of hospitals and universities in our study-regions: Both locations are considered key hubs for universities and research organizations in the life science and medical field (Tödtling and Trippl 2013, LISAvienna 2015, Medicon Valley Alliance 2017). Furthermore, the highly interactive partnership that spans over a relatively long development period of new products is more easily established and maintained when partners are in close proximity.

However, despite the continued importance awarded to these partners for product development, firms in both case studies reported increased difficulty in accessing competent individuals in hospitals over the past decade or two (Grillitsch and Rekers 2016). Reasons for this change include an increasing formalization of processes and relations to and within hospitals, and less time of doctors and hospital staff for exchanging experiences with firms about products and user-needs. The formalization of collaborative relations in hospitals, thus, has reduced the value of informal and social (regional) networks accumulated in the past. The firms stated that being geographically close has helped to build these networks. With a devaluation of the networks, also the premium of colocation diminishes.

Skilled labour

A second highly important factor is the region as a space for recruiting highly qualified and skilled labor. In Vienna this was indicated by 14 out of 20 companies. This finding is first and foremost related to the quality of universities in both regions, providing a pool of graduates and collaborators not just in medicine but also in related fields such as IT, mechanical engineering, and other technological and business studies (Tödtling and Trippl 2013). Geographical proximity eases recruitment of talent directly from the university, but the bustling university atmosphere also contributes to an attractive environment to retain highly qualified personnel (see table 4 in the

appendix for interview material). A second regional source of skilled labour is found in the density of firms in med-tech and related sectors, and the qualified workforce in those firms. Although there are strong codification trends through IT, new software and applications, qualified labor is still an important carrier of tacit knowledge essential for doing business and innovating. In Scania, access to labour with experience working in large firms was considered particularly important for growing firms, as they bring with them routines, norms and networks that small technology-oriented firms often lack.

However, although skilled *technical* labour remains important in both case studies, there are now additional demands for skilled *management and marketing* personnel. As part of the regulatory changes at European and national levels, an increasing number of product categories need to demonstrate their products' safety (and increasingly also their effectiveness) in formal and standardized procedures (not limited to in-vitro technologies). This places new demands on the business skills of small and specialized technology firms. Although these skills may not be critical to innovation activities and product development, they are important for firm survival, especially in an industry where firms are often small, development timelines are long, and products' performance in a market is highly uncertain, often requiring customization.

Sources of finance

Sources of finance are often found in the region, but the mix of public support, venture capital and private investment through small firm listings has varied over time. Although in Scania there have been periods where there was plenty of financing available, this has not been consistent over time (Grillitsch and Rekers 2016). Venture capital has shrunk and a large amount of what remained has switched to other industries for quicker returns on investment. Often, these sources of finance are rather small and available for some stages of development more than others, and therefore need to be complemented by national and European programs and public funding. In Vienna, funding for the med-tech sector is often based on the refunding of hospitals and patients from the public sector and health insurance. Venture capital is very scarce and limited in the region (and in Austria) in international comparison. Although some small public programs for start-ups and innovation exist (e.g. LISAvienna for the life sciences), firms have to use international venture capital funds for financing larger innovation projects. As a result, companies are confronted with a rather complicated multi-scale support space for finance that is difficult to use, in particular for start-ups and small firms.

Supply chains

It is interesting to observe, that only four of the 20 firms interviewed in Vienna indicated that other firms in the region, such as suppliers and services, are important for supporting business and innovation (table 2 in the appendix). Contrary to expectations from the cluster literature it seems that many of these supplier relations are taking place at higher spatial scales. The same pattern could be observed in Scania (table 3 in the appendix), where firms either could not find adequate regional production partners and suppliers, or regional partners were not seen to contribute to the firm's success (with the exception of consulting and attorney services). In other words, supply chains cannot be considered to be regional in either of the cases. Once their product is developed and ready for production, firms source specialized as well as low-cost supplies from anywhere in the world.

What remains of regional factors for cluster development?

