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From here, from there, and from beyond: endogenous and exogenous factors triggering change along the cluster life cycle in a multi-scalar environment

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Abstract:

While explaining cluster-internal impacts on cluster development, cluster life cycle theory fails to explain the influence of cluster-external factors. Based on a multiscalar approach, this study investigates factors causing change within an agritech cluster applying a qualitative approach. Main shifts in cluster development and their inducing factors from multiple scalar and thematic contexts are investigated. Concluding, incremental changes are mainly induced by knowledge dynamics within the same industry, especially from the local level. Radical change is the result of an exogenous shock from the national institutional environment. In total, specific changes are induced by specific factors from specific scales.

Keywords: endogenous factors, exogenous factors, cluster development, multi-scalarity, cluster life cycle

JEL Classifications: L64, O31, O33, R11

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1 Clusters and cluster change

Clusters have been investigated for a long time as static spatial phenomena. Early concepts of clusters and similar entities like industrial districts and innovative milieux (Porter 1990; Porter 2000; Sforzi 1989; Amin and Robins 1990; Crevoisier and Maillat 1991; Ratti et al. 1997) remained static, and are not able to explain change systematically. As stated by Boschma and Fornahl (2011), more recently, the ideas of cluster-specific path dependence and life cycles have been taken into account (Audretsch and Feldman 1996; Pouder and St. John 1996; Swann et al. 1998; Porter 1998; Maggioni 2002; T. Brenner 2004; Iammarino and McCann 2006; Martin and Sunley 2006; Menzel and Fornahl 2010; Ter Wal and Boschma 2011). Models of cluster evolution have been developed within Evolutionary Economic Geography frameworks. Based on industry life cycle theory (Klepper 1997), Menzel and Fornahl (2010) assume in their cluster life cycle approach that the development of clusters follows a life cycle clearly distinguishable from the global development of the respective sector. According to the model, clusters follow different stages of development from emergence via a growth and a sustainment phase to decline (figure 1). The concept also entails the possibility of renewal of clusters towards new periods of growth and innovation, which is seen as an important issue of evolutionary economic research (Martin 2010). The driving force of innovation and therefore of growth, decline and renewal of clusters, is the availability of heterogeneous knowledge. This availability depends on the absorptive capacity of the companies (Cohen and Levinthal 1990) and is associated with spatial and cognitive proximity (Nooteboom 2000; Boschma 2005) as well as the relatedness of the different sources of knowledge (Frenken et al. 2007). Menzel and Fornahl (2010) follow the idea that a cluster is the spatial concentration of a specific industry characterised by interconnectedness of companies and organisations (figure 2).

This concept has the advantage of offering a synoptic explanation of cluster development over time. Furthermore, it highlights the importance of heterogeneous knowledge and learning for the development of clusters. However, it also shows some shortcomings regarding the explanatory power for factors causing this development. The cluster life cycle concept has been criticised by Martin and Sunley (2011) for several reasons. One main critique of Martin and Sunley (2011) is that the cluster life cycle approach of Menzel and Fornahl (2010) is not sensitive enough to external influences affecting cluster development. It treats development and changes in accessible knowledge and its heterogeneity as internal processes. In reality clusters are not isolated from external forces. There exists a two-way interaction between the cluster and its external environment (figure 3). National institutions, global markets and so on shape the development of the cluster. However, the cluster has its own partly independent dynamic. It also has an impact on its external environment. This interplay of cluster-internal and external factors is an important issue for understanding causes for changes in cluster knowledge and thus cluster development. This study wants to put the focus on the influences of the external environment on the cluster. Thus, one main assumption of this study is that cluster development is driven by a combination of internal and external factors. To investigate this interplay one needs to conceptualise the external sphere in a more detailed way. Approaches on multi-scalarity issues offer a framework for this. In the next section the

multi-scalar characteristics of cluster-internal and external contexts are discussed.

The remainder of the paper is as follows. Section 2 deals with the issue of multi-scalarity as an important issue for a conceptualisation of the external sphere. Section 3 develops the model based on the previous assumptions. Section 4 introduces the case study including its methodology. Section 5 includes the presentation of the case study results and Section 6 draws some conclusions including implications for cluster life cycle theory and politics.

2 Endogenous and exogenous triggers and drivers for change

According to cluster life cycle theory, cluster development is the cluster's change in size and heterogeneity over time. Cluster change is associated with the processes of adaptation, renewal and transformation described in the cluster life cycle approach. Factors influencing this development can be relatively sudden events (triggers) or long-time processes (drivers) that change the environmental structure of the cluster. As a result, the value and utility of existing internal and new external knowledge is altered. Triggers and drivers can be, for example, political interventions, market changes, historical events, chances and shocks, general societal trends and the like. They alter the conditions in the cluster and occasionally give rise to innovation. Therefore, they influence firm strategy. Due to cluster-specific characteristics like proximity issues, a shared institutional environment and interconnectedness, the recombination of endogenous and exogenous knowledge leads to cluster-specific development patterns. The literature on resilience highlights the relevance of shocks and slow burns that force systems like clusters to adjust to rapidly or slowly changing conditions (Chapple and Lester 2007; Swanstrom 2008; Hassink 2010; Pendall et al. 2010; Martin 2012). However, change is not always caused by system shaking events and critical processes. Often events and processes open up chances for development without challenging the pre-existing system, but leading to new stages of incremental development (Anderson and Tushman 1990; Lundvall 1988), especially in spatial proximity (Gertler 1995). All in all, triggers and drivers are potentially coming from within or without the cluster. The analysis of triggers and drivers of knowledge and cluster development needs to be sensitive to the specific context of those factors to understand cluster development, and needs to distinguish between the types of changes that these events cause.

This issue is not conceptualised in the concept of Menzel and Fornahl (2010). An analysis of it needs to include concepts able to explain this interrelatedness. This interrelatedness is a driver of technological evolution. The recombination of different knowledge drives innovation. Clusters and regional economies are not isolated entities. There exist two-way interactions between them and their external environment (Martin and Sunley 2011) (figure 3). This environment is complex and differentiated, and calls for a multi-scalar perspective. So triggers and drivers of change may originate from multiple contexts. The literature provides several arguments for a multi-scalar perspective. N. Brenner (2004) points out, for example, that in modern Western-European countries statehood has increasingly become rescaled, leading to political influences on regional

economic development from levels beyond and below the nation state. Crevoisier and Jeannerat (2009) argue that knowledge has a mobile and an immobile form. Agents are able to get access to external knowledge due to the similarity and proximity of the knowledge bases (Nooteboom 2000; Boschma 2005) and their absorptive capacity (Cohen and Levinthal 1990). Mobile knowledge moves through space and between scales, getting in contact with immobile territorially- bounded knowledge. As a result, knowledge is recombined depending of the absorptive capacity of the holders of knowledge. Economic performance is increasingly dependent on agents' abilities to get access to and to use external knowledge from different thematic and spatial contexts (Crevoisier and Jeannerat 2009). The cluster life cycle approach of Menzel and Fornahl (2010) has an underdeveloped concept of the sphere external to the cluster. It makes no distinctions between possible multiple scales (as can be seen in figure 2) and remains within a classical local/non-local thinking very prominent in classical cluster research (e.g. Bathelt et al. 2004). Thus, a complete picture of factors causing knowledge change based on cluster life cycle theory needs to go beyond this by developing a multi-scalar concept.

