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Cluster-internal and external drivers of cluster renewal: evidence from two German agricultural engineering case studies

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ABSTRACT

The question on how regional clusters renew themselves and start a new cycle of prosperity is of vital interest for affected companies, politicians and regions. Recently, the idea of renewing clusters has been conceptualized within the cluster life cycle (CLC) literature. CLC approaches generally assume that cluster renewal is widely driven cluster-internally through agent capability building processes and the systemic utilization of novelty. Critique from other authors highlights the neglected role of the external environment in the CLC literature. This article sheds light on renewal processes in two German agricultural engineering clusters. It is shown that in the case of a farm trailer cluster renewal can be widely explained cluster-internally, while in the case of a stable technology cluster that diversified into the field of biogas technology, internal factors played a less significant role and much of the development was driven externally by political decisions on the national level. Possible explanations for diverging roles of cluster-internal and external factors lie in the differences in the stage of the novel technologies' development and the complexity of the novel technology.

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1. Introduction

Today the idea of regional industrial clusters has become one of the main tools for regional economic policy. Policy-makers generally expect clustered firms of a common industrial-thematic context to grow more prosperously and innovate more dynamically due to positive spillover effects between co-located firms. However, several empirical examples reveal that clusters may experience a downfall due to unfavourable developments and cognitive lock-in (e.g. Grabher, 1993). Thus, clustered firms as well as policy-makers have a vital interest to build and maintain the economic prosperity of their clusters to prevent this decline. One promising option may be to renew the cluster by introducing novel knowledge, routines and technology.

In the past years, the issue of cluster renewal experienced an increasing degree of attention in academia. It has been a subject of discussion in various studies with different

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research foci and conclusions in the past (e.g. Cooke, 1995; Fornahl, Hassink, Klaerding, Mossig, & Schröder, 2012; Sammarra & Belussi, 2006; Staber & Sautter, 2011; Tappi, 2005; Tomlinson & Branston, 2014; Tödtling & Trippl, 2004). For example, Tödtling and Trippl (2004) argue that clusters may renew themselves if they can build upon a strong regional innovation system, newly established innovation networks and more indirect forms of policy intervention. Staber and Sautter (2011) highlight the role of a strong and flexible cluster identity and Fornahl et al. (2012) point to the relevance of opening windows of opportunity to initiate renewal processes. It has to be stressed that all of these studies point to single aspects of cluster renewal without offering an encompassing explanation. However, recently, the idea of cluster renewal has been integrated within the literature on cluster life cycles (CLC) (e.g. Brenner, 2004; Maskell & Malmberg, 2007; Menzel & Fornahl, 2010; Press, 2006; Swann, 1998; Ter Wal & Boschma, 2011)[1] within the research field of evolutionary economic geography. CLC concepts are based on arguments from the product life cycle (Utterback & Abernathy, 1975; Vernon, 1966) and industry life cycle (Klepper, 1997) literature. They mostly assume that cluster development follows a sequence from an embryonic or emergent stage, via a growth stage, to a stage of maturity and ends in the downturn of a stage of decline (see also Figure 1).

This development along the life cycle is based on the general assumption that cluster development is a path-dependent, self-organizing and emergent process (Boschma & Frenken, 2011; Fredin, 2014; Tanner, 2011). Or in other words, cluster development is believed to be driven by the cluster and its agents themselves. Therefore, the CLC can be strictly distinguished from the industry life cycle. CLC concepts point to a number of relevant cluster-internal driving factors including changing firm capabilities like the firm's absorptive capacity (Menzel & Fornahl, 2010; Ter Wal & Boschma, 2011), cluster-internal network formation processes (Menzel & Fornahl, 2010; Ter Wal & Boschma, 2011) as well as adjustments of the cluster's institutional settings (Maskell & Malmberg, 2007). As cluster renewal as an integral part of cluster evolution is also believed to mainly rely on these cluster-internal factors in a systemic cluster-internal adaptation process, cluster renewal is a process of co-evolution of cluster agent's capabilities, cluster-internal network structures and cluster-specific institutional settings.

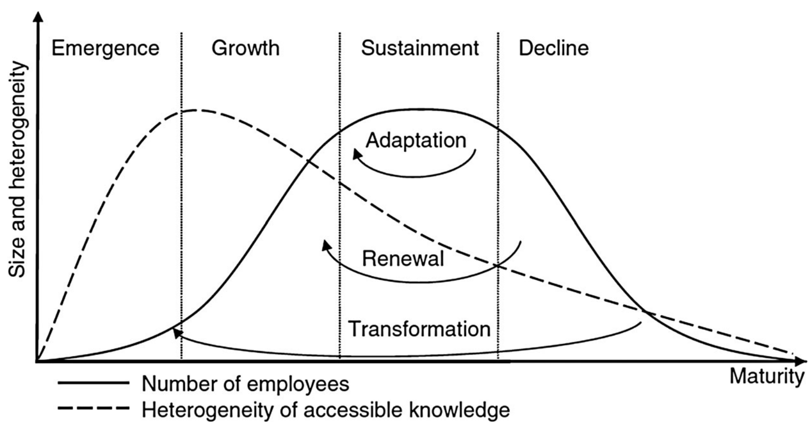

Figure 1. Quantitative and qualitative dimensions of the CLC. Source: Menzel and Fornahl (2010, p. 218).