Summing up the findings, we can argue that despite strong trends towards internationalization and globalization, the region still matters for companies as a space for drawing knowledge from universities, hospitals and doctors. In many of our interviewed firms, and in contrast to the research driven biotechnology- and pharma sectors, this knowledge is of applied nature and related to understanding user needs and requirements, or is related to the testing of new products or services. Quite often, but not exclusively, these relations are in the form of formal or informal cooperations or within networks. The region also matters for recruiting highly qualified and skilled labor needed in this knowledge- and technology intensive sector. However, the professional labor market increasingly reaches beyond the region. The region seems not to be relevant for relations to supporting firms such as suppliers and services. In both case studies, these inter-firm relations are often and increasingly at the national and international scale.

5. Regional Policy for supporting the performance of medical clusters

In this section, we first discuss the possible rationales legitimizing innovation policy interventions in the med-tech sector and consequently move to the central question of what role regional policy can play considering the increasing importance of extra-regional scales for learning and innovation.

6.1 Rationale for a regional policy under new conditions

Regional policy to promote the med-tech sector and its innovation can be justified from different theoretical perspectives (Weber and Rohracher, 2012, Schot and Steinmueller, 2018). The neoclassical school rests on the concept of market failure to justify policy interventions. As regards innovation policy, the main argument is that the benefits of research and development cannot be fully privatized, and that there is - as a consequence - an underinvestment in R&D. Value spreads in the system through various processes such as knowledge spillovers, labour-mobility, imitation or spin-offs. The additional social value beyond the bottom-line of the organisation investing in R&D provides the rationale for an innovation policy following the neoclassical paradigm focussing on subsidising research and development, which has been framed as linear innovation policy. Linear because investments in research and development are expected to increase innovation and productivity in a quasi-mechanistic way. In relation to the med-tech industry, this would suggest that regional innovation policy should focus on strengthening and subsidising the research environment in relevant fields.

To the contrary, the systemic perspective of innovation argues that i) innovation is a much wider concept not only resulting from research and development, and that ii) the transfer of knowledge and the generation of innovation is shaped by the embeddedness of actors in a social and institutional context (Asheim et al. 2016). This implies that new knowledge does not necessarily spread and transform into innovation and economic value for several reasons. Firms may have limited capacity to absorb the new knowledge (Cohen and Levinthal, 1990) or have no access due to a lack or fragmentation of networks (Tödtling and Trippl, 2005). Furthermore, depending on the type of innovation, user-producer interactions are an essential part of the knowledge generation and innovation process (Asheim, 2007, Jensen et al., 2007). Problems of absorptive capacity at the level of the firms, barriers to access key innovation partners such as the university hospital, and deficient user-producer interactions have surfaced as key challenges for med-tech innovation in both Vienna and Scania, although both regions are well endowed with scientific knowledge and research capacity. In the given context, therefore, the systemic perspective arguably provides a stronger legitimization for regional innovation policy than the traditional rationale resting on neoclassic market failures.

Recently a new rationale for innovation policy has emerged, according to which innovations should contribute to addressing societal challenges (OECD, 2015). Sweden and Austria, like many

other industrial nations, struggle to care for an aging population. People live longer and the dependency of retired on working-age population becomes increasingly pronounced. As people grow older, health related costs increase while fewer people in working-age pay into the system. Med-tech innovations can help to address this challenge in the long-term by providing cost-efficient solutions for health and elderly care. From that perspective, med-tech innovations are not only about creating economic growth, but also about wider societal benefits. It is thus not surprising that the European Commission (2017) emphasises the societal benefit of innovations in the med-tech sector (see section 3). Challenge-driven innovation is often associated with a focus on system change. In that regard OECD (OECD, 2015, p. 9) reminds us that "by and large, most innovation policies aim to foster incremental change; fostering wider system change is a new challenge for innovation policy makers, especially as many of the actions will fall in areas outside the direct remit of research ministries or innovation agencies but where their input, coordination and implementation actions will remain critical". Such a wider system change, thus, often requires major transformations of societal subsectors that are faced with strong resistance of dominant players. From this perspective, innovation policy then may be justified through the need to overcome "transformation failures" (Weber and Rohracher, 2012).