Multi-scalar impacts on regional development have been an issue in recent discussions (N. Brenner 2004; Asheim and Coenen 2006; Peck and Theodore 2007; Crevoisier and Jeannerat 2009; Coenen et al. 2012). Coenen et al. (2012) address this issue by drawing a geographic perspective of sustainability transition. Based on the non-spatial multi-level concept of sustainability transition (Geels 2002; Geels, Hekkert, et al. 2010; Geels and Schot 2010) they argue for a multi-level scale-sensitive interpretation (Markard et al. 2012). Change in knowledge of clusters is thus an outcome of multiple processes occurring on various levels. Coenen et al. (2012) point out that the consideration of scale is important because similar phenomena operating on different scales and representing the same underlying process can look very different. Tacit knowledge spillovers can, for example, occur on the local level via face-to-face contact (Storper and Venables 2004) while on the international scale 'epistemic community building processes' like conferences or journal communities (Haas 1992) provide the needed cognitive proximity (Coenen et al. 2012). This coherence is valid for a large set of factors.

Coenen et al. (2012) argue that the benefits of a geographical perspective for comparative transition analysis lie in the explanatory power about these inter-scalar mechanisms and how they affect local development. Drawing upon this they develop a geographical perspective of comparative transition analysis interpreting multi-level analysis in a multi-scalar way. This interpretation shows some distinctions from a multi-level view because of several characteristics of space. First, scale is a socio-spacial construction, an instrument of social actors to pursue their goals within spatial frameworks (Jonas 2006). Secondly, economic activity is of relational character. The third assumption is that scales have no hierarchies (N. Brenner 2001). Scale matters and different scales promote different processes. Knowledge can diffuse between different scales, and territorial units have specific influences regarding the context of its origin and its target (Crevoisier and Jeannerat 2009). These knowledge dynamics are triggered by factors originating on different scales internal and external to the cluster. Coenen et al. (2012) draw upon the concepts of comparative institutional advantage and institutional thickness to explain spatial differences in innovation patterns. Thus, they offer arguments for the inclusion

of national and regional factors and, furthermore, for a multi-scalar perspective.

Concluding from this, an analysis of factors influencing knowledge change in clusters and, therefore, cluster development and innovation needs to be sensitive to two aspects. First, it needs to offer a model able to explain cluster and knowledge change systematically. Second, it has to be sensitive to scale because clusters interact with their complex their environment. The next section points out these aspects by developing a multi-scalar and multi-contextual framework for cluster-specific interaction processes.

3 A framework for a multi-scalar perspective

As has been discussed, a model for impacts on knowledge development in clusters needs to be sensitive to scale. Furthermore, it needs to be sensitive to different characteristics of changes such as radical and incremental innovation and the like.

Cluster changes in terms of innovation are the result of knowledge dynamics and learning processes. In the cluster context these knowledge dynamics occur between cluster agents and other agents on various scales and from various contexts internal and external to the cluster. A concept of the cluster's integration in its external environment is illustrated in figure 4. Based on the concept of Menzel and Fornahl (2010) the cluster is seen as a regionally localised set of actors belonging to a specific thematic field or industry (compare figure 2). The external environment is subdivided into different scales based on the specific socio-economic conditions that form these scales (e.g. regional, sub-national, national, supra-national and global). Because the environment can be industry-related or not, the possible number of analytic contexts for origins of factors affecting cluster development is twice the number of scales.

The key question when applying this framework is whether all of these contexts matter to the same degree and, if not, which contexts affect cluster and knowledge development the most. Furthermore, the question arises, whether there are specific cause-effect-constellations that are associated with specific contexts. Or in other words, are specific changes related to specific contexts and does thematic or spatial relatedness matter?

The framework shown in figure 4 indicates a simplified direct coherence between origins of factors and knowledge and cluster changes. As stated before, this coherence occurs in reality via knowledge dynamics and learning processes that can happen between cluster agents and other agents possibly coming from various contexts and scales. Thus, the depicted coherence is, in reality, more complex. However, it is not always easy to distinguish between knowledge dynamics as original inducing factors and those induced themselves by other factors (e.g. institutional or market-related). Therefore, the model always treats knowledge dynamics as original inducing factors.

It is widely unknown where multi-scalar and multi-locational impacts of cluster development, the triggers and drivers of cluster change, come from. In this study an investigation of these factors for a specific case study is applied. Concluding from the previous argumentation, and according to this general goal, three research questions emerge:

1. What causes specific changes in cluster development?

2. From which scalar contexts inside and outside to the industry do these influences come from?

3. What specific cause-change constellations do exist? Is incremental and radical change, and thus, path-enhancing and path-emerging change, the result of different mechanisms?

These questions are applied in the study on the case of the agricultural engineering industry of North-Western Germany. The argumentation follows the spatial and thematic categories shown in figure 4. The following sections introduce the study and the empirical results.

4 Data and methodology

The study is based on the 'cluster life cycle' project funded by the European Science Foundation. It includes qualitative research on agricultural engineering in North-Western Germany. 30 semi-structured interviews with stakeholders from the cluster were held in 2012 and 2013. It encompasses 21 interviews with stakeholders from 21 companies and eight with seven stakeholders from other organisations and industry experts. The interviews lasted between 45 minutes and four hours. Most interviews lasted between 60 and 75 minutes. Questions regarding organisational and cluster change made up approximately one third of the total interview.

Relevant interview partners were identified in different ways. First, five interviews with selected industry and regional experts in 2012. These interview partners were asked to mention the most relevant companies and institutional agents in the cluster. Second, participation lists of relevant national and international sectoral trade shows and sector and region-specific literature and company data banks were analysed. Third, this list of companies and agents was again verified by some of the interviewed industry experts in a second interview. Fourth, additional relevant actors were identified in a snowball-system in the interviews. Contacting the companies took place firstly by mail followed by a phone call about one week after the arrival of the letter. In total, 41% of the contacted companies and 90% of the contacted institutional agents participated in the study.

The agricultural engineering industry is scattered over large parts of North-Western Germany (figure 5), covering parts of three German federal states: Lower Saxony, North Rhine-Westphalia and the Free Hanseatic City of Bremen. The interviews were only held with stakeholders from Lower Saxony. The reason is that the core of the cluster with the highest concentration of companies is located in the districts of Osnabrück, Vechta and Cloppenburg, all part of Lower Saxony (Müller 2012). Companies situated in the same federal state share the same political and institutional environment. For reasons of comparability the study was limited to companies from the most important federal state in terms of agricultural engineering industry shares.

