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Cluster Ambidexterity towards Exploration and Exploitation – Strategies and Cluster Management

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Abstract

Cluster studies have shown that innovation can be understood as the result of an inter-organizational process, where a division of labor with regard to exploration and exploitation exists among the actors inside the cluster. A cluster is ambidextrous if it manages to balance innovative activities that exploit existing competencies and is open to novel technological approaches by means of exploration. In this context we are interested in the supportive role of cluster management, assuming that a cluster organization can only persist sustainably if exploitation and exploration are pursued in an appropriate balance. Our analysis is based on surveys that have been conducted between 2011 and 2012 with 10 cluster managements and their respective cluster firms of the first two rounds of the German Leading Edge Cluster Competition. Our results indicate that the demand for services offered by the cluster management depends on companies' strategies with respect to exploration, exploitation and ambidexterity. In turn, the priorities set by the cluster management can be explained by the firm' needs. Accordingly, we argue that the cluster management acts as a service provider helping the cluster companies to become ambidextrous which in turn makes the cluster as a whole ambidextrous.

Keywords: Cluster, Ambidexterity, Cluster Management, Exploration, Exploitation

JEL Classification: O30, O32, O38, R11

1. Introduction

Innovative firms develop their knowledge base in two directions in order to stay competitive over a longer time period: Firstly, existing products are constantly refined and the efficiency of production processes is increased. Secondly, in order to be competitive in the long run, firms explore new technological paths to develop new capacities that bring future revenue (O'Reilly & Tushman, 2004). This ability to pursue exploration as well as exploitation at the same time is called ambidexterity, a concept that was originally developed by Duncan (1976) and March (1991). However, it is not easy for firms to pursue both types of activity at the same time (March, 1991).

As local cooperation in clusters facilitates learning and knowledge flows between local actors and enhances cooperative activities (Porter, 1998), we ask to which extent firms can and actually do use cooperation in cluster structures both for exploitation and exploration. In general, cluster cooperation can be useful in both respects: (i) Cooperation in clusters can help firms to improve their knowledge base with, however, the danger that too much focus is given to further developing existing competences. (ii) Cooperation in clusters can also give new impulses that lead to new competences required for the development of completely new products (e.g. by cooperating with firms from other industries or by learning about new developments from science through cooperation in the cluster region with universities or research institutes).

Many studies investigate clusters from the perspective of organic development of competences (e.g. Keeble & Wilkinson, 1999; Fornahl, Hassink, & Menzel, 2015): in local cooperation along the value-added chain, firms develop their existing competences and are able to increase competitiveness by cooperating within the cluster region. However, the question is not far-fetched, whether and under what conditions cooperation in clusters can contribute to competitiveness of the cluster regions. Thus, by not investigating the individual firm but the local cluster, we can shift perspective and ask whether a cluster is ambidextrous, which increases the probability that the cluster region develops successfully also in the long run. Kauppila (2007) argues that this can possibly happen in two ways: First the cluster becomes ambidextrous when each and all actors are ambidextrous. Second, the network in sum becomes ambidextrous as each actor concentrates on either exploration or exploitation. In this case, either firms that concentrate in exploitation incorporate knowledge from actors focusing on exploration (either via mergers and acquisitions or via contracts). Alternatively, competition may force unsuccessful firms out of the business (either such firms that concentrate on exploitation or exploration) but the cluster in total adapts in a dynamic process and survives as the environment changes. Of course, firm cluster dynamics in reality will often be more complex and comprise of several "in-between" strategies of survival. Thus, a cluster is ambidextrous if it

features a mix of activities towards exploitation and exploration that allows the cluster in total to obtain profits in the short-term and at the same time to stay competitive in the long run.

Cluster policies influence these cluster dynamics by giving an impulse for the development of cluster organizations and by directly influencing cooperation behavior. The design of cluster policies determines some framework conditions for firm activities and therefore might also influence strategies that address the challenges of ambidexterity. In such a setting, cluster management organizations are intermediaries that directly address the needs of cluster actors (also in respect to ambidexterity in cooperation strategies).

We conduct our study on cluster ambidexterity among participants of a recent, large scale cluster policy in Germany. The “Spitzencluster-Wettbewerb” (Leading-Edge Cluster Competition – LECC) encouraged applicants – cluster initiatives of firms, public research organizations and other organizations – to agree on a common strategy in order to utilize unused development potential. This funding tournament provided an impulse towards the development of efficient cluster organizations. At the same time, cooperative research projects between cluster actors were funded. Since the LECC required the applicants to develop a common strategy and promoted regional development, the question arises whether the cluster firms used cooperation in the LECC initiatives in order to better cope with the institutional challenges of creating an environment that allows the individual firm or the total cluster to be ambidextrous.