As regards med-tech innovation, an important transformation failure is the lack of demand articulation for elderly care solutions. Lack of demand articulation is often related to a lack of lead users – a role the elderly may have difficulties to fill – that require products that are different from what presently exists (Schot et al., 2016). Demand articulation is also associated with a lack of innovation procurement (often due to cost reasons), which is defined as "the purchasing activities carried out by public agencies that may lead to innovation" (Guerzoni and Raiteri, 2015). Innovation procurement necessitates new competences in defining evaluation criteria by functional requirements, which leave room and create incentives for firms to develop new solutions (Edquist and Zabala-Iturriagagoitia, 2012).

Another issue, which can be legitimized both from a system- and transformation failure perspective, is the need for policy coordination. In the two cases, Vienna and Scania, we find that the essential policy domains concerned with the health system are poorly coordinated with an innovation policy for this sector. This despite Vienna being the capital city with all relevant ministries and decision-makers, and Scania being one of the Swedish regions that has the responsibility for regional development as well as the delivery of health care. Due to augmenting cost pressures in the wake of the financial crises, national and regional health systems focus on

increasing cost efficiency whereas incentivising med-tech innovation plays only a minor role. From a system- and challenge-driven innovation perspective, thus, there is a call for policy coordination with the aim to transform the system to accommodate with future needs.

Having presented different rationales for policy intervention that promote med-tech innovation, the key question is to what extent and how regional policy can provide a substantial contribution against the backdrop of recent scale shifts. This is discussed in the next section, based on examples from the two case studies.

6.2 How can regional innovation policy support the med-tech industry?

We find three forms of policy support for the med-tech industry that might complement each other: (a) improving locational factor- and innovation conditions for the industry; (b) supporting regional collaborations, in particular between firms and hospitals; (c) supporting the development of international networks, in particular with suppliers, partner-firms and markets, as well as research organisations.

In Vienna and Scania, the med-tech clusters have been supported by regional policy since the 1990s. As regards improving locational and factor conditions for the med-tech sector, our interviews clearly show the importance of local labour markets, access to universities and medical research. Also, intermediary organisations such as IDEON in Scania were highlighted as important for attracting firms, and as facilitators of knowledge transfer between universities, hospitals, and firms. Another factor that has been mentioned repeatedly, but is largely lacking in both regions, concerns access to funding for innovation projects (in particular venture capital). Investments in these locational and factor conditions are only partly in the control of the region. Especially in sectors so complex, specialised and expensive like health care, coordination of actors at multiple geographical scales and between different stakeholder groups is inevitable. For instance, science parks such as IDEON may act a collaboration platform between the region, the university, and the business sector.

In Austria there is public financial support for industries including the medical device sector assisting companies to implement innovative projects by granting loans and awarding subsidies. In addition, there is a specific support program for start-ups in the life science sector (Life Science Austria: LISA). It serves the whole spectrum from the business plan to financial and managerial

support. Moreover, it represents the medical device sector internationally and assists respective companies to move abroad. It closely collaborates with regional cluster initiatives such as LISAvienna aiming at enhancing regional network structures. Our analysis has demonstrated that in particular the technology intensive med-tech firms quite strongly benefit from these support instruments (Tödtling et al., 2016).

Regional factors for cluster development are considered to be strong, when we find a strong presence of local universities, hospitals and a diversified labour market. However, due to institutional changes at national and European scales, these regional assets are increasingly difficult to access for small med-tech firms. On the one hand, hospitals have less time to spend on collaborative product development, which is a question of national health care system priorities. On the other hand, access has become more difficult due to the increasingly formalized procurement procedures and channels through which collaborations are established. Small firms lack the experience and competence to navigate these formalized access routes, which require legal paperwork and persuasive marketing to hospital administration, rather than social networks directly with physicians that previously has dominated. Here is where we see a new potential role for regional support; helping firms to access (public) hospital administration, doctors and responsible players (including the necessary bureaucratic procedures), so that they can sell innovative products and collaborate to develop new products.