However, clusters are not isolated from the rest of the world. Especially cluster renewal involves new knowledge, routines and technology that are introduced to the cluster and its agents. CLC concepts generally recognize this fact by stressing the global pipeline argument (Bathelt, Malmberg, & Maskell, 2004). Novel knowledge, routines and technology are tapped and absorbed by cluster agents through collaboration ties with cluster-external agents from different geographical and/or industrial-thematic contexts. However, the process of knowledge acquisition and adaptation is perceived to be solely cluster-internally driven by the cluster agents themselves.

This strong focus on cluster-internal drivers of development in the CLC literature has been criticized in the last years. One of the most recognized critiques has been formulated by Martin and Sunley (2011). They argue that the assumptions in the CLC literature are too deterministic and that cluster development is in reality much more complex and cannot sufficiently be described by a simple life cycle model. One core argument of them takes a strong focus on the role of the external environment of clusters. Martin and Sunley (2011) state that clusters are subsystems of larger systems (e.g. the national economy or the respective global industrial sector) and that systems and subsystems influence each other in a two-way interrelationship. Even though Martin and Sunley (2011) acknowledge that subsystems like clusters show a certain degree of system autonomy, it cannot be ignored that clusters may be very well influenced and driven in their development by factors of their external environment and that such a development can be still cluster-specific due to cluster- and agent-specific capabilities and structures.

This article seeks to investigate this interrelationship of internal and external factors for cluster renewal processes. It is investigated through the analysis of two empirical case studies of agricultural engineering clusters in north-western Germany, namely the Osnabrück-centred farm trailer cluster and the Vechta-centred stable technology cluster. Both clusters share a very similar and overlapping regional, social and industrial context, and both clusters experienced cluster renewal within the first years of the twenty-first century. However, renewal processes occurred very differently. In the case of the farm trailer cluster, cluster renewal was mainly driven cluster-internally through cluster-internal knowledge and network formation and capability building processes, including the creation of a cluster-specific local organizational and academic infrastructure, which enabled firms to gain better access to external knowledge. In the second case study on stable technology, a significant renewal process was mainly driven by external policy intervention on the national scale that was not directly designed to target this specific industry or cluster. In this case, cluster-internal factors played a much smaller role and cluster-internal systemic utilization was less developed.

The remainder of this article is as follows. The second section describes and discusses the concept of cluster renewal as it has been formulated in the CLC literature including its critique. It concludes with some research expectations. The third section investigates the two case studies of agricultural engineering clusters in north-western Germany. And finally, the fourth section offers a discussion of the results and draws some conclusions.

2. Cluster renewal and the CLC

As stated before, the issue of cluster development, including the occasional event of cluster renewal, has been recently conceptualized within the CLC literature (e.g. Bergman, 2008;

Brenner, 2004; Maskell & Malmberg, 2007; Menzel & Fornahl, 2010; Press, 2006; Swann, 1998; Ter Wal & Boschma, 2011). As already mentioned, CLC approaches tend to explain cluster development and renewal as mainly cluster-internally driven, while also acknowledging the significance of external knowledge and routines that occasionally are adopted by cluster agents. This section seeks to take a closer look on what the CLC literature tells us about cluster renewal. Three more recent CLC approaches, namely the concepts of Menzel and Fornahl (2010), Ter Wal and Boschma (2011) and Maskell and Malmberg (2007), are observed regarding their assumptions on cluster development in general and cluster renewal in particular. Furthermore, this section discusses the critique on the CLC that has been formulated recently. Based on the assumptions formulated in the discussed literature, two research expectations are formulated in the end of this section.

In the CLC approach of Menzel and Fornahl (2010), cluster development is a function of the interplay of the cluster's size (number of firms or employees) and the accessibility of heterogeneous knowledge to cluster agents (see Figure 1). This development pattern is based on three presumed factors: the absorptive capacities and capabilities of individual firms, the systemic character of a cluster and the role of external knowledge. New external knowledge is introduced to the cluster through network ties to agents that are geographically and/or industrial-thematically external to the cluster. The adaptation of such knowledge by individual cluster agents has the potential to enhance the agent's absorptive capacity (Cohen & Levinthal, 1990), which in turn enhances its future possibilities for interactive learning with heterogeneous partners. However, individual learning alone is not sufficient to drive the development of a whole cluster. Menzel and Fornahl (2010) state that to drive cluster development, it is necessary to utilize knowledge in a systemic way within the cluster through interactive learning. This may be supported by specific cluster-related local organizations like professional and trade organizations or R&D-agents like universities (Martínez-Cháfer, Capó-Vicedo, & Molina-Morales, 2011). Interactive learning among cluster agents helps to diffuse knowledge within the cluster. As a result, through knowledge diffusion and the incorporation of new agents into the cluster, the thematic and/or geographical boundaries of the cluster may be enhanced. Such an event may have the potential to take the cluster to a new growth phase. To distinguish different degrees of such a change, Menzel and Fornahl (2010) distinguish between three forms: incremental adaptation, renewal through the integration of a different technology beyond the cognitive scope of cluster agents or transformation into a totally different field of application.