5 Agricultural engineering in Western Lower Saxony

North-Western Germany (compare figure 5), especially the rural districts of Osnabrück (also known as Osnabrücker Land), as well as Vechta and Cloppenburg (also known as Oldenburger Münsterland), shows one of the highest concentrations of the agricultural engineering sector worldwide. It is home to some of the most innovative and significant companies of this sector, including larger companies and highly innovative SMEs. This set of companies is accompanied by industry-related research institutes from engineering and other disciplines. Windhorst (2004) refers to the cluster being the 'Silicon Valley of agricultural engineering'. It consists of two sub-clusters, one based on animal house technology and one based on agricultural vehicles, especially trailers. There are some links between the two industries. Biogas plant manufacturing combines competences from both as well as other sectors. The cluster is part of an even larger agribusiness cluster in the region, built up by agriculture, agricultural engineering, the food industry, the veterinary industry etc.

A historical overview of the early development of the region is given by Windhorst (1975). After World War II, the region developed into a prosperous industrialised area. Alongside the industrialisation of pig and chicken-keeping as well as crop farming, a strong and competitive animal house and field vehicle industry emerged. In the following decades the cluster specialised within these two trajectories, showing long-term growth until today. Some of the companies remained highly innovative introducing constantly new technologies to their production within their existing technological trajectories. A more radical innovation emerged with biogas plant manufacturing triggered by the Renewable Energy Act 2000. By this federal German law renewable energy is put in a favoured position towards conventional energy sources by an altered institutional framework, leading to the emergence of competitive renewable energy sectors (Jacobsson and Lauber 2006; Langniß et al. 2009). The biogas plant manufacturing industry recombines knowledge from the two older sub-clusters with additional knowledge from other industries like metal production and the concrete industry from within and outside of the region.

The cluster region is characterised by certain cultural and institutional settings having strong impacts on the economic development and entrepreneurial habits. Local politics have been dominated by conservative forces for decades. This political stability reduces uncertainty for entrepreneurial projects. People share a sense of togetherness and a common identity even between entrepreneurs and employees. Industry expert E4 points this out:

> 'Well, in the region of Oldenburger Münsterland regional politics surely contributed to growth within the last decades. Simply because of the stability of the circumstances.'

Since the 1980s, the regional development of agriculture and agricultural engineering has been increasingly accompanied by scientific institutes and universities (University of Applied Sciences Osnabrück, University of Vechta, etc.) resulting in an enhanced interconnectedness of science with companies. Recently, many companies from the cluster

show a tendency to enter international markets being today strongly export-oriented. Additionally, the regional market remains important. Local farmers today often play the role of test users for new products. Challenges to cluster growth come from political intervention and society (animal protection, building laws, highway code, etc.) as well as from environmental effects (liquid manure, extensive groundwater use). Unlike agriculture, most producers from the agricultural engineering sector use these challenges as chances for innovation and growth as farmers need to adapt new technology to fit the new requirements.

The following section deals with the results from the interview study. It consists of three parts. First, general characteristics of the interviewed companies and organisations are depicted. Second, the main changes and development patterns within the cluster are analysed. It will be shown which changes are affected from which scale and which context. Furthermore, the main triggers and drivers of these specific changes are described. And third, a closer look on the inducing factors, the triggers and drivers, is taken. It will be shown which factors originate from which scalar and thematic context.

6 Results from the qualitative study

Overview of the interviewed organisations

The following interpretation of the respective interview results is based on the 30 semi-structured qualitative interviews held in 2012 and 2013. Of these interviews, 22 are included within the core analysis of agent-specific changes within the time frame of analysis, 21 interviews with stakeholders from companies and one interview with one institutional stakeholder who is involved in the innovation process in the cluster. The remaining eight interviews were held with seven industry experts and institutional agents who are not directly involved in the innovation processes. Nevertheless, the total of 30 interviews is the basis for the qualitative interpretation of the results. An overview of the data set is given in table 1.

The 22 interviewed organisations can be classified along the three sub-sectors of the agricultural engineering industry. As some companies are active in more than one field they can be assigned to more than one. Organisations are included in a group if they have been active in the respective field within the last 15 years. Twelve organisations were active in the livestock-related technology industry including stable designers and their suppliers. Nine interviewed organisations are active in the field of plant-related technology, mainly in agricultural trailer production including suppliers. Four organisations produced complete biogas plants or parts of it.

Most organisations have mainly been in a phase of growth during the last 15 years. The statements of the agents does not necessarily mean that the cluster as a whole is in a growth phase as the perception of individual firm growth is not automatically associated with the growth phase in a cluster life cycle. In most cases this kind of growth is of incremental character. Therefore, the cluster is in a phase of sustainment according to the model of Menzel and Fornahl (2010). There are tendencies of renewal and diversification, as the case of biogas plant manufacturing shows. The cluster is

looking back on a relatively long history. Many of the interviewed organisations are at least twenty years old.

Many cluster companies follow an internationalisation strategy. While some have been doing so for decades, many others internationalised more recently. Most interviewed organisations sell their products internationally, with nine organisations oriented towards European (EU, EFTA) and six towards global markets (including Non-EU/EFTA Eastern Europe). Eastern and Central European countries, South-East Asia, China and North America are the most important international markets. Internationalisation strategies are often accompanied with standardisation. Thus, it is a typical characteristic of a sustaining cluster.

The interviewed organisations are mainly medium-sized (compare table 1). Almost all interviewed companies of all sizes are family enterprises. This structure is representative for the cluster and the region and brings along some specific characteristics as expert E4 describes:

> 'Well, many companies are tied to the region due to the fact that they are family businesses. They just got this social environment. This is really important for those companies.'

Cluster development and main changes

The time period of investigation includes the time span of 15 years prior to the interview (ca. 1998–2013). The main changes and developments to cluster agents occurring within this time period include increasing internationalisation strategies, the emergence of biogas plant manufacturing and innovation within the pre-existing paths of animal house technology and farm vehicle production. Other developments include general increases and decreases in sales, the increase of R&D quality, the omission of product fields and the modernisation of production. This last set of changes has been mentioned only by single stakeholders. Following, the main changes of internationalisation, biogas plant manufacturing emergence and path-dependent innovation are introduced. The origin of certain triggers and drivers is analysed in the next subsection of this paper. The emergence of biogas plat manufacturing is a process of path emergence and thus associated with cluster renewal. It means a significant addition of knowledge to the cluster. On the other hand, incremental innovation within pre-existing trajectories and internationalisation are associated with incremental growth and the sustainment phase. Both processes, radical and incremental, serve different markets and do not compete with each other. Thus, the cluster is renewing while most agents successfully follow the old paths.

Individual firm growth is in many cases related to exports and internationalisation strategies. 15 of 22 interviewed agents have an international market orientation (table 1). Industry expert E4 points out for the large firms in the cluster:

> 'One can say that in the last 20 years for many companies like company XA the keyword is "international growth". Company XB and company XC worked internationally even before, the same applies to company XD. The

trend in the last 20 years surely is that all, especially the larger ones, strongly grew internationally.'

But also smaller companies started to follow internationalisation strategies as the manager of the smaller business C6 mentions:

'We restructured the company two years ago. [...] We introduced modern computer systems, also due to that fact that we are going to become more international. When we hired new staff, we paid attention that they are able to speak English and so on, because international business becomes more and more important. The international business is where we see our future.'