In Sweden, we find that the national industry association adopts a similar mediating role between hospitals and industry through supporting procurement. "It's one of our big areas where we work a lot to try to provide good conditions for procurement and especially for more innovations-friendly procurement" (interview with National Industry Association, Sweden), which would be characterized by procurers (hospitals) considering value in relation to price. They do this by explaining the value of innovation to procurers – for example in wound care, the use of specialized bandages, although more expensive, actually leads to fewer days in hospital which reduces overall cost of care. Today, however, hospitals like to buy from one player in bulk, focusing on price (interview with National Industry Association, Sweden).

Going beyond the support of national industry associations and innovation funds, we argue that regional policy could play a more pro-active role in facilitating the interactions between local firms and university hospitals. In Sweden, regions have a powerful position because they are responsible for the delivery of health care services. Furthermore, at the regional level it is possible

to identify more concretely the opportunities that may emerge through the novel combination of capabilities and of knowledge at the level of firms, hospitals and universities. Given their position in the system, regional governments have a mandate to negotiate and partly co-finance an innovation space for med-tech (remember that such spaces are increasingly limited due to financial pressures on the health care system). This is a process of searching for institutional complementarities in rather uncoordinated policy domains; or of inventing institutional arrangements (for example innovation procurement) that make collaborations at the regional level possible.

In Vienna, life sciences and medical devices are central pillars of the local science, technology and innovation policy since the mid 1990s, implemented by policy agencies such as the Technology Agency of the City of Vienna (ZIT) and the Vienna Science and Technolgy Fund (WWTF). One of the main objectives is to improve Vienna's economic and innovation infrastructure for these and other sectors in order to stimulate innovation and attract external knowledge and capital to the region (Tödtling et al. 2013).

Whereas access to university hospitals is a decisively regional competitive asset, our findings showed that suppliers, partners and markets are increasingly found anywhere in the world. Internationalization is therefore a key concept for med-tech firms. Specialized suppliers are often not found inside the region, the market needs to go well beyond the region, and firms to partner with or get acquired by are likely not found in the region. In Scania, our respondents commented positively on the forms of policy support that helped them to reach international markets: "we have been on a lot of seminars that has been hosted by Ideon together with Invest in Skåne, where they have the Swedish trade council coming from India, having a speech about the Indian business or markets and so on and that had been quite valuable in many ways. So, to learn more about the specific market." (Medical IT 1, Lund). The regional development agency also sees internationalization as one of their core activities: "our mission, and that's an important part, and we constantly remind our partners and the companies we meet: we help in internationalization. So, for example, on Monday when we have a speaker from this VC Fund, west coast US, we do an event where we open up eyes and ears on, 'okay, if you want to get your product financed by business in the US what do you need to think about? How can you be more innovative? How can you be a part of this, you know?' Our goals are then to secure the competitiveness of this region through strategic alliances, through capital and also exports that we get" (Regional Development Agency, Scania). In addition to bringing the rest of the world into the region, they also take firms

from the region out to build networks elsewhere in the world: “A typical example: in Asia it is about inhalation, right? So, you have companies that are in the biotech field and in the med tech field, and service providers. It’s a group of companies from this consortium. We are going there because they want to develop their strategic alliances in Asia. So, okay, let’s do that, and what is our tool then to do this? Then we’ll say, “Okay, there is a conference, there is a first Asian inhalation conference. And to be successful here, these companies need to know why they’re going there. They have their goals. They know what they want to reach, and then we prepare together, we’re out there together and we follow-up together. We are not going to do the negotiation for them” (Regional Development Agency, Scania).