In a very similar way like Menzel and Fornahl (2010), Ter Wal and Boschma (2011) describe the CLC to be mainly driven by the systemic character of the cluster (or its network dynamics) and the individual capabilities of cluster firms. However, in contrast to Menzel and Fornahl (2010), they conceptualize agent capabilities much more detailed. In addition to individual absorptive capacities, they add two other forms of capabilities: the ability of the firm to reposition itself within the cluster network and the ability to reproduce routines into new geographic contexts.[2] Ter Wal and Boschma (2011) state that these three forms of individual capabilities are dynamic capabilities as they not simply help the firm to solve problems but help to change the way a firm solves problems (Zahra, Sapienza, & Davidsson, 2006). Through network effects, these dynamic capabilities have the potential to drive the development of the whole cluster towards new systemic problem-solving structures. Or in other words, changes in the dynamic capabilities of cluster firms may lead to cluster change. If agents strategically build and use their dynamic capabilities, they potentially help to renew the cluster in a way that fits their needs. Thus, according to Ter Wal and Boschma (2011), cluster development and renewal are mainly driven by those cluster agents that were most successful in building their absorptive capacities, strategically repositioning themselves within the cluster network to gain access to knowledge and resources and reproducing their routines to new promising contexts.

The role of individual firm routines and their cluster-internal systemic effects is also highlighted by Maskell and Malmberg (2007). However, in contrast to Menzel and Fornahl (2010) and Ter Wal and Boschma (2011), they take a stronger focus on cluster-specific institutional settings. According to Maskell and Malmberg (2007), routines of cluster agents co-evolve with the cluster's institutional setting. The value of individual routines is strongly enhanced if other relevant agents share the same or similar routines. Shared routines are the foundation for the creation of a common institutional setting, which in turn enables and eases mutual learning and collaboration. However, such a dynamic is perceived by Maskell and Malmberg (2007) to be much more likely within a shared industrial and/or regional context as agents tend to search myopically for potential collaboration partners within spatial, cognitive or social proximity. According to Maskell and Malmberg (2007), cluster evolution is driven by these processes. Myopic search and pinpointed institutional adjustment are main cluster-internal factors driving the CLC. This also applies for the event of cluster renewal, which they call cluster rejuvenation. The rejuvenation of the cluster depends on whether some of the co-located firms remain able to acquire and utilize external ties to external agents with dissimilar routines and thus, start a new co-development with new and adjusted institutions. Thus, cluster rejuvenation is the cluster-internal utilization process of external novel routines.

This brief overview shows that cluster development in general as well as cluster renewal in particular are perceived in the CLC literature to be mainly driven cluster-internally while external knowledge links do only unfold their potential through cluster-internal utilization processes. All three studies are based on the two main assumptions that cluster development depends on the two cluster-internal factors of cluster agent capabilities (or routines) and the systemic character of the cluster of interacting agents within the shared spatial and thematic context. However, this strong focus on cluster-internal factors in the CLC literature is not unchallenged. Martin and Sunley (2011) formulate broad criticism. They argue that the assumption in the CLC literature that cluster development that can be distinguished from the more general industry live cycle can only be explained by cluster-internal factors is too deterministic and gives little space for alternative forms of cluster development and renewal. According to them, clusters may develop very differently due to the clusters' specific characteristics and their environment. Due to individual specific circumstances and characteristics of single clusters, they suggest a model of an adaptive cycle with multiple possible development patterns of phases of emergence, growth, conservation and decline that is interdependent with the cluster-internal interconnectedness of agents and resources. One of the main arguments of Martin and Sunley (2011) to explain this variety lies in their conceptualization of the cluster within its external and internal environment. As Martin and Sunley (2011) state, CLC approaches tend to explain development from the analytical unit of the cluster. Thus, the clustering affects, for example, firms' capability building in a downward causation process. External novelty is actively utilized through the cluster network. However, Martin and Sunley (2011) argue that this interrelationship is much more complex and that cluster development has to be understood as a two-way interactive interrelationship of the cluster with its internal and external environment. Subsystems (like clusters) receive development impulses from their larger parental systems (like the national economy) that may help a cluster to 'remember' and restore its growth, leading to renewal processes (Martin & Sunley, 2011, p. 1310). Clusters are affected by large-scale regularities and seemingly erratic evolutionary trends (Martin & Sunley, 2011, p. 1309). Clusters are intertwined with the national and global economy and mostly also with clusters in other locations. Furthermore, they are affected by general societal trends and political decisions on various geographical scales. These interrelationships have a strong influence on the cluster-internal knowledge flows and spillovers. Often, these interaction ties to cluster-external partners are more intense than these to other firms within the cluster. Thus, it is unwise to believe that cluster development and renewal are mainly based on cluster-internal factors. Especially cluster renewal strongly depends on these external knowledge flows. Therefore, one can assume that cluster development and renewal can be driven by external factors. However, because the cluster itself retains its own specific system characteristics and, thus, a certain degree of system autonomy, cluster development can be still distinguished from the more general life cycle and external factors alone cannot sufficiently explain cluster change.

Thus, two possible general patterns of cluster renewal can be distinguished from this literature. The CLC literature strongly emphasizes the role of cluster-internal factors, while Martin and Sunley (2011) advocate for a more open concept that combines varying patterns of cluster-internal and cluster-external factors, depending on the specific situation of the investigated cluster. In such a concept, the assumptions from the CLC literature represent only one possible case. Thus, the two following research expectations can be formulated:

(1) Cluster renewal is driven cluster-internally by two interacting factors: the building and using of individual agent capabilities and routines (especially of core agents) that enable agents to get access to novelty as well as the systemic and interactive utilization of that novelty among cluster agents.
(2) This development is interrelated with driving and influencing factors from the external environment of the cluster.