The contextual origins of factors affecting market-related developments of cluster agents are depicted in table 2. The table has to be interpreted in a way that each count stands for a specific combination of agent-related changes with a specific factor causing it. This means that each agent could mention as many factors causing a certain change. Thus, the possible number of counts in the table exceeds the number of companies.

As can be seen in the table, internationalisation is particularly driven by industry-related supra-national and global factors. International demand is the main pull factor. Other factors include national laws that hamper national growth forcing a company to internationalise. Sales increases and decreases are often caused by non-industry-related factors on various scales. Especially national laws play an important role. They partly hamper growth and partly promote it. The manager of company C4 speaks about occasional regional and national sales increases induced by the European Laying Hen Regulation:

'[The regional and national market] played a large role, but this is again decreasing. This has its origin in that new law [the Laying Hen Regulation], forcing our clients to restructure. This led to a real hype in Germany and especially in our region.'

The biogas plant manufacturing sub-sector's development is also strongly dependent on a national law, the Renewable Energy Act and its amendments, causing ups and downs in sales as the manager of company C12 states:

'Well, I would say the essential cornerstones [for our development] were always the single amendments of the Renewable Energy Act. We had in 2004, with the amendment, the first real starting shot for the German biogas industry. Also, the extensive professional use of biogas technology that was caused by the amendment of 2009. That gave a real push. Well, and the amendment of 2012, that one now slows down.'

In total, six instances of actor-specific sales increases and eight instances of sales decreases were caused by laws. Sales slow-downs are also caused by other factors. Especially

the animal house technology sector is affected by discourses. Animal treatment in industrial livestock farming has been a topic in German society and media in recent years. Several television documentaries impeaching animal treatment on farms caused damage to the image of the industry.

Market-related changes are, all in all, caused by various factors on different scales. Internationalisation is induced by industry-related factors beyond the national scale while general changes in sales are mostly caused by factors that are not industry-related. These factors are mainly institutional ones including laws as a main set of factors affecting the development. Interestingly, cluster-internal factors do not play a role in most cases. This has some reasons. On the one hand, formal institutions like laws are mostly not organised on the cluster level. The cluster in the case study is not strongly institutionalised. The existing cluster organisations, like NieKE, are thematically relatively broad, encompassing the whole agribusiness sector. Furthermore, there is no such thing as a membership of firms. The cluster network is therefore relatively loose. An exception is CCI, a network of some farm vehicle producers and accompanying research institutions based on joint innovation on the industry standard ISOBUS. CCI is not a cluster organisation as it has no explicit regional agenda, but most of the members as well as the office of CCI itself are located in North-Western Germany. The animanl house technology sector and the biogas plant manufacturing sector are less characterised by cooperation but more by competition.

The second set of important changes in agents' development are associated with innovation (table 3). These innovations can be agent path-dependent or opening up a new path. They are strongly associated with the mechanisms of adaptation, renewal and transformation in cluster life cycle theory. Adaptation is a process of incremental innovation prolonging the sustainment phase. Radical innovation into new paths is, dependent on the degree of change, is associated with cluster renewal and transformation. Path-dependent, incremental innovation includes the development of new products within the same family of existing products and the refinement of pre-existing products and processes.

The development into a new path is a relatively rare event. It includes the emergence of new technological paths within pre-existing firms as well as the foundation of the firm. Eight interviewed agents mentioned that this kind of change happened to the organisation. Four organisations were newly founded and four diversified into new paths. The emergence of new paths is associated with cluster renewal within cluster life cycle theory. In the case of agritech in North-Western Germany the most important new path that developed within the period of investigation was the emerging biogas plant manufacturing sector. Four of the eight agents who mentioned having developed into a new path are associated with biogas. As mentioned earlier, biogas plant manufacturing was mainly induced by the national Renewable Energy Act. This act is a law that favours the use of renewable energy including wind, water, solar and biogas power by offering guaranteed prices for the producers of this energy, creating a market for renewable energy plants. In Germany as a whole, and in the region in particular, this triggered the emergence of producers of biogas plants. This often happened due to the recombination of knowledge held by cluster firms and other firms, often found in spatial proximity, as

the manager of company C21 from the animal house technology sector describes:

> 'Our clients made a proposal to us, if we could offer the control and pumping technology for biogas plants. Based on this emerged the situation that we purchased this infrastructure except the process containers, fermenters and storage containers. Well, and then we had a project where we sat at one table with company XE from the town of XF, right here around the corner that produces just these containers. [...] For that we ideally complemented each other.'

Path-dependent innovation, including the development of new products and incremental innovation, is much more common in the cluster than the development into a new product field. As can be seen in table 3, these types of innovation are induced by factors from various scales within and outside of the industry. Similar to other changes, the development of new products and incremental innovation are often induced by, often national, laws, coming from the non-industry-related sphere. In the case study, radical change is the result of an external shock. The Renewable Energy Act opened a window of opportunity, leading to cluster renewal. But laws also have an influence on incremental change. In general, laws often alter market conditions. As an example, the Laying Hen Regulation led to the development of new chicken coop solutions by several companies. These new products often use modern general purpose technology as in the example of company C9 from the farm vehicle sector:

> 'One important point is that we now conduct our data management via iPad®. If anyone had told me this three years ago I probably had tapped my forehead. Today we really sell this software, produced by an external partner. We sell our own app that conducts the data management for our vehicles via iPad®. This is a completely new product that has not existed before, even not from other companies.'

The new knowledge for these path-related innovations is often induced by different forms of knowledge dynamics like R&D cooperation, customer contacts and the like. The most important trigger for the development of new products within existing trajectories is targeted R&D cooperation. This cooperation occurs on various scales, especially on the local and the national scale and mostly within the industry (as can be seen in the next subsection). This is in contrast to cooperation for new path creation that happens to be between cluster agents and other agents from different industries. In combination with the fact that this kind of knowledge dynamics often occurs on the cluster level, one can find a hint that path-dependent development of new products is more likely within cognitive and spatial proximity. The task of developing new products is a complicated one, demanding close and intense interaction ties. Proximity enhances the absorptive capacity of agents for this task. In contrast to this, the refinement of existing products and processes is very often induced by customer contacts. These customers (mostly farmers) offer information on the usability of products. This information is directly

application-oriented. Proximity is not always necessary for the underlying communication. Therefore, customers who offer this information can be found on all scales. However, regional customers play a special role as test users for new products and refined versions of older products. In this case, spatial proximity facilitates the innovation process. The importance of this relationship is formulated by industry expert E9:

> 'Company XG tests new products the first in the region. It is a strongly export-oriented firm. There exist strong interdependencies between local farmers and the company. Its success is based on the fact that innovation is implemented very quickly by regional farmers. Therefore, one can present the products in application to international potential buyers.'