In our interview material, one frequently-mentioned industry-wide forum that is a source of knowledge about international markets for med-tech, is the trade-fair Medica, held in Dusseldorf every November: “Medica, that’s the best place where…first of all, you will see that you’re not alone, which can scare the living daylights out of you because suddenly you find 11 similar products. But you will meet people who can immediately be interested in talking, ‘can I bring this to your market? But, you know, I can’t bring it to your place if it looks like this. You’ll have to help me. You have to fix this and this, and then I can bring it to…’ So you’ll get a lot of market feedback…” (Diagnostics 1, Lund). These temporary clusters are where firms can make new partners that help to reach new markets: [How did you get in touch with this Indian company you partnered with to develop further applications]? “we met them at Medica…I’ve been 30 times maybe…This is the place…We had a booth they had a booth not far away. So we discussed there” (Diagnostics 1, Lund). There has been some policy support to help firms to participate in these global fairs: “To be quite honest, we wouldn’t be here as we are today if it was not with the support from Invest in Skåne, because they gave us the opportunity to exhibit at these bigger international congresses where we would not be able to exhibit ourselves. So, we were part of the Swedish Pavilion and they were very supportive and that led to us having the possibility of creating a network of international partners. You heard about Medica, right, the biggest medical fair that is once a year in Düsseldorf: it’s a huge exhibition and for the first 2 years, we were part of the Invest in Skåne exhibition but thanks to the presence there, we were able to find new partners and now, we are exhibiting with other companies at the same fair. So, we have sort of grown past that first Swedish Pavilion thing”. (Medical IT 1, Lund)

Our empirical material thus suggests that regional authorities are well equipped to support firms to access those competitive factors that are located *outside* the region. Regional authorities can be

much closer to the firms in terms of understanding their constraints and needs, thus providing more tailed support, than for instance national policy initiatives. As regards support by the National Industry Association in Sweden, one interviewee expressed dissatisfaction as follows: “during their meetings, they're talking so much about the Swedish tenders and regulations and specific for the Swedish market. So, it’s much better to have my distributor being part of those meetings because they need to learn more about their market, but it didn’t give me that much, I would be more interested if they had a more international focus” (Medical IT 1, Lund).

Our case study thus shows that industry-specific regional innovation policy goes far beyond the traditional cluster idea. Some competitive factors remain local despite the observed shifts of actor-network and institutional configurations towards higher scales in the med-tech sectors. In particular, this concerns access to hospitals, universities, and the local labor market. We find that the two regions are not fully exploiting their potential in providing access for small innovative med-tech firms to hospitals and universities. This could provide for a distinctive, hard-to-imitate, regional competitive advantage. Other competitive factors are not predominantly regional even though Vienna and Scania represent strong med-tech clusters. Due to increasing specialisation in the sector, and growing costs for bringing products to the market, firms are ever more in need of access to global suppliers, partners, and markets. Regional support organisations have been active in facilitating global networks, thereby responding well to the needs of firms. This illustrates that regional support organisation can indeed be close to the need of firms whereas the perhaps more subtle effects of regulatory change on access to the factors that indeed matter in the region has either gone unnoticed or – at least – is not actively addressed.

7. Conclusions

Our study shows that scale shifts matter for the med-tech sector, but overall the sector appears less globalised than the other life science industries – pharmaceuticals and biotechnology. In Med-Tech scale shifts take place rather in the form of shifts from local and regional levels to national and European ones. The global scale is relevant, but so far only in a selective way: We find a few global firms that are important sources of foreign direct investments, a growing importance of foreign markets, production relocations to emerging countries, global knowledge- and innovation interdependencies, and a reinforcing global competition. Besides the scale shifts, other challenges act as drivers for change in the sector such as a high cost pressure due to ‘aging’ societies, high

treatment costs, and new demands for the health system. Jointly these have reinforced competition among medical technology suppliers and led to more formalised tender procedures of hospitals and social insurances, and their relations to the firms.