3. Case studies

3.1. General information and methodology

This section describes two case studies of the farm trailer and stable technology clusters in north-western Germany, with the first roughly centred on the city of Osnabrück and the second roughly centred on the city of Vechta (see Figure 2). The analysis is based on 33 semi-structured qualitative interviews which were conducted between 2012 and 2015 for an international research project on CLC. Interviewees can be classified on the one hand as relevant agents (executives and managers) from cluster firms from the stable technology, farm trailer and biogas technology sectors of which all but one had been working

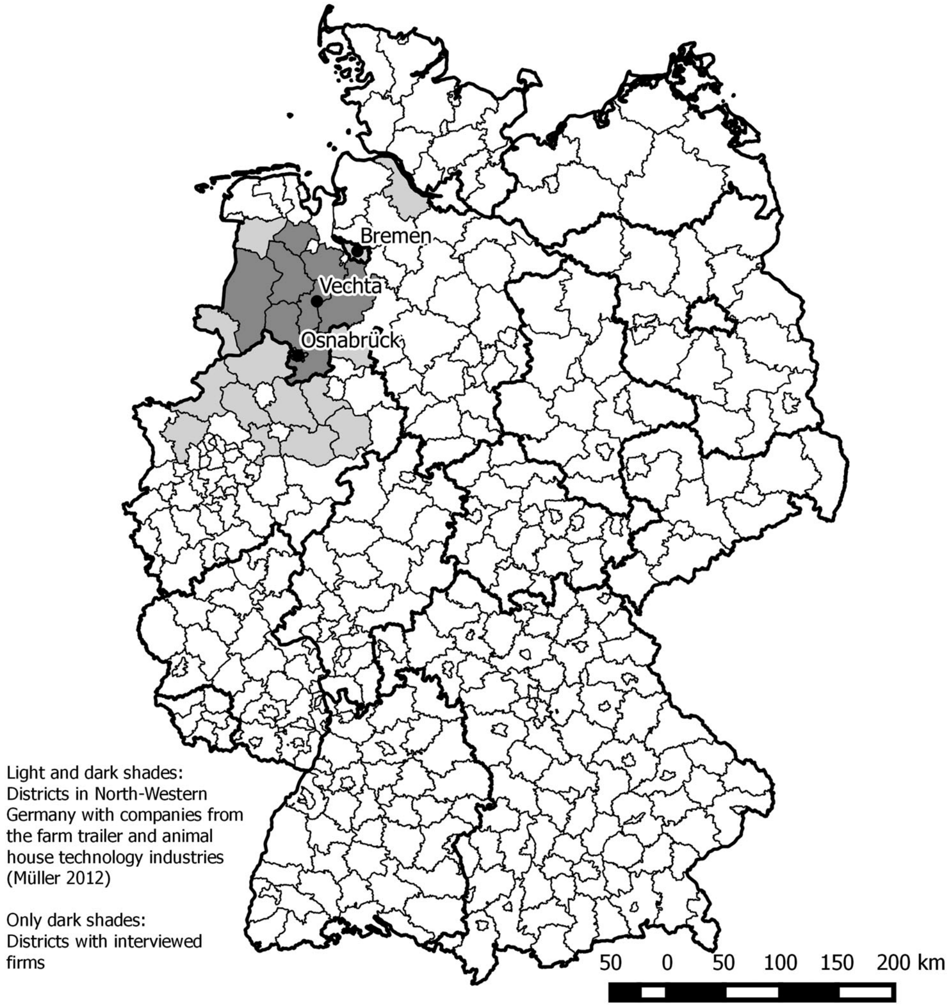

Figure 2. The investigated region within Germany. Source: Santner (2016a, p. 7).

for their company since at least five years prior to the interview or, in the case of younger firms, since the founding of the firm. The second group of interviewees is made up by industry experts from various contexts like the local chamber of handicrafts, academia, regional politics and administration and the like. The first group was mainly asked about the development of their own firm during the last 10–15 years prior to the interview with a strong focus on innovation and collaboration activities. The second group were mainly asked about general economic trends within the industry and the region within the same time frame, but also in earlier times when appropriate. All interviews were conducted in German. The cited interview sequences have been translated by the author.

The investigated clusters are located in an industrialized rural region with some urban centres (mainly Osnabrück, Oldenburg, Vechta and Cloppenburg). The region is situated halfway between the metropolitan areas of the Ruhr to the south and Hamburg and Bremen to the north. Since the post-war period, it is well connected to the national transport systems through the motorway A1. Since the beginning of the twentieth century, the region is also one of the most productive agricultural areas in Germany, including livestock (mainly chicken and pigs) and crop farming (potatoes, turnips, strawberries, salad and others). It is the region with the highest concentration of livestock in Germany (StÄBL, 2007). Around this very productive agricultural sector, a fully grown agribusiness industry has been developed, including notable companies from the food sector (with the most notable firm PHW/Wiesenhof and many other firms) and relevant food and agriculture-related research institutes (e.g. DIL). The two investigated clusters of this study from the agricultural engineering context represent supportive sectors that emerged in the region and that developed into own prosperous clusters by themselves. Having a partly common historical and regional background, both clusters share a similar, social and partly institutional context. However, they are also characterized by various dissimilarities in terms of industrial structure and innovation activities. These differences also become evident when having a closer look at cluster renewal processes.