On that background, we analyze how cluster cooperation patterns in the leading-edge clusters relate to actors’ cooperation strategies in respect to exploration and exploitation and ask how cluster organizations can contribute to ambidexterity in clusters. In section 2, we discuss the concept of ambidexterity from a theoretical viewpoint and ask how cooperation in clusters can support both exploitation and exploration at the firm and cluster level. Section 3 presents the data and in section 4, we analyze how cooperation activities of firms in the LECC networks in general are used to pursue exploration and exploitation, and we look at how they focus their cooperation within the LECC networks on exploitation and/or exploration. Then, we analyze the role played by cluster management organizations in pursuing exploitation and exploration strategies. Section 5 concludes.

2. Ambidexterity as an organizational and cluster-level strategy

Exploration, exploitation and ambidexterity

The long term innovation dynamics of exploration and exploitation can be displayed within the stylized model of a life cycle of innovation (March, 1991; Nooteboom, 2000). The life cycle can be observed not necessarily within one organization but rather across the boundaries of single organizations. At the same time, the process is less a logic sequence of predefined events but rather an iterative one that can take different forms (in respect to timing, phases, and

involvement of actors). Exploration is devoted to the search for knowledge and disruptive innovation while exploitation focuses on the commercialization and gradual improvement of results out of explorative activities.

Both types of activities pose different challenges for firms depending on the sector or technology field. However, there are also similarities that can be discussed from a system perspective. In *exploitation*, a product or production process is optimized within a fixed “domain” (a representation of the relevant world, Arthur, 2009, pp. 79–80) that comprises certain technologies which are used as a toolbox, pieces of hardware and software, and also fixed rules and practices. So, the focus is on increasing the effectiveness of a given system (whether it is a plant or a vehicle component) within a fixed domain. The challenge is to improve parts of that system by using the tools available in this domain and – at the same time – keeping in mind the effect of these changes on other parts of the system, the system as a whole and its performance. So expertise is needed in knowing how to improve parts (e.g. material characteristics) and how to assess the feedbacks within the whole system.

In contrast, *exploration* requires openness and disengagement from current solutions in order to search for new possibilities to create a totally new system. Therefore, a change in the relevant “domain” that is used for the development of new products and the optimization of production processes. This new domain also requires the use of technologies and rules in the design of products and production processes. Experimenting with innovative alternatives and flexibility is required, and also being prepared that it is very likely that some routes of innovation will not be successful.

Ambidexterity at the firm level

The challenge of aligning long-term development of new competences and market fields with present revenue from an existing knowledge base becomes obvious by looking at the situation from a resource-based view of firm development: a firm’s knowledge base, which is unique and difficult to imitate, constitutes a key competitive advantage (Grant & Baden-Fuller, 1995). Firms seek to create internal knowledge but cannot neglect to assimilate external knowledge in a sufficient way (Zahra & George, 2002). Therefore, collaborative activities – which are useful to gain access to the knowledge of the cooperation partner (or to pool knowledge in a research project) – are an important way to enrich and make the best use of the most crucial resource of a firm, namely the knowledge base.

From this perspective, implementing the concept of ambidexterity implies a combination of organizational routines, resources or capabilities that to some degree contradict each other, organizational efficiency on the one hand and organizational flexibility on the other (e.g. Adler, Goldoftas, & Levine, 1999; Raisch, Birkinshaw, Probst, & Tushman, 2009). In innovation and related search activities, the basic problem for a firm is to accomplish sufficient exploitation of

known options to secure current profits and at the same time to explore new options in order to safeguard future revenues, keeping in mind the different framework conditions needed for both and to develop organizational structures that allow for combining these tasks.

How to successfully pursue these two directions at the same time has been discussed in organization science since Burns and Stalker (1961). A first line of research argues that a firm itself is required to pursue both aims at the same time, thus being purely ambidextrous, in order to gain a sustainable competitive advantage (Gibson & Birkinshaw, 2004). Cohen and Levinthal (1990) argue that firms need to do research in some respect in order to make use of new knowledge. From that observation one could infer that firms need to pursue both exploitation and exploration in order to keep the level of internal knowledge high enough to understand and use knowledge from outside. Thus, firms that do not explore new technological possibilities would not be able to integrate the other side of the continuum since they would lack absorptive capacities.

Alternatively, according to O'Reilly and Tushman (2004), exploration and exploitation are considered enormous complex and opposing concepts such that firms might gain from specializing in the one or the other. For a long-term prosperous development, this would require firms specialized in exploitation to interact with firms that rather explore and vice versa – a division of labor. One reason for the difficulty of pursuing exploitation and exploration at the same time is that they require different organizational structures. Exploration benefits from a decentralized and organic design whereas successful exploitation environments are rather centralized and mechanistic (Boumgarden, Nickerson, & Zenger, 2012; O'Reilly & Tushman, 2008). Usually, firms devote most of their activities to exploiting their existing knowledge base that creates short- to medium-term revenue and profit, while only a small fraction of effort goes into exploration of new ventures. Thus, firms do not pursue both paths with the same intensity and not always simultaneously (Gilsing & Nooteboom, 2006).