This analysis of changes offers a picture on how different kinds of cluster agent-specific changes in development are affected by aspects from different scales and contexts. It shows that there exist specific constellations of factors and changes and that different changes are affected by factors originating on various scales. Path-dependent innovation is often induced by intra-industry knowledge dynamics, often within the cluster context. The path-creating process of biogas plant manufacturing emergence occurred because of the triggering event of the national Renewable Energy Act. Internationalisation is triggered by industry-specific international demand. All in all, incremental innovation and internationalisation as path-dependent processes associated with the sustainment phase in cluster life cycle theory are mainly induced from within the industry and its value chain on different levels. Radical change is induced by an industry-external shock. The local level is an important arena for certain types of knowledge dynamics that favour spatial proximity, while the national level, accompanied by the supra-national EU-level, is the dominant institutional force for change. In the next subsection a closer look will be taken at the different types of inducing factors and their scalar and thematic origin.

Triggers and drivers for change

This study assumes that triggers and drivers for change have their origin on different spatial scales inside and outside the thematic context of the respective industry (figure 4). In this section a more detailed look at the scalar and thematic contexts of triggers and drivers will be taken.

In the interviews, the questions regarding specific factors causing change were widely open and every interviewee was free to describe the organisation's development in its whole complexity. There exists a very broad set of specific triggers and drivers for change within the cluster. For an empirical analysis it is necessary to group these single factors into sets with similar characteristics. The main triggers and drivers that have been identified were four types of institutional factors (laws, industry standards, political and societal discourses and cultural factors), three types of knowledge dynamics (R&D cooperation, customer needs and general networking activity) and four market-related factors (demand, competition, price fluctuations and labour market issues). The remaining factors that were only mentioned by single stakeholders include individual decisions,

historical coincidences and firm-specific factors. This last group of factors will not be analysed in detail within this paper as these factors are highly individual and thus give no real input for an overall cluster-wide pattern. All factors are certainly interrelated. Especially, knowledge dynamics are often by themselves induced by other factors including institutional and market factors. If these original factors could be identified in the interviews, these original factors were counted for the analysis. However, knowledge dynamics are by themselves important triggers and drivers for change as they provide new knowledge. Thus, they are treated equally as inducing factors like market, institutional and other factors.

The institutional triggers and drivers that had an influence on organisations' development are shown in table 4. The table has to be interpreted as follows. Every count in the table is associated with a specific change that happened to an organisation in combination with a certain factor causing it. This means that every organisation could mention as many changes that were relevant within the time period of investigation and for every change they could mention as many factors as were relevant. Therefore, the total number of triggers and drivers for change exceeds the number of organisations.

The table reveals that laws were a main group of factors having an influence on the development of the organisations. These laws include environmental laws, animal protection laws, building laws, the Highway Code, and the Renewable Energy Act. All of these laws were not directly industry-related, but had important impacts on the development of many interviewed organisations. These laws came from the sub-national (Lower Saxony and other German federal states), the national (Germany) and the supra-national levels (European Union), mostly and not surprisingly from the national one. The nation state is still the most important agent for defining formal laws even if other scales are becoming more prominent for regional development (N. Brenner 2004). Regional development is often affected by policy impacts from multiple scales and contexts (Uyarra and Flanagan 2010; Flanagan et al. 2011). Laws have multiple impacts on the development of cluster agents as has been shown before. They can trigger the emergence of new industries (in this case biogas plant manufacturing by the Renewable Energy Act); they can stimulate or hamper companies' economic development and force path-dependent innovation. Furthermore, they cause changes in firm strategies including internationalisation.

As mentioned earlier, the industry is affected by more or less intensive political and societal discussions and media reports. These occur on various levels and are often associated with conditions and external effects caused by the users of the produced technology, the farmers. Local and regional discourses include direct impacts of farms and biogas plants on their neighbouring environment. Within the last years, the number of biogas plants and fattening farms in parts of the cluster region became high, leading to environmental problems including noise, ground water pollution, over-fertilisation and odour nuisance. Sub-national and national discourses also mostly address farmers. Recently, animal right issues have been a topic in German media, including television and print media. But also other topics on intensive farming and their impacts on the environment and food safety are occasionally discussed. The impact of these discourses on the producers of farm equipment is of an indirect character as they mostly address farmers first. On the one hand, they occasionally cause sales decreases. But on the other hand, they

might be a starting point for new innovation, especially if these discourses lead to formal laws.

The other two types of institutional inducing factors are industry standards and cultural factors. Industry standards are mostly industry-related according to their specific characteristics. An exception might occur if these standards apply to general purpose technology. In general, industry standards are of global character. Sometimes, special standards are formulated nationally or on the EU-level. Industry standards and dominant designs are an outcome of the sustainment phase of the cluster life cycle and indicate path stabilisation. Similar to knowledge dynamics, it is not always clear if standardisation is a cause or a result of organisational and cluster change. In the case study, several firms from the farm vehicle sub-sector in the cluster are actively involved in the development and refinement of the ISOBUS standard. However, the emergence of this standard was cluster external and functioned as a trigger for path-related innovation as the manager of company C1 points out:

> 'We got some agritech-related core competences, one of them is ISOBUS-related technology. [...] ISOBUS is an ISO standard which controls the communication between tractor and trailer. But it also supplies data management and the like. We use this for input and output devices and also for applications on the input devices. It is something where we are well-positioned and generated more demand for solutions over time. We got a whole product portfolio based on that. Well, that standard, this international standard, influences this enterprise very much.'

The influence of cultural factors is undoubtedly omnipresent. Most stakeholders are probably not aware of these influences. The only cases where cultural factors were mentioned as relevant triggers and drivers were regional ones. The conservative and politically stable environment was mentioned by some stakeholders as reducing uncertainty and benefiting the organisation's development. Most of the interviewed stakeholders nevertheless said that the regional social environment does not provide any special advantages to the organisation.

The main market-related groups of inducing factors are depicted in table 5. As mentioned earlier, international demand is a main trigger for internationalisation strategies. This instance can also be seen in the table. All in all, demand as an inducing factor is of industry-specific character. National, sub-national and regional demand is less relevant. Competition within the industry is most relevant on the national level. Labour market issues are a regional problem mostly hampering growth because of shortages in skilled employees. Market-related triggers and drivers are, all in all, less relevant than institutional factors. Nevertheless, internationalisation as an important change in the cluster is mainly the outcome of international demand from the supra-national and global level.

Knowledge dynamics as inducing factors for cluster agent development patterns are listed in table 6. It is not easy to distinguish between knowledge dynamics as original inducing factors and knowledge dynamics induced themselves by other factors. Knowledge dynamics are a central mechanism inducing innovation. They are the source for learning

processes and the recombination of knowledge. The main interesting conclusion that can be drawn from the table is that knowledge dynamics that have an influence on the development of cluster agents mainly occur within the industry. Knowledge exchange with companies from other industries is rare but important for radical innovation as has been shown for the biogas case. R&D cooperation occurs on all scales except the global level. The regional context is important, especially in the farm vehicle sub-sector. This applies for R&D cooperation and general networking activities. Customer contacts are relevant on all scales as these are often problem-oriented and related to incremental innovation that does not need spatial proximity. If customer contacts are associated with tests for new products, spatial proximity is important to some agents as mentioned before.