3.2. The farm trailer cluster

The farm trailer cluster in north-western Germany consists of headquarters and dependencies of several larger, medium-sized and smaller companies, including firms like Amazone, Grimme, Krone, Lemken, Claas, Bergmann, Kotte, Tebbe and Grégoire-Besson. Some of them are world market leaders in their specific field. The cluster is more or less located around the city of Osnabrück and stretches from the area around Oldenburg in the north to the Münsterland and Ostwestfalen regions in the south. The north-west is one of the core regions of that industry in Germany (Krawczyk & Nowak, 2009). Furthermore, specialized suppliers from sectors like tire making, farm vehicle electronics and others can be found in the region as well. The cluster is more or less specialized in farm trailers and self-propelled farm vehicles. Tractors are not produced in the region.[3] Many of the firms have a long history dating back up to the nineteenth century. Most of them are family owned until today.

Since the beginning of the twenty-first century, the cluster faced a technological upgrading through the introduction of high-tech information and communication technology (ICT) in various application fields. The firms of the cluster were able to reposition themselves on the market and to enhance their technological scope, resulting in a process of cluster renewal. The introduction of modern ICT was a general trend in many industries of this time. One of the main challenges for the farm vehicle industry was that tractors and trailers are mostly produced by different firms. Thus, the communication between the control system in the tractor cabin and the machinery of the trailer depends on a functioning electronic interface between both. Therefore, after a longer period of failing standardization efforts, the global ISOBUS standard was introduced in 2001. ISOBUS is a standard of an interface, including related software solutions, between devices in the trailer and the control systems in the tractor. Today, it is used by most notable producers of farm vehicles and related machinery. It is designed for the often adverse and dirty conditions in the agricultural context.

The introduction of ISOBUS generated a growth impulse for farm vehicle producers worldwide, including most of the firms in north-western Germany. Within only a couple of years, the region developed into one of the core innovative regions for ICT in farm vehicle applications in general and the refinement of ISOBUS technology in particular. The main reason why the cluster was able to do so was that its agents were able to learn collectively and utilize the new technological knowledge systemically in a very efficient way through the creation of a strong and supportive cluster-internal organizational infrastructure: first, a focused and professional research centre for farm vehicle engineering at the University of Applied Sciences in Osnabrück, the so-called COALA centre (Competence Of Applied Agricultural Engineering), was founded that provides focused and sophisticated high-tech solutions for the cluster's firms; second, an institutionalized collaboration network, the so-called CCI network (Competence Centre ISOBUS), was formed that helped firms to receive access to external knowledge and to utilize it within the cluster network in an efficient way.

COALA was founded in 2007 as an interdisciplinary research centre at the University of Applied Sciences in Osnabrück. It combines several competences that are relevant for modern farm vehicle engineering, including research groups for engineering itself and other fields like crop research. COALA is today a very relevant collaboration partner for farm trailer companies in the region and beyond. Several interviewees from cluster firms mentioned that the personal engagement and the high competence of the researchers of COALA are a major input for high-end innovation for their firms (see also Santner, 2016a). Some of the cluster firms became able to enhance their cognitive scope and, thus, their absorptive capacity through interactive learning within the innovation process with COALA. For example, one interviewee mentioned:

> We got in contact with Professor [X] from COALA. He thought about our problem and finally said that we will find a solution. And this Friday we build the prototype of our sensor. We had now two, three years of groundwork and we found a sensor of which we think it will fit to our needs. Now we build a prototype of this sensor and hope that we can develop a product that we can sell in one year.

The firms of the farm trailer sector generated a demand for high-tech solutions for new applications that were beyond the scope of their own cognitive capacities. Furthermore, students from COALA often were engaged by the local firms after graduation. The cognitive abilities (or absorptive capacity) of both COALA and the firms were enhanced in this process. The firms provided the researchers with the necessary problems that needed to be solved and the researchers provided the respective problem solutions. For example, the same interviewee stated:

> […] in the fields one often has the problem that when one tries to spread manure it is unclear whether it is running or not. You do not fertilise the ground when the hose is clogged. A farmer asked us if we can find a solution for this problem: 'How can I recognise the problem when I am sitting in the cabin.' And then we said: 'Let us see if we can find a technical solution.' We asked several research organisations and then we ended up with Professor [X] from Osnabrück. He thought about it and said: 'We will find a solution.' And so they did.

The COALA research centre was founded in 2007. However, the core researchers have worked at the University of Applied Sciences of Osnabrück earlier due to the regional demand for specialized academic education. The motivation to found COALA came due to the strong concentration of the farm vehicle industry in the region and the resulting demand for high-tech solutions and specialized engineering personnel. However, it was not initialized on behalf of the industry but through the initiative of the researchers. The development was accompanied with the further specialization of working groups into the field of farm vehicle engineering. For example, the laboratory for farm vehicle technology and mobile work machines spun off from another more general engineering working group after the topic of farm vehicles became increasingly important. Thus, the cognitive scope and, thus, the absorptive capacities of both, firms and researchers, were systematically enhanced in a co-evolutionary way.[4]