Firms can also try to “externalize” a part of the process in exploration: Ferrary (2011) comes to the conclusion that this specialization model can also describe firm behavior with respect to the use of new knowledge sources: He shows that Cisco Systems has been able to successfully grow although it has been specialized on exploitation. Thanks to its close ties to venture capital firms and start-ups in Silicon Valley, Cisco was integrating new knowledge by mergers and acquisitions of highly explorative start-ups. However, based on the discussion above, still some important activities stay within the firm: These are the monitoring of new technologies and other relevant factors and the competences needed to select between the different possibilities. As the discussion above has shown, addressing both the demands of exploration and exploitation is crucial for long-term firm survival. However, as Lavie, Stettner, and Tushman (2010) show in their literature review, balancing both kinds of activities is a complex task. Different organizational solutions are discussed for the separation and/or balancing of both types of

activities with no superior organization structure arising (Lavie et al., 2010, pp. 129–135; Nooteboom, 2000, pp. 261–263).

From the discussion it becomes clear, that external sources of knowledge (from within the cluster or other sources) can be important both in exploration and in exploitation. In exploitation, they enable the individual firm to pursue their goals within a domain (i) by commonly created solutions in user-producer relations or (ii) by providing external expertise that is needed to refine a product (e.g. by optimizing material characteristics or design). In exploration, external sources are important especially (i) for the creation of new ideas, (ii) for the common R&D projects that pursue new ideas by combining different technologies under a new technological (or market, distribution etc.) regime, (iii) for a creative environment that large firms can use as “breeding ground” for new ideas which are followed by new ventures.

Based on these considerations, the following section focuses on the role that cooperation in clusters can play both in exploitation and in exploration within the mentioned steps of implementing new routes for technological progress.

Ambidexterity at the cluster level

Even though the core of the knowledge base lies within individual firms, cooperation activities play a key role for the development of internal knowledge and for long-term competitiveness. Thus, innovation often results from an inter-organizational process, with a division of labor regarding exploration and exploitation among the actors inside a cluster (Chesbrough & Appleyard, 2007; Ferrary & Granovetter, 2009; Porter, 1998). Therefore, it seems obvious to analyze cooperation in clusters by looking at R&D networking between regional actors with a focus on ambidexterity. When we look at *ambidexterity of a cluster*, the focus is on the existence and the form of division of labor activities in respect to exploration and exploitation.

According to Kauppila (2007) a cluster can be ambidextrous in two ways. First of all, firms can be specialized either in exploration or in exploitation such that the network as a composite of its parts (firms) is ambidextrous. This would mean that the nodes are either ‘explorer’ or ‘exploiter’ while the network becomes ambidextrous. One could say that according to this view, the firms are making the cluster R&D network ambidextrous by serving different functions of the innovation process (Kauppila, 2007). The alternative way how clusters could function with respect to ambidexterity is that all or most firms engage in both, exploration and exploitation, such that each firm (each node of the network) is ambidextrous by itself. The alternative way how clusters could function with respect to ambidexterity is that all or most firms engage in both, exploration and exploitation, such that each firm (each node of the network) is ambidextrous by itself. According to Kauppila (2007), this idea follows Gibson and Birkinshaw’s (2004) proposition, where employees embody ambidexterity which manifests itself at the level

of the organization. Thus, Kauppila (2007) concludes that if each firm in the cluster is ambidextrous, also the network is ambidextrous.

There is still no definite answer to the question, which of the two models is superior, on the organizational as well as on the cluster level. It might turn out that both work conditional on the circumstances they meet also with respect to the sector the firms are active in (Bocquet & Mothe, 2015). Both models assume that it is nearly impossible for a single firm to pursue exploration and exploitation with the same intensity since both require activities and strategies that are too contradictory. Kauppila (2007) argues that the notion that firms are in general ambidextrous might be more appropriate. By accessing resources of other actors, companies are able to avoid the problems that occur in trying to be ambidextrous. To some degree, they “outsource” explorative or exploitative activities and become ambidextrous in the way that their network activities actively pursue both kinds of activities. Clusters that comprise of such firms are ambidextrous as their individual actors’ networks (whether within the cluster or beyond) are ambidextrous.

The role of cluster management for cluster ambidexterity

In cluster initiatives, actors within the cluster regions join forces in order to pursue common goals and develop a common strategy. The organizational framework for this cooperation is given by a cluster organization that usually comprises boards that decide on strategical and operational issues and a cluster management that takes over several tasks to foster the common strategy and the development of the initiative. Within that context, cluster policies foster the development of clusters and individual actors in several ways. Especially, they set incentives and finance cluster initiatives and related cluster organizations to support cooperation in the cluster regions.