Despite the scale shifts, the sector remains rooted in the respective regions and countries. This embeddedness rests on the high importance that firms attribute to a highly qualified work force, hospitals with different kinds of specialisation, health insurances and funding organisations, medical universities and research organisations as well as platforms for knowledge exchange and –mediation, among others. Given the continuous importance of local factors, regional innovation policies might first of all address the improvement of respective factor-and supply conditions (such as raising qualifications, research and finance). However, these are currently not the main bottlenecks in the knowledge intensive regions of Scania and Vienna.

An important challenge is the increasingly difficult access – in particular for SMEs – to key resources such as hospitals and markets that regional innovation policy needs to focus on. Locally, this can be done through a variety of instruments, such as providing test markets in local hospitals, procurement for innovation, offering communication platforms, or taking a mediating role. In fact, it is in localized clusters where largely segregated policy areas such as health policy and innovation policy intersect and thereby potentially create unique regional advantages. Last but not least policies might support local companies to enter international or global markets, and to link up with global networks for acquiring relevant knowledge in the areas of markets, regulations and standards, and new technologies.

Our study sheds light on regional policy implications of dynamic multi-scalar actor-network and institutional configurations, which has been identified as major gap in the literature on cluster evolution (Trippl et al. 2015). Due to the complex regulatory and financial structure of the sector there is a strong need for well-coordinated or cooperative policy- and support programs among relevant actors. These include local and regional actors (such as hospitals and their financing organisations, regional policy actors), organisations and actors at national level (universities, educational and regulatory bodies, social insurances, policy agents), as well as actors at the European scale (regulatory institutions, research and innovation programs).

Summing up, we have observed both upward scale shifts of driving factors, and a continuing role of certain local and regional actors and settings. As our observations are only based on two med-tech clusters in the knowledge-intensive regions of Scania and Vienna, any generalisation needs to

be done with caution. In particular, the relevance of specific scales and scale shifts may differ by industry and region, and may change over time. It is thus an empirical and contextual question, which factors can be sources of locational advantages and in what respect regional policy should support relationships and networks at higher spatial scales. Keeping this in mind, our study moves beyond traditional cluster policies and calls for policy approaches that are appreciative of time and space. Concretely, this implies asking where the decisive factors of a sector's competitiveness are located and how this changes over time. This enhances the need for a multi-scalar perspective for the development of this sector, including the need of policy coordination among those various actors at the different spatial levels.

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Appendix

Table 1) Regional factors that med-tech firms in Vienna indicated as important for their performance

Company Nr. / products	Qualifications and Skills	Universities / Hospitals	Cooperations / Networks	Sales Market	Subsidies / Support	Other factors of relevance
1 Med data security	X	X	X (Med. U)		X (LISA)	
2 Diagnostic software		X	X (Reg. U)	X (40% regional)	X	
3 Skin diagnostic instr.	X	X			X	suppliers/assembly
4 Tissue imaging&analysis		X	X (U)		X (Seed Finance)	
5 Diabetes app.	X	X	X (Med. U)		X	
6 Skin analysis app.					X (seed finance)	Vienna Biocenter
7 Sensomotoric devices	X	X	X	X (40% regional)	X	
8 IT support for hospitals			X			
9 Dermascopy, cameras	X	X (AKH)				
10 Intubation tools, ec.	X		X			regulations
11 Cardiology devices	X	X (U, H)				
12 Eye&face surgery instr.	X	X	X (codevelopment U, H)			
13 Prostetics	X	X				
14 Orthopedic technology		X (H)	X (knowledge links)	X (40% regional)		suppliers, regulations
15 Orthopedic devices		X (FH, H)		X (WGK)		WGK regulations
16 Contrast agents	X	X (AKH)				Orthopädic companiy

17 Dentistry products	X		X (Dentists)	X (25% regional)		
18 Implants sinuslifts	X		X (Doctors)	X	X (WGK funding, VC)	related firms
19 Dental braces, 3D	X	X (AIT)			X	
20 Defilibrators, First Aid	X	X		X	X	
Total	**14**	**15**	**11**	**7**	**10**	**7**