The second cluster-internal factor that played a significant role in the process of cluster renewal was the formation of the Osnabrück-based CCI network in 2009. CCI is a network organization of farm trailer producers, supporting firms as well as COALA that seeks to further develop the global ISOBUS standard and to establish its member firms as global technology leaders. The foundation of CCI occurred shortly after the establishment of the globally organized AEF network (Agricultural Electronics Foundation) that follows a very similar strategy (CCI, 2015). CCI is a member of AEF. CCI was founded by six companies such as Amazone, Grimme, Krone, Lemken, Kuhn and Rauch. The first four companies of that list are located in north-western Germany, while Kuhn and Rauch are located in eastern and southern Germany, respectively. The office of CCI is located in Osnabrück in close proximity to COALA, another core member of CCI. Until April 2016, the network grew up to 20 members. Today, the members of CCI hold a significant share of the global market on farm vehicles.[5] The founding members and COALA form the core of the network. Members that joined later are from the core region (e.g. Bergmann) as well as from outside the region including some companies in other European countries (e.g. Pöttinger from Austria). The network also includes companies that are not farm trailer producers by themselves, such as Anedo, a producer of ISOBUS interfaces. It supplies farm trailer producers with ISOBUS technology and know-how. CCI holds an important role here as it enlarges the cluster's network by including new firms and technology developers from inside and outside of the region. The membership in CCI eases and enables trailer firms to get access and utilize sophisticated knowledge from (formally external) partners such as COALA, Anedo and others.

So, this description of the case study shows that the renewal process of the farm trailer cluster towards a more sophisticated ICT-based technological paradigm was strongly cluster-internally driven and that the successful systemic utilization and capability building of core agents, supported by the creation of a local cluster-specific organizational infrastructure, were key factors. The collaboration between farm trailer firms and other agents such as COALA or Anedo started a process that enabled the collaborating agents to learn from each other and to enhance their own absorptive capacity. Furthermore, the creation of the CCI network gave participating firms the chance to reposition themselves within the cluster's as well as the global innovation network. Some, if not all, of the firms of the CCI network are today better positioned in their innovation network than before because the CCI network provides better access to strategic technology partners like COALA or firms like Anedo. The strong involvement of the firms within the CCI network enabled them to utilize their knowledge systemically. The formation of COALA and CCI was, furthermore, an outcome of myopic search as the shared regional and social context of most of the participating firms increased their awareness for the potential of joint collaboration and the possibilities for frequent interactions with partners like COALA. However, in the end, the cluster agents were not just able to renew the cluster but also enhanced their thematic and spatial borders by including new agents from other locations (e.g. Pöttinger) and other industries (e.g. Anedo) over time.

3.3. Biogas diversification in the stable technology cluster

The stable technology cluster, roughly centred on the city of Vechta, emerged with the region's upswing of a vertically integrated livestock farming industry (Tamásy, 2013; Windhorst, 1975), in the second half of the twentieth century. It is specialized in pork- and poultry-related machinery, including feeding, water supply, stable climate, egg collection, manure disposal, caging and other technologies. It is made up by stable designers, such as Big Dutchman, WEDA, Schulz, PAL-Bullermann and others, and supplying firms producing components (like cages, machinery and others), including companies such as Lubing, Hellmann, Stallkamp, Atka and so forth.

The time since the turn of the millennium was widely characterized by economic growth. Farmers today increasingly demand larger stables with increasingly effective stable technology. Technologically, two main developments can be distinguished in the stable technology cluster during the last two decades (see also for a more detailed description Santner, 2016b): firstly, the general incremental refinement of existing technology, including the enhanced, but still incremental development of modern ICT[6]; and secondly, an event of cluster renewal through the diversification of some stable designers into the field of biogas technology. However, this renewal process differs in two significant points from what can be observed for the case of the farm trailer cluster: firstly, this renewal process into biogas technology was initiated and widely driven by cluster-external factors (mainly national jurisdiction); and secondly, due to the low-tech character of biogas and the strong focus on mainly firm-internal incremental innovation, the cluster-internal adaptation of biogas technology was characterized by a very weak systemic utilization of the new knowledge within the cluster and a missing creation of a common technology-related organizational and academic infrastructure.

The firms in the stable technology cluster today strongly rely on more or less incremental innovation. Technological developments are mainly conducted on behalf of farmers who request changes or due to changing animal protection or environmental legislations. Stable designers often develop adjusted products and assign supplying companies to build them, as stated by the interviewee from a supplying company:

> We produce client-oriented products, meaning, the client comes to us with an idea or a drawing or a blueprint and says: 'I need something like that. Can you make this for me?' Well, and then we make an offer.

Most of the innovation is within the cognitive scope of the companies, and there is only little need for collaboration with research organizations. Thus, in the region no research organization exists that is directly involved in technological developments in the stable technology context (like, for example, the COALA centre in the case of the farm trailer industry). However, there are some R&D facilities like the Bakum dependency of the Veterinary University of Hannover that test new products regarding their fit to animal purposes, juridical demands and other factors.