Inducing factors for cluster agent and cluster and knowledge development do not originate from all scales and from all contexts to the same degree. The analysis in this section shows that certain triggers and drivers are associated with specific scalar and thematic contexts. Knowledge dynamics and market factors as triggers and drivers are mostly industry-related factors, while institutional ones are more general and influence the development from contexts beyond the industry.

One main issue of this paper is multi-scalar analysis. In the case study, influencing and inducing factors do come from all scales. Nevertheless, some scalar contexts are the origin of more factors than others. Furthermore, some scalar contexts are associated with specific processes in the cluster like the supra-national and the global level in the case of internationalisation. The regional scale does matter in these instances where proximity promotes complex innovation as in the case of R&D cooperation. Furthermore, the national level can be identified as a relevant scalar context. This is due to the fact that politics and industrial institutions are very often organised on the national level. In the case study, cluster agents were very often affected by national laws having multiple impacts on the development in the cluster. Similar patterns have been observed in a case study in North West England (Uyarra and Flanagan 2010; Flanagan et al. 2011). This is very interesting as cluster-specific policy is often organised on the regional level.

7 Conclusion

At the beginning of this paper three research questions regarding external influences on cluster development were raised:

1. Which changes in cluster development are induced by which factors from which context?

2. From which scalar contexts inside and outside to the industry do these influences come from?

3. What specific cause-change constellations do exist? Is incremental and radical change, and thus, path-enhancing and path-emerging change, the result of different mechanisms?

As has been stated before, the main developments within the time frame of investigation were path-dependent innovation, the emergence of biogas plant manufacturing as a new path and the shift towards international market orientation by many firms as another process associated with cluster sustainment. Path-dependent innovation is mainly induced by industry-internal and industry-related knowledge dynamics but also by mainly national laws that are not really industry-specific by character. The development of path-related new products is often induced by R&D cooperation which occurs often within the cluster context. Incremental innovation is often induced by customer needs and internationalisation is mainly induced by international demand from farmers. Thus, it is an industry-internal process. Therefore, path-dependent processes are mainly induced by forces from within the industry context on various scales. Especially incremental innovation is associated with spatial proximity if the task is more complicated. Spatial proximity thus seems to provide chances to receive the needed degree of absorptive capacity. Less complex innovation tasks in the term of refinement of existing products is more application oriented. Spatial proximity is less important here and only sufficient

On the other hand, the new path of biogas plant manufacturing was mainly triggered by the Renewable Energy Act, a national law without an industry-specific character. It induced the recombination of knowledge between cluster agents and agents from other industries that were often situated within the same regional context. Thus, spatial proximity supplied the necessary absorptive capacity for this knowledge transfer as well.

As a result it can be seen, that path-dependent and path-emerging processes are triggered and driven by factors of different quality and from different contexts. The first are mainly the result of industry-internal processes while the latter had been triggered by factors beyond the industry context. Scale matters regarding the quality of the inducing factors. The institutional context having the strongest impact on the development of the cluster and its companies is the national one, accompanied by the sub-national and the supra-national level. Especially formal laws, but also political discourses had an impact on the development of the cluster and its agents. Laws induce innovation, the emergence of new paths and sales increases, but they also may hamper business and lead to sales decreases. Furthermore political influences were almost always not specific to the sector but of more general character. Knowledge dynamics as a factor on the cluster's development occur with agents from all scales. Nevertheless, the local scale has a special role here, as spatial proximity promotes complicated innovation tasks like the recombination of knowledge via R&D cooperation and networking leading to the development of new products and technological fields in both cases of path-related and path-emerging development. Market factors as triggers and drivers are also influencing from all scales, while international demand had a special influence on firm strategies in the case study.

All in all a pattern of specific cause-change constellation can be identified with differences between radical and incremental changes and certain types of influences typically originating an specific scales. Figure 6 shows which contexts have the strongest impact on the cluster's development.

These findings give some important implications for cluster life cycle theory. The observed processes and changes in the cluster can be either classified as path-related

or related to the emergence of a new path. The first ones include different types of innovation within the pre-existing paths of animal house technology and farm vehicle production. Furthermore, the trend to internationalise falls into this category as it is associated with global sales of products based on stable and well-developed technological competences. Path-related, incremental development is associated with the basic cluster life cycle phase sequence of growth, sustainment and decline as well as the process of adaptation. The second type of processes associated with path emergence is represented in the case study by the emerging biogas plant manufacturing sector. This emergence is partly path-dependent on existing knowledge from the cluster as well, but it also encompasses the integration of knowledge from different industries. It is represented in cluster life cycle theory by the process of cluster renewal (and possibly transformation). This renewal is induced by factors that are not only cluster-external but also external to the industry context in general. In terms used in the resilience literature one could label it as a shock. The development along the basic cluster life cycle on the one hand, and cluster renewal on the other, are therefore associated with totally different inducing processes. While path-dependent development is induced from within the cluster or at least the industry, novelty needed an external triggering event.

Further research may investigate these differences in more detail. It is not clear to which degree these findings are representative for other clusters. It might be possible that triggering events causing cluster renewal may be industry-internal in other instances. Furthermore, it remains unclear if necessarily the different scales like the regional or the national are to the same degree the origin of inducing factors in other cases. To answer these questions further research on other case studies needs to be applied.

Because of these limitations one needs to be careful with policy implications. Nevertheless, the findings from this study may give some hints for policy makers. Cluster policies became one of the most popular instruments in regional economic development strategies. Policy makers often try to stimulate regional economic growth by promoting networking activities between firms within a regional or cluster context. Thus, cluster policy is often linked to the regional level with a regional focus. As can be seen in the case study, the interconnectedness between regional actors is only one part of an even more complex system of interdependencies between the cluster and factors from different scales and contexts. Local networking might be a good strategy to promote path-dependent, but also path-emerging innovation. The installation of structures promoting R&D cooperation can be a good strategy. Nevertheless, knowledge dynamics occur between cluster agents and external agents as well, especially within the same industrial context. Depending on the specific background of a cluster and the specific needs of cluster agents it might be wise if policy makers also follow strategies that promote knowledge dynamics that conduct external knowledge into the cluster. This is most critical in the case of cluster renewal. This renewal probably might be induced by an occasional external factor like a national law opening windows of opportunity. If regional policy makers are able to recognise and evaluate these critical events a good policy intervention should involve the promotion of networking and knowledge flows from the right external sources.

Another instance regarding policy implications is of a more general character. Cluster agents' development and thus the development of the whole cluster is affected by a lot

of factors from various scales. In the presented case study the cluster is influenced by national laws in multiple ways. On the one hand, regional policy makers need to develop strategies to promote cluster firms to react to these impacts in a satisfactory way. On the other hand, regional policy makers are by themselves integrated into the national political system. Thus, they have the potential to integrate their policy in processes on the national, sub-national or supra-national level to a certain degree. Good cluster policies need to combine cluster-internal adaptation strategies to changing conditions with actions altering these conditions coming from the sphere external to the cluster.