X = important factor
H = hospital, AKH = General Hospital, U = University, FH = tech. College, AIT = Austrian Institute of Technology, WGK = Vienna Social Insurance, LISA Vienna = life sciences support program Vienna

Table 2) Innovation-relevant network partners for med-tech firms in Vienna (n=20)

	Regional	National	EU	Global	Total
Supplier	4	1	7	3	15
Client	9	17	10	4	40
Other firm	1	4	2	3	10
University	16	11	6	3	36
Public agency	2	0	0	1	3
Total	32	33	25	14	104

Table 3) Innovation-relevant network partners for med-tech firms in Scania (n=10)[5]

	Regional	National	EU	Global	Total
Supplier	1	0	1	0	2
Client/User(Hospital)	8	1	0	0	9
Other firm	2	0	1	2	5
University/Research centre	3	0	2	0	3
Public Agency/ Policy	2	1	1	0	3
Total	13	2	4	2	22

[5] The difference in the number of network partners is due to differences in the methodological approach. In Vienna, the survey asked for network links in general allowing for multiple responses while the in-depth interviews in Scania focussed on the most important links. However, we are not interested in the absolute number of links but similarities or differences in the pattern (i.e. the relative proportions).

Table 4) Regional Factors of Cluster Development in Scania. Illustrations from Interview Material.

Factors	Keywords	Quotes
Regional Hospital	Source of ideas	"We are using the local hospital as a test site in many ways. We do have some customers or users that are very technically interested as well… we call them to say, 'Hey, we're thinking about this and this, what do You think about that as a doctor? Would that make your life easier or would it just be a gimmick?' So, we do have this kind of interesting discussions" (Medical IT1, Lund)
	Development partner	"We are close to the University and [the technical school]. Another thing that's really important is that you're close to someone where you can get your samples." (Diagnostics 1, Lund) "We understood that we have a clinical situation here that's so much better than in the US because we know all the doctors and we can get them to test our products even before CE market, because we had a network where people trusted us and they were happy to be involved…we had this network" (Medical device 3, Lund).
	(Test) Market	"The occupational health centres are important to get proof of concept in Sweden" (Diagnostics 2, Lund)
	Demonstration site	"as soon as we do trainings…we do the field trips to the hospital so customers can see the actual installations and talk to the users sometimes and so on". (Medical IT 1, Lund)
Regional Pool of Skilled Labour	Recruitment from university	"We have already started collaboration with [the technical school]…we will have a PhD student start working here in one week's time to do the new tests in the lab for a couple of months. During the fall, there will be another student from the Medical Faculty, who will do a job here" (Medical device 1, Lund).
	Recruitment from other firms	"We have changed out the whole team. From 2007 everyone has a background with a bigger company, such as Gambro and Astra…Regional networks based on the earlier team were also very important "(Assistive device 1, Lund).
	Retention of talent	"When we established this R&D center here in 2006 one of the reasons was getting close to the university hospital and universities. This environment is highly attractive for younger people" (Assistive device 2, Lund).
	Demand for new skills	"Yes, skilled people are available. We have a constant inflow of people from [the technical school]. I can get for my development and production as many people as I like. Not for sales and marketing … If I want to find people who can bring this to the US, or Europe, if you're going to grow outside your local market and your friends, there's an influx of information that needs to come to these smaller companies. It's not just reading FDA rules" (Diagnostics 1, Lund)
Suppliers	Specialized suppliers	"We have some hardware requirements that were very difficult to find locally. That's why we were on the market searching for medical compliant products. We're doing a lot of stuff with other companies but they are not from the region…They are based in Hamburg…I think that the general companies here in Lund are

	like us, very small and very much focusing on a very tight niche" (Medical IT 1, Lund)
Basic suppliers	"We have outsourced the manufacturing. So we buy complete building blocks from different suppliers: the battery from Korea, the backpack from China, the plastics from Taiwan, the electric motor from China and we buy a couple of things in Europe as well and now we assemble in Sweden…we want to have the final assembly, final test close by so we can respond if needed" (assistive device E, Lund)

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