These findings also widely apply to the field of biogas technology in which some stable designers (mainly Big Dutchman, Schulz and WEDA/Stallkamp) diversified since the beginning of the millennium (see also Santner, 2016a, 2016b). Modern biogas technology was developed in Germany and other European countries since at least the 1980s and gained a certain degree of professionalization till the end of the 1990s, including an established national innovation network around the so-called widely southern Germany-based Bundschuh practicals group and its successor the German Biogas Association. The diversification of the stable technology cluster into biogas technology was strongly externally induced and driven: the Renewable Energy Act (REA) of 2000 and its amendment of 2004, a law providing attractive feed-in tariffs for renewable energies including biogas, offered a chance for firms from the stable cluster to diversify into this field. Furthermore, the amendments of 2004, 2009, 2012 and 2014 were the main drivers for the technological development in the national biogas industry, including those of the cluster. Much of the technological development was oriented on the incentives from the feed-in tariff policy as the subsidization categories of the law directly created the market for specific technological biogas solutions. For example, the 2004 amendment introduced an attractive bonus for the digestion of plant material, resulting in the technological shift of most producers towards energy maize digestion. Thus, biogas firms in Germany, including the diversifying stable designers, oriented the design of their plants after the creation of the REA on these incentives.

Before the REA, the firms from the stable technology cluster were not involved in biogas or electricity technology. However, after the initiation of the REA, firms like Schulz (Envitec) and Big Dutchman integrated formerly independent small biogas companies. In contrast, WEDA founded a new biogas firm (Weltec) in cooperation with the company Stallkamp, a firm that has been active as a supplier for stable designers before. The reason for these firms to engage into a totally new technology cannot only be explained by the simple fact that the REA was created, but also due to the fact that biogas and stable technology share some similarities. For example, biogas technology is technologically very similar to stable technology. It is technologically related to manure treatment and disposal as well as technology for wet feeding, as stated by one interviewee:

> [Biogas technology and our original competences] are similar. […] We also already had these experiences with disposal products like manure, because in the first years one mainly fermented disposal products in the biogas plants.

Thus, some of the diversifying firms, such as WEDA and Stallkamp, were able to engage in the field of biogas mainly due to incremental learning and collaboration within established structures from the stable technology context. The similarities of both technologies are even more comprehensive (Müller, 2012). Both application fields rely on a similar form of computer control technology, and the construction of stables and biogas plants are both project-oriented tasks. Furthermore, the existence of a heavily intense agriculture with a high degree of manure production in the region constituted a big potential market for biogas technology in the region, as biogas plants of the early years often digested manure and other disposals. Local farmers played an important role in the establishment of biogas technology in the stable technology context as trustful and established relationships among farmers and firms helped to communicate demand and innovation impulses between them (Santner, 2016b).

Besides these similarities, both technologies target different application fields within the common farm context and are subject to different legislations and institutional settings. Thus, they constitute two different technological application fields within the common socio-economic context of the farm. The technological similarities and the similar client context enabled stable technology firms to diversify into the field of biogas without significant changes in their cognitive abilities.

So, according to the assumptions from the CLC literature, one can see that some cluster-internal factors played an important role in the renewal process of the stable technology cluster into the field of biogas technology. Most importantly, firm capability building has been a very important factor. The diversifying firms increased their absorptive capacity to become able to engage in the field of biogas technology through strategic organizational integration. The fact that firms like Schulz or Big Dutchman integrated small biogas firms enabled them to be prepared for their challenge. This organizational integration had also a network effect as it repositioned (or better newly positioned) the firms within the network of the biogas industry. Due to the fact that stable and biogas technology share technological similarities, the firms were able to reproduce their routines within a different industrial context quite easily. However, the systemic utilization of the new knowledge mainly targeted on the context of the biogas industry and had little impact on the structures and dynamics of the pre-existing stable technology cluster context. Thus, the systemic utilization of the novelty did not much occur in the pre-existing cluster context as such. It was limited to local farmers that helped to anchor biogas technology to the stable technology context (see also Santner, 2016b). In contrast to the farm trailer case, the diversifying firms from the stable technology cluster did not engage in the creation of a cluster- and technology-related local organizational and academic infrastructure, as they could widely rely on their own cognitive capabilities in incremental innovation processes when adopting the technologically similar biogas technology. Biogas diversification occurred parallel to the still ongoing incremental innovation path of stable technology. The diversification process occurred widely externally driven. The REA and its amendments were the main driving factors and technological impulses came not from within the cluster but more induced by the REA and from within the industrial context of the national biogas technology industry. However, the pre-existing technological knowledge developed in the stable technology context built the path for this process. Thus, the renewal process occurred in a tight interrelationship between the cluster and its external environment. The technological and socio-economic fit of both technologies in combination with external policy forces enabled the cluster to renew in the way it did.

4. Discussion and conclusion

As has been shown in this paper, cluster renewal processes occurred very differently in the two case studies of the farm trailer and stable technology clusters. The processes observable for the farm trailer cluster very much follow the expectations that have been developed in the CLC literature with a strong explanatory power of cluster-internal agents' capability building and systemic utilization processes. Thus, the case of the farm trailer cluster fits very much to research expectation 1. In contrast, the renewal process of the stable technology cluster into the field of biogas technology was more driven by a mixture of cluster-internal and cluster-external elements. On the one hand, cluster-internal capability building processes linked biogas technology to the stable technology cluster. On the other hand, this process was only thinkable due to the strong driving force of the cluster-external REA, which pushed the biogas industry nationwide, but also had a very specific effect in north-western Germany, as it resulted in the linking of biogas technology to the stable technology context (see also Santner, 2016b). However, capacious systemic utilization processes within the stable technology cluster did not occur as biogas technology was already to a strong degree standardized and sufficient organizational structures have already been developed in southern Germany. Furthermore, the strong technological relatedness of biogas and stable technology enabled firms to innovate widely incrementally. Thus, this case study fits much better to research expectation 2.