This study shows that the external environment of a cluster matters. It is very complex and has multiple impacts on cluster development. As shown, it offers new insights for cluster life cycle theory. Future research should focus on this point. To underline and validate the findings, additional studies on other clusters might bring additional value. Furthermore, the present case study deals with a mature and renewing cluster. Thus, the findings are limited to the respective phases of the cluster life cycle. Studies on multi-scalar and multi-context impacts on clusters in other phases of the life cycle might complete the picture of external impacts on cluster development.

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Tables

Table 1: Overview of interviewed cluster companies and organisations

Organisations	Number	Organisations	Number
Interviews:		*Subsector*:*	
companies	21	lifestock related technology	12
other organisations	1	plant related technology	9
(other experts**)	(8)	biogas technology	4
Stage of development:		*Scale of market orientation:*	
emergence	2	regional	1
growth	18	national	6
sustainment	1	european	9
decline	1	global	6
Number of employees:		*Share of university degree employees:*	
1 to 9	2	0 to less than 10%	9
10 to 49	3	10 to less than 25%	5
50 to 499	13	25 to less than 50%	4
500 or more	4	50 to 100%	4

**multiple answers possible*
***not considered in descriptive analysis*

Table 2: Market related changes

Changes		Internat.	Sales incr.	Sales down
Industry-related	regional (cluster)	–	1	1
	sub-national	–	1	–
	national	–	1	–
	supra-national	6	–	–
	global	7	–	–
Not industry-related	regional	–	–	9
	sub-national	–	1	6
	national	1	6	7
	supra-national	–	2	2
	global	–	1	2

Table 3: Innovation related changes

Changes		New path	New product	Incremental
Industry-related	regional (cluster)	3	17	10
	sub-national	–	9	7
	national	2	11	10
	supra-national	–	9	8
	global	–	5	7
Not industry-related	regional	–	1	2
	sub-national	–	5	2
	national	4	14	6
	supra-national	–	3	1
	global	–	1	1

Table 4: Institutional triggers and drivers

Trigger/Driver		Laws	Standards	Discourses	Culture
Industry-related	regional (cluster)	–	–	1	–
	sub-national	–	–	–	–
	national	–	1	1	–
	supra-national	–	1	–	–
	global	–	6	–	–
Not industry-related	regional	–	–	3	4
	sub-national	8	–	4	–
	national	29	1	4	–
	supra-national	6	–	–	–
	global	–	–	–	–

Table 5: Market related triggers and drivers

Trigger/Driver		Demand	Competition	Prices	Labour
Industry-related	regional (cluster)	2	1	–	–
	sub-national	1	1	–	–
	national	2	6	–	–
	supra-national	5	2	–	–
	global	7	1	–	–
Not industry-related	regional	–	–	–	8
	sub-national	–	–	–	–
	national	–	–	–	–
	supra-national	–	–	1	–
	global	–	1	3	–

Table 6: Knowledge dynamics triggers and drivers

Trigger/Driver		R&D coop.	Customers	Networking
Industry-related	regional (cluster)	17	11	6
	sub-national	9	6	1
	national	10	14	2
	supra-national	8	10	1
	global	–	6	–
Not industry-related	regional	2	–	1
	sub-national	2	–	–
	national	7	–	–
	supra-national	1	–	–
	global	–	–	–

Figures

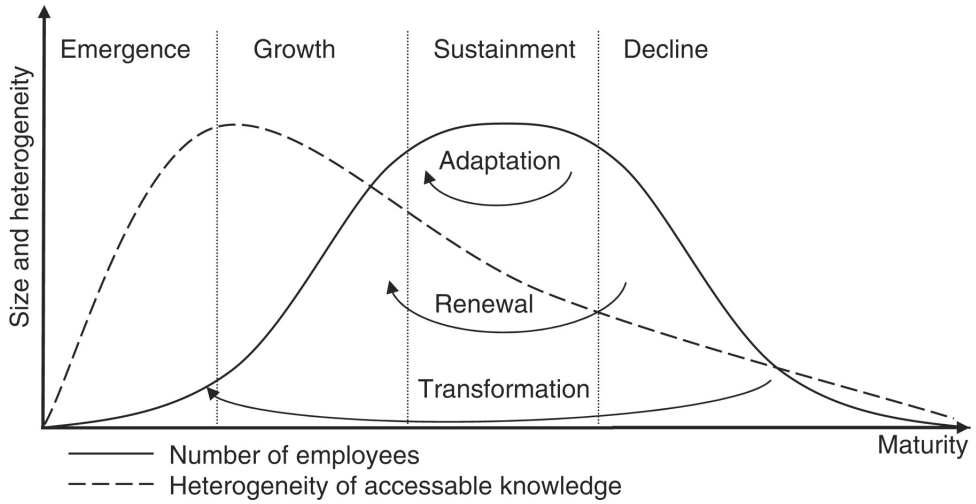

Figure 1: Cluster Life Cycle. Source: Menzel and Fornahl (2010, p. 218)

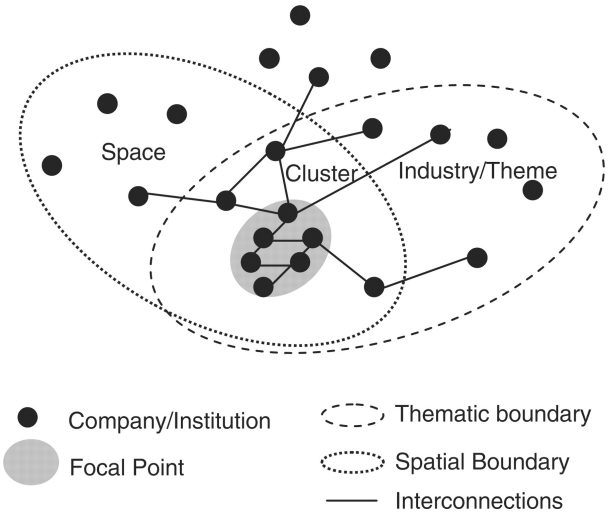

Figure 2: Elements of a cluster. Source: Menzel and Fornahl (2010, p. 214)

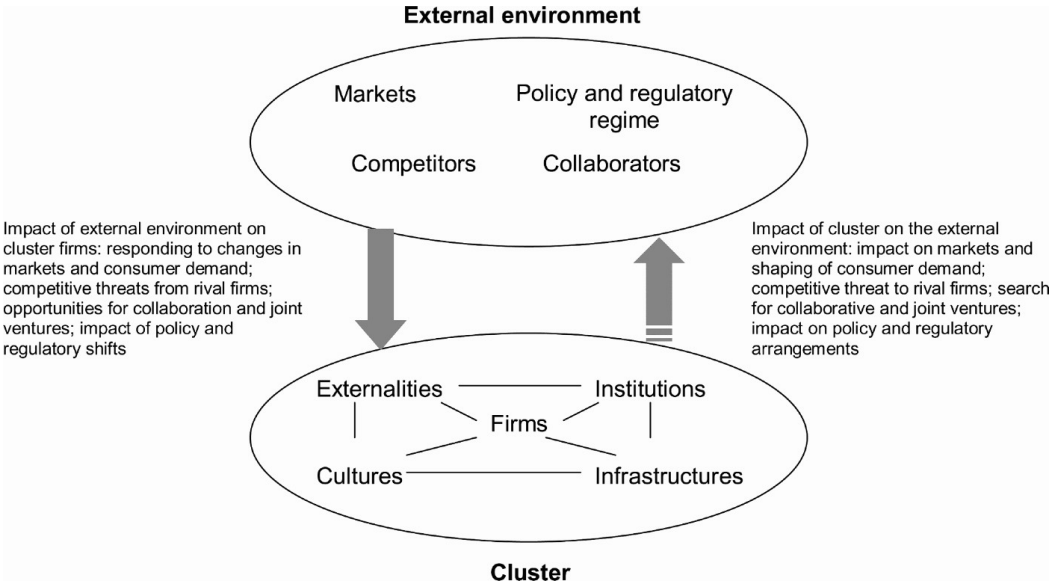

Figure 3: Two-way interactions between a cluster and its external environment. Source: Martin and Sunley (2011, p. 1311)