The activities of these cluster organizations can influence both exploitation and exploration in the cluster and thus contribute to the ambidexterity of the individual firms and the cluster in total by stimulating the development of clusters in several ways (Gilsing, 2000; Maskell, 2001). They can set impulses on different levels of cluster activities:

- At the *project level*, the cluster initiative can foster common projects (R&D and innovation projects) that either can contribute to the further development of existing competencies within the cluster or the development of new competencies and explore future possibilities of cluster development.
- At the *actor level*, firms can use the cluster network and the cluster organization either to develop their existing competencies (by refining products or production processes) or to look for new competencies (e.g. by working together on new topics that may develop into future markets). For the individual firms, the cooperation in clusters for new topics has the advantages (i) that new views can be incorporated by working together with

other actors, (ii) that it is easier to gain information on new trends in markets or in technology from other actors and (iii) the cluster organization creates a framework that is not so much dominated by strict routines as it is often the case within the individual firm.

- At the level of the *cluster organizations*, a common strategy (or common goals) can be pursued which either is related to further developing existing technologies or creating new routes for innovation. This can be done within the cluster initiative or in cooperation within the cluster regions (e.g. by universities and research institutes searching for totally new products and to create new markets), but also in cooperation with other cluster organizations in other regions (or even in the same region as is the case when e.g. clusters for aircraft technology and wind park technologies work together in respect to the development of new materials and the creation of new markets with these technologies).

In our analysis, we look at the potentially supportive role of cluster managements and on ambidexterity in and of clusters. By pursuing a common strategy and supporting individual actors, the cluster managements play an important role for the development of the cluster initiatives and therefore deserve special attention. The role of management for ambidexterity in firms was discussed in some studies: for example Levinthal and March (1993) argue that knowledge of individuals should be managed in a way that some of them can pursue flexibility and search for new knowledge while others go for efficiency and the use of already existing knowledge. Translating this to a cluster perspective the task of a cluster initiative would be to coordinate the interaction among the specialized actors. Bocquet and Mothe (2015) address the cluster level in arguing more in favor of a cluster's absorptive capacities; they suggest that a cluster management enhances potential and realized absorptive capacities by managing external knowledge flows into the cluster. In this framework, a cluster management is supposed to provide skills and processing abilities to support acquisition, assimilation, transformation and exploitation of knowledge. Here the role a cluster management assumes is less moderating and supportive but rather leadership oriented and strategic.

One certainly might question the view of the cluster management as an institution having a hand in all the relations among the cluster actors and beyond, being aware of all their needs and bottlenecks, and being able to guide and strategically position the cluster actors appropriately. Having considerable doubts about such a design, we argue in a different direction and consider a cluster management rather as a service organization which is oriented towards the needs of its members and which is continuously adapting its services in response to cluster dynamics. For example, the cluster management handbook suggests a joint network management by all partners in order to coordinate cluster activities, to handle internal and external networking as well as to develop a common image to the public and the markets as crucial for the success of a cluster (Scheer & von Zallinger, 2007). Accordingly, a cluster can only

persist sustainably if the cluster management succeeds in developing and offering services which address the needs and bottlenecks of the businesses – this is quite a customer oriented design.

Applying this to our context of ambidexterity, a cluster management can foster a cluster's ambidexterity by providing services that facilitate the R&D activities of cluster actors (firms). However, the direction (exploration or exploitation) that is fostered by the cluster organisation has to take into account actors' needs. If the firms themselves should be ambidextrous, the services they demand from the cluster management will serve both strategies: exploitation and exploration. By this, the cluster management is also sustaining the firms to do what Bocquet and Mothe (2015) propose: kindly handle external knowledge into the cluster, but more in an indirect way. On that background, our paper takes a closer look at core aspects of ambidexterity at the level of the cluster actors and their relation to the cluster managements.

3. Data and Methods

Cluster Initiatives in the Leading-Edge Cluster Competition

The funding instrument LECC followed a bottom-up strategy. Cluster initiatives from all regions of Germany could apply in a competition for being selected as Leading-Edge Cluster and receiving the financial funds that could be used for projects (mainly R&D projects). In a two-stage process that involved a jury suggestion, the awarded clusters were chosen based on an outline of the cluster (first stage) and a comprehensive strategy paper (second stage). Within the context of the funding instrument, the cluster initiative could address ambidexterity on the strategy level. The program required the members of the cluster initiatives to set mid-term and long term targets (for the following years) and to develop a common strategy.¹ The program documents required that future market and technical developments are discussed and that targets with respect to common research and innovation are set. Especially, the applicants were also required to address the role of disruptive technologies for cluster development and discuss whether "leap innovations", i.e. the development of completely new products or production processes were necessary in order to stay competitive.

Thus, competition enables the actors to follow a strategy which is partly focused on exploitation but also sets the preconditions to address questions in respect to explorative activities. During the selection process, the jury discussed, whether individual clusters were focusing on strategies that relied on new research activities in comparison to what had been done before and if they address long-term strategy elements of the clusters. In practice, the strategies of the winner clusters represented a mix of strategies that aim at both, exploration and exploitation.

¹ The programme requirements are described in the official guideline for proposals (BMBF, 2010).

Different strategies with respect to exploration and exploitation on the cluster strategy level can be illustrated by the following examples. The LECC awarded 'Software-Cluster' provides a good case for mixed strategies of clusters.² The Software-Cluster developed around SAP, one of the two world-leading firms that supply software for the handling of business processes. In the past, a "monolithic" software with different modules for individual applications constituted the core of SAP's product portfolio. Within a given domain, this software was optimized, extended by other modules, and adapted to the needs of different firms. This was done not only by SAP but also by other firms that closely cooperate with SAP, many of which are located in the cluster region close to SAP.

A new domain developed as a result of exploitation, in search for a possible future design of business software. Since software in other fields (in consumer products such as smartphones and tablets) was increasingly used as a platform for application software (apps) developed by other software firms, the question arose, whether such a development would also take place in business software. This would require the development of a new and radically different domain. SAP would supply a platform technology and make sure that the interface for software created by other firms would work. As this platform (SAP NetWeaver) has been developed, this new software generation also requires changes in the market structure. Firms are needed (especially in the cluster region) that supply the business apps that are used by the customers. Thus, the changes in the domain require different characteristics of the software, a different business model (supplying a platform vs. supplying a fully developed product that has to be adapted to the needs of the customer), and changes in the structure and relationship between actors in the cluster. As it is not yet clear whether this new model of business software will succeed in the long-run, the future of the cluster depends on the "right" strategy in respect to the "old" and "new" domain.

Specialization in exploration can be observed in the cluster Forum Organic Electronics which addresses future markets for innovations that use technologies within the field of Organic Electronics. These technologies still have to be developed and markets do not yet exist. Thus, both with respect to the cluster and the individual firms, the cluster activities focus on the exploration of future market innovations with no direct relation to existing exploitative activities. The strategy of the cluster Microtec Südwest illustrates specialization in exploitation. The strategy of Microtec Südwest focuses mainly on the application of microelectronic devices in the automobile industry, a technology which is already well established in that industry. This

² The description of this supposed development towards a new generation of software (called "emergent" software originates from the cluster strategy document of the software cluster (p.23, Strategy Document, October 8, 2009). Additional information was collected in several expert interviews with the cluster representatives (both cluster management, cluster board and cluster members).

primary focus of cluster activities is supplemented by a secondary focus on medical applications, a field, in which a far greater potential for new applications is expected. In general, the strategies of many clusters address future challenges that require exploration (eco-efficient computers, the future of airplanes, next generation of business software) but also allow for exploitative activities and projects.

This is also reflected in the mix of R&D projects that were initiated within the cluster strategies. For single R&D projects, the question whether they pursue targets with respect to exploration or exploitation was assessed by asking the project managers, whether the project itself aims at a radically new solutions and/or innovations (five categories from “strongly agree” to “strongly disagree”).³ 12% of the project managers of the first two rounds strongly agree that their project aims at something radically new, while another 20% agree. As such, the majority of the projects aim at innovation results that are not completely new. This finding is strengthened by anecdotal evidence collected during interviews with selected project managers. While some projects in each cluster address fundamentally new applications, most of them aim at results that exploit and amend the existing knowledge base rather than focusing on exploration.

Data

Our analyses are based on data collected in several surveys and structured interviews, which are presented in a special section in the appendix. For the econometric analysis, we use data of two surveys. One survey addressed the cluster management organizations, the other one was answered by representatives of the firms that received funding within the first two rounds of the LECC. These 10 clusters are specialized in a variety of technologies and/or industries, namely biotechnology, semiconductors, organic electronics, logistics, aviation, medical technology, microelectronics, software and photovoltaics.

The data was collected via standardized questionnaires in 2011 and 2012. The cluster management provided information on cluster management activities, financial and employee data as well as on the number of cluster actors, recent fluctuation and technological embeddedness. The cluster members were asked to provide general information about the firm, on their innovative activities and success and, most important for our research question, information on the activities of the cluster management and its evaluation.

Altogether, the data set on cluster firms comprises 229 observations, all of them funding recipients that are associated with one of the 10 clusters of the first two rounds of the LECC. Below, we describe the variables that we used from the two surveys. An overview on the variables and their characteristics is provided in table 5 in the appendix.

³ See appendix for a description of the different data sources and their collection.

Exploration

The variable *Exploration* is based on answers to the question: *How important is the 'development of new technological fields' as motif for your cooperative R&D activities?* The answer to this question had to be specified according to a 5 point scale, where 5 means 'very important' and 1 means 'unimportant'. Therefore, a high value of this variable indicates that the firm is stressing explorative activities in its R&D strategy.

Exploitation

The variable *Exploitation* is based on answers to the question: *How important is the 'deepening of existing competencies' as motif for your cooperative R&D activities?* Again the answer to this question could have ranged between 1 and 5, where 5 means 'very important' and 1 means 'unimportant'.

Pure Ambidexterity

The dummy variable *PureAmbidexTech* combines the two variables *exploration* and *exploitation*. Specifically, *PureAmbidexTech* is equal to one if *exploration* and *exploitation* are very important or important (rated with 1 or 2) and zero otherwise (see highlighted area in the lower left of figure 1). Therefore, this variable measures whether the firms are stressing both activities within their R&D strategy in the same way and therefore are purely ambidextrous.

[figure 1 (The two ends of the ambidexterity continuum) about here]

Continuum Ambidexterity

As described above, ambidexterity lies on a continuum between specialization in exploration and exploitation respectively. To display this in form of a variable, we created the variable *ContAmbidex* out of the two variables *exploration* and *exploitation* by subtracting these two from each other and excluding those observations where both items have the same irrelevance (which means that the values are 4 or 5, top right area "X" in figure 1). In the variable *ContAmbidex*, a value of -4 indicates specialization in exploration (exploration = 1 and exploitation = 5) and the value of +4 specialization in exploitation (exploration = 5 and exploitation = 1). This indicator is centered at 0, i.e. for cases where both dimension are of equal relevance.

Cluster management services

The basic aim of this paper is to find out in how far the cluster management is aligning its services with the needs of the cluster actors with regards to ambidexterity.

With regards to these activities and services, the cluster managements as well as the cluster actors were asked several questions. First, in order to find out about the supply of services in a cluster, the cluster management was asked about the importance of offering specific services. Possible answers ranged between 1 (very important) and 5 (unimportant) for each of the services listed in table 1, which gives the number of clusters that provide a specific service, the mean relevance among those clusters offering the service and the mean share of actors that demand such a service.

[table 1 (Descriptive overview on the services as provided by the cluster management) about here]

Second, we asked the cluster actors whether they are in need of or have a demand in a certain service of the cluster management. These became binary variables according to the variables indicated above: *Need_R&D/Infrastructure*, *Need_Qualification/Education*, *Need_Events for cluster actors*, *Need_Public relations*, *Need_Consulting R&D funding*, *Need_Networking within the cluster*, *Need_IT Platform*, *Need_Contact to funding agency of LECC*, *Need_Contact to external actors*, *Need_Networking with other clusters* and *Need_International contacts*.

Controls

We use cluster dummies to control for technological fields and account for firm size with the variable *SME*, which is equal to one if the firm is small or medium sized and zero if it is a large company. Also, firm's evaluation of the overall benefits of the Leading Edge Cluster Competition might indicate the degree of identification with the cluster strategy and influence the demand for cluster management services. Therefore, we used the variable *Benefits/Costs LECC* as additional control. This variable is based on answers to the question: *How do you evaluate today, the relation between benefits and costs for your company of attending in the Leading Edge Cluster Competition?* The answers could range between 1 (costs exceed the benefits) and 5 (benefits exceed the costs). The variable *Member of other cluster* is of a binary nature and indicates whether the firm is also member of another cluster organization. Finally, we control

for experience in joint R&D (*Experience in cooperation*) since experienced firms might require other services than firms which have not cooperated in R&D before.

In the following section, we analyze the aspects of cluster cooperation, cluster organizations and their influence on ambidexterity empirically. This can be done from three perspectives: First of all, we ask from the perspective of the individual firm, how cluster cooperation contributes to ambidexterity at the firm level. Secondly, we analyze, whether and under which conditions a cluster as such can be assessed to be ambidextrous, being able to cope with external threats to long-term development. Thirdly, we look at the cluster management as a core organizational unit of cluster organizations and at how the cluster management contributes to cluster ambidexterity.

4. Analysis

Firm Ambidexterity and cluster cooperation

As discussed in chapter 2, external sources of knowledge can be important for exploration as well as exploitation. Therefore, we look at the R&D cooperation patterns of cluster firms and the role that exploration and exploitation play in cooperation (a) in general and (b) within the LECC context.⁴ Again, cooperation within the cluster and in general can be used to amend the existing knowledge stock or to look for new paths. While the programme encourages a long-term view and search for new routes of technology and market development, we expect different motives for LECC collaborations and others. Our information on motives for R&D cooperation (both qualitative and quantitative) allow us to analyze to what extent cluster firms use the regional knowledge base differently from the knowledge base in other regions. The analysis is based on the question whether the firms use within cluster cooperation and cooperation in general to deepen their core competencies or to develop new research fields (as motive for performing R&D cooperation). As the answers of the firm representatives show, R&D cooperation both within the cluster and in general is assessed to be more important with respect to exploitation than to exploration. When rated from 1 (very important) to 5 (unimportant), firm representatives value exploration with 2.6 on average and exploitation with 2.1 (similar for cluster-internal cooperation). This is in line with the observation that firms in general often emphasize exploitation more in their R&D activities (see section 2).

When we examine the difference between the assessment of within-cluster R&D cooperation and R&D cooperation in general for individual firms, we only find slight differences: Most firms do not assess within-cluster cooperation and cooperation beyond differently when it comes to

⁴ The analysis here is based on answers on a written survey from 112 firms that participated in the 2nd round of the LECC (from the year 2010).

its importance for exploration. The same holds for exploitation. We cannot find the expected substantial difference (beyond-cluster cooperation are not more important in respect to exploration). 67% of all firms give exploration the same rate for within-cluster cooperation and R&D cooperation in general. With respect to exploitation, even 79% of all firms do not rate within-cluster cooperation differently from cooperation beyond the cluster regions.⁵

This observation is also in line with the results from our expert interviews which also show certain patterns of behavior in regional R&D cooperation that explain why cluster cooperation is rather important not only for exploitation but also for exploration:

- We could observe firms that looked for new impulses within the LECC regions by searching for new firms from completely other industries. These firms can be found more easily within the cluster regions than beyond. They may allow e.g. entering new markets by transferring projects to other industries or new impulses through cooperation with firms that provide knowledge on new technologies (e.g. 3d printing).
- Many firms also use cluster cooperation (especially with universities and research institutes) as a hub for collecting information on new technological developments. Within the R&D cooperation projects, the possibilities of these new technologies are tested out, and later, the firms often perform internal projects in order to adapt results internally. This pattern is especially important for SMEs but also large firms use this channel for being informed about new developments.
- The cluster initiatives themselves and the LECC both contributed to the relatively high importance of cluster activities for exploration as the cluster strategies in all cases address topics that are of long-term importance for the exploration of future technologies and markets.

These results indicate that local cluster cooperation – in contrast to the first hindsight – does in fact contribute significantly not only to exploitation but also to exploration at the firm level.

Other than ambidexterity on the firm level, cluster ambidexterity relates to the mix of exploration and exploitation in cluster activities. Our empirical analysis of cluster ambidexterity proceeds along a distinction at the structural level of clusters as suggested by Kauppila (2007). He proposes two models of network ambidexterity: in model A each firm of the network specializes either on exploration or on exploitation and the network as a composite shows varying degrees of ambidexterity depending on these firm strategies; in model B, each firm engages in both, exploration and exploitation, such that each firm has its own, specific degree of ambidexterity. We have to note that previous studies usually analyze the general R&D strategy

⁵ The correlation between both variables - assessment of the importance exploration (exploitation) within the cluster context and in general – also is positive and highly significant.

of firms with respect to ambidexterity. We take a slightly different avenue and concentrate our analyses on the question in how far firms use R&D cooperation in order to pursue exploitation and exploration strategies, which is of course part of the whole R&D strategy of the firm.

Classifying clusters

In a first step, we classify clusters as type A or type B in our dataset. In order to do this, we use the variable *ContAmbidex* which indicates the degree of ambidexterity of the cluster firms' R&D strategy. Table 2 delivers the distribution of this ambidexterity variable for all firms within the ten LECC clusters.

[table 2 (Distribution of Ambidexterity in Clusters) about here]

Table 2 shows that within each cluster as well as for all clusters together, most of the firms are ambidextrous in the sense that they devote the same (or a slightly different) relevance to exploration and exploitation. The majority of firms falls in the range between (-1) and (1) in each cluster (on the cluster level between 65% and 100%; and overall 73%). If we examine the observations that depart from the center we see that almost all of these specialized firms (overall 24% and between 0% and 33% on the cluster level) tend to be ambidextrous towards exploitation. We find only two cases, where firms have a priority in exploitation and do not do explore at all such that they reach a value of 4 in the *ContAmbidex* variable. Bringing these first descriptive results together with Kauppila's (2007) models of network ambidexterity, we find that the ten LECC clusters are rather of a model B type. This means that the majority of firms follow an ambidextrous strategy in their research activities.

Demand for cluster management services

We have argued above that the cluster management can be seen as an agency offering different services for the cluster agents. On that background, we take a look at the services provided by the cluster managements and their relation to the cooperation strategies of the individual actors. As there is in general no market for these services and no market prices are paid for by the cluster actors, it is not clear whether these services relate to the demand from the individual actors. However, there are other mechanisms that can safeguard for these services to be closely related towards what the individual actors expect: First of all, all clusters have established cluster boards with firm representatives as members that accompany the activities and services of the cluster managements. Secondly, the clusters depend on the membership and active participation of the relevant firms which itself depends on their assessment of the benefits associated with cluster membership. Thus, the services supplied by the cluster should

also reflect the demand of its participants. This is what we want to test in our analysis. This analysis can also be taken as a kind of test of Bocquet and Mothe's (2015) model since it might occur that we do not find a relationship between ambidexterity strategies of the actors and cluster management activities.

In order to explore this dimension, we want to find out which services firms require to be offered by their cluster management, depending on their strategy with respect to exploration, exploitation and ambidexterity. Table 3 shows the results of logistic regressions for each of the 11 types of services described above. We are particularly interested in how the firm strategies of exploration and exploitation as well as the ambidextrous strategy are related to them, controlling for additional firm characteristics such as firm size, cluster affiliation, cooperation experience, membership in other clusters and the perceived benefit from the LECC.

[table 3 (Logistic regression on the influence of a firms R&D strategy on its demand for cluster management services) about here]

Based on the different services of the cluster management, we analyze whether firms with a certain focus in respect to exploitation or exploration demand (i) general services, such as qualification measures or a common R&D infrastructure, (ii) services that aim at improving cluster-internal cooperation and networking (contacts to funding agency for common projects, internal networking) or (iii) services that aim at external relations for new impulses (like international contacts or contacts to other clusters). In general, these different services often can be used both in activities that relate to exploitation or exploration. However, we can test whether firms that aim at exploitation in their research cooperation search assistance more in cluster-internal activities while firms that aim at exploration in their cooperation activities demand services in respect to cross-cluster activities.

Focusing on the research strategies, we find that purely ambidextrous firms show a need for R&D infrastructure but compared to firms that are more specialized in their research strategy they do not need the cluster management to provide networking with other clusters and international contacts. Firms that view exploration as an important motive to cooperate need cluster management services with respect to activities that provide them with new R&D financing sources (consulting with respect to R&D funding and contacts to the funding agency), with respect to help in networking with other clusters and international contacts and they want to have the cluster management to do public relations. Thus, the cluster management seems to have a special role for making contacts with actors in other clusters who might add new

impulses for research. Firms that concentrate on exploitation (recall that this is the majority of the not purely ambidextrous firms) do not need the cluster management to provide an IT-platform for knowledge exchange – which might be a special feature of our dataset. As we know from our interviews, the use and benefit of these IT-platforms often suffers from data quality issues. Apart from that, no special demands of firms aiming at exploitation can be identified.

To sum up, we find that depending on the individual strategy, firms have different needs with respect to the services offered by the cluster management organizations. Firms that focus on exploration use the help from the cluster managements especially in order to come into contact with cluster-external actors.

Cluster management response to firm demand for services

The preceding estimations aimed at explaining to which extent exploration and exploitation strategies are driving demand for services provided by the cluster management. In a final step, we now bring together the strategy driven demand of the firms with the actual management supply and ask: *To what extent is the cluster management organization orienting its service to the needs of its cluster's actors?* In an OLS regression, we use as a dependent variable the cluster management's evaluation of the priority of a certain service; here the answers ranged from 1 for a very high to 5 for a very low priority. Since the demand of a specific service depends on several characteristics of the firm, we explain this priority with the fitted needs of the actors. For the needs, we use the fitted values of the estimations in table 3 which gives us the probability of having a demand for this service given the individual R&D strategy and given some other characteristics like size, cluster membership and so on (see table 3). Table 4 shows the results. For each service, we estimate three different models. In model 1, we use the fitted value of the demand of each service in order to explain the supply of this service (*Fit_Need_...Service*). Since we lose some observations when generating the fitted values due to missing values, we also used models 2 and 3 as a robustness check. In model 2, we take either the fitted value or the true value of the demand as explanation for the supply (*True/Fit_Need_...Service*). In model 3, we explain the supply of a certain service with the true value of the demand (*Need_...Service*).⁶

[table 4 (OLS regression of the firms' demand on the cluster management's perceived relevance of services) about here]

⁶ Our robustness checks either reinforce the results from model 1 estimations or show up not significant.

Referring to the results of models 1, we find that overall (in 7 out of 11 cases) the cluster management organizations indeed orient their services along the needs of the firms (as indicated by a negative and significant coefficient). The argument by Bocquet and Mothe (2015) that a cluster management is an intermediary for the fulfillment of ambidexterity strategies of cluster firms seems to find support here. In detail, we find that a need on the side of the firms is positively related with a high priority for the cluster management for the following services: R&D infrastructure, events for the cluster members, consulting with regards to R&D funding opportunities, contact to the funding agency of the 'leading edge cluster competition', networking with actors outside the cluster and arrangement of international contacts. For the service 'networking with other cluster members' we find a negative effect (a higher need correlates with less prioritization). This surprising result can be explained by the fact that all cluster managements give a priority of 1 and 2 to this service, which are actually the two highest possible values. But in the regression, 1 is the 'good' while 2 is the 'bad' value and the variance of this variable is very low. Since in our data a high need for this service on the side of the firms is usually combined with a priority of 2 on the side of the cluster management a positive coefficient and hence a negative relationship is not surprising at all.

These results are also confirmed by the expert interviews both with firm and cluster management representatives. Cluster managements closely orient their services towards the needs of the cluster firms and therefore also support the strategies of the individual firms towards ambidexterity. The relation results from the fact that cluster management activities are oriented towards the cluster strategies. In some cases, also activities were started with a special focus on exploration (this is the case in one cluster where a knowledge management tool was developed with that goal).

5. Conclusions

A rich literature on the topic ambidexterity shows that addressing the conflicting demands of exploiting the existing knowledge base and developing new routes (exploration) is one core task for long-term firm survival. A closer look into the preconditions for both kinds of activities shows that it is rather difficult to pursue both of them within one firm. This has especially to do with the change in domain (rules and instruments used for solving R&D problems) which is required by switching from exploitation to exploration.

Recently, some