The explanation to this difference seems to be complex, but one main factor seems to lie in the development stage of ISOBUS technology that has been introduced to the cluster in the process of cluster renewal. In the case of the farm trailer cluster, the novel ISOBUS technology was an infant technology. Technological development and global innovation networks were not yet formed and established. Therefore, the existing industrial and innovation structures of the farm trailer cluster in north-western Germany represented a fruitful ground for the establishment of such structures. Because there were no strong and dominant external structures yet established, but there existed a global demand for such structures, the agents of the cluster could build upon their internal capabilities and innovation networks to adjust them to the needs for the new technology. Furthermore, ICT-related technology was beyond the cognitive scope of farm trailer producers. Thus, they were dependent on a strong organizational infrastructure that helped them to build their capabilities. The firms needed a strong academic partner who helped them in the development of sophisticated technology and they needed a focused network organization who helped them to get access to the knowledge of (formally) external partners and to utilize them in their network efficiently. The fact that agents tended to search myopically for their collaboration partners within their existing cluster and regional context enhanced this dynamic towards a cluster-specific renewal into the globally developing ISOBUS technology. The cluster could establish itself in a global leading position within its industry by building mainly on cluster-internal factors. In recent years, the success of the cluster resulted in the cluster's growth and the enhancement of its geographical and thematic borders.

In contrast to this, biogas technology was as such much more advanced and standardized when it was introduced to the investigated stable technology cluster. Modern biogas technology was developed since the 1980s, and a central innovation network had developed outside of the context of the stable technology cluster before. When biogas technology was introduced to the stable technology cluster in the early years of the twenty-first century, this cluster renewal process was mainly cluster-externally driven through the REA and the pre-existing cluster-external innovation network structures. However, a certain degree of cluster-internal factors remained necessary to explain cluster renewal. The building and using of cluster-internal capabilities was fundamental for the linking of the technology to the cluster. However, the cluster-internal systemic utilization of the novelty remained weak because cluster-external structures were already established. Furthermore, the low-tech character of biogas technology and the fact that the new technology was technologically strongly related to the established stable technology enabled firms to rely mainly on their own capabilities when adapting the new technology without creating a new local organizational and academic infrastructure. External ties to other partners were also not that important as the firms could easily adopt the technology by, for example, buying small biogas businesses.

These findings imply that cluster renewal is a complex process of which specific characteristics strongly depend on a variety of factors. Cluster-internal factors seem to be relevant to explain cluster renewal when the cluster-internal utilization of the novelty has the potential to offer a significant advantage for innovation activities. Especially young technologies have not yet developed their own effective innovation networks and certain specialized and established clusters may offer a fruitful ground to develop such structures. However, if such structures have already established elsewhere and a cluster starts to diversify or renew into a more mature technological path, it seems to be more effective to rely on established structures of that technology outside of the cluster. Furthermore, the complexity of the new technology and its cognitive proximity from the established technological background of the cluster seem to play a large role when it comes to complex cluster-internal utilization processes. However, cluster-internal networks and capabilities may offer an advantageous background to position the cluster within the established national or global industrial context. The development status of the novel technology and its own specific life cycle is an external factor to the specific cluster development. As supposed by Martin and Sunley (2011), the cluster's development and the development of the novel technology are interrelated with each other but remain to a certain degree independent. However, the degree varies and these findings should not be understood as a neglecting of the arguments from the CLC literature, but better as an enhancement. While in the case of ISOBUS the investigated farm trailer cluster established itself as a central part of the global innovation network with a strong influence of cluster-internal dynamics, the case of biogas shows that a renewing cluster may just take a peripheral position within the national or global context and that this peripheral role resulted in a much stronger external influence. Future research may take a closer look on this interrelationship of clusters, their technologies and the national and global industrial structures in which they are embedded. As clusters have become one of the main instruments for contemporary regional economic development policies, a stronger focus on and better understanding of these nuances may help to find better and pinpointed policy tools when it comes to the renewal of individual clusters.

This study, for sure, has also some limitations. Firstly, the observations come in both cases from engineering industries that rely on similar principles and forms of knowledge (a synthetic knowledge base, Asheim & Coenen, 2005). Thus, it offers only limited explanatory power for differently structured industries from the creative or science-based sectors. Future research on cluster renewal in those industries may also offer a more comprehensive view. Another limitation of the study lies in the possibilities of a qualitative study. 'Hard' facts from a quantitative analysis may offer much more stronger findings. However, the advantage of a qualitative study lies in its ability to reveal new patterns of socio-economic developments. For example, qualitative data offer detailed insights into aspects like firm strategies, perceptions and beliefs that cannot be gained by the use of quantitative data. However, a future quantitative analysis of cluster renewal, for example of patent data, may offer better insights on the diffusion of novelty within and outside of a cluster and other things.

Notes

1. An overview on early approaches is given in Bergman (2008).
2. Although Ter Wal and Boschma (2011) do only point to new geographic contexts, one could also think about the ability of agents to reproduce their routines into new thematic or social contexts.

3. However, Claas produces tractors in another location.
4. Co-evolutionary as in the sense of, for example, Murmann (2003).
5. According to an interviewee more than 50% in spring 2013. However, the author is aware of the fact that this kind of information may be very subjective.
6. The use of ICT in the stable technology sector has a long tradition and dates back to the 1970s. Furthermore, it is strongly related to control technology in plants of other industries.

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