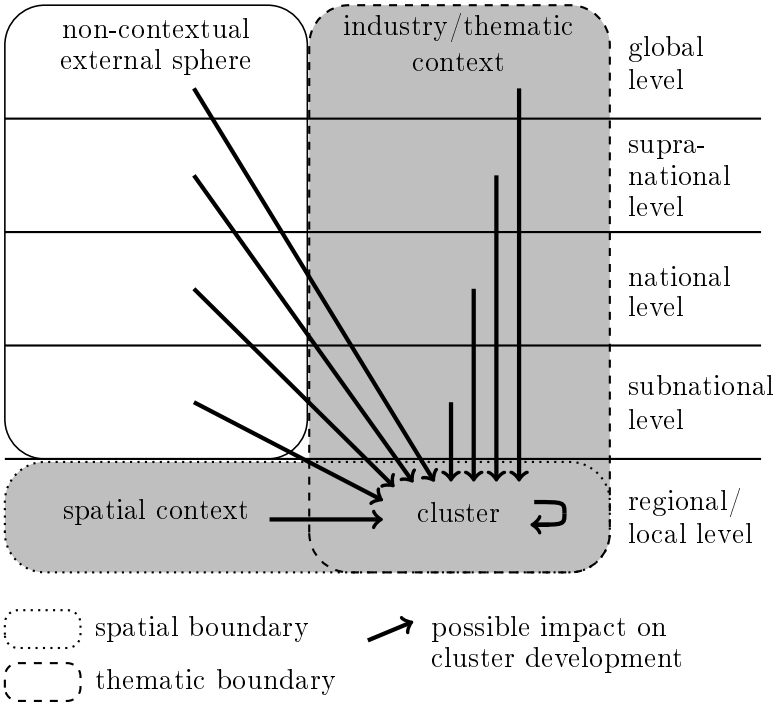

Figure 4: A multi-scalar pattern of impacts on cluster development. Source: own contribution

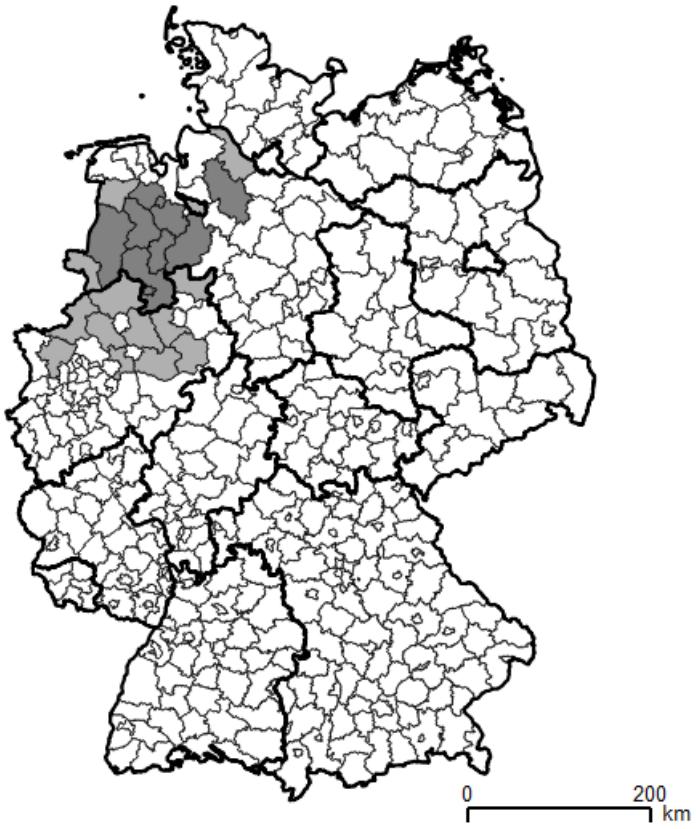

Figure 5: The agricultural engineering industry in North-Western Germany (Darker shades: base of interviewed stakeholders; lighter shades: districts where other agritech firms are based (Müller 2012)). Source: own contribution.

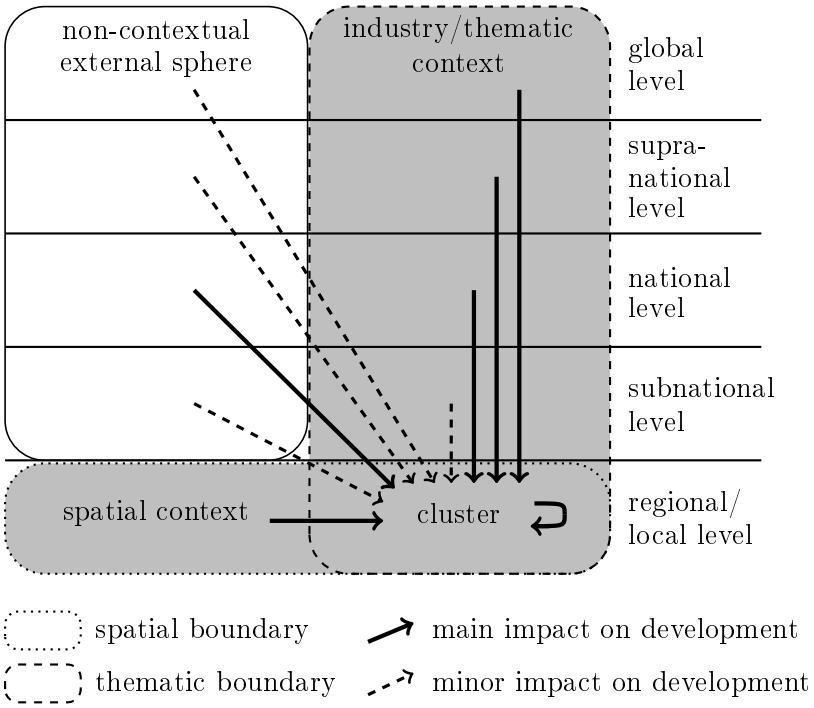

Figure 6: Contexts of main and minor impacts on the development of the North-Western German agritech cluster. Source: own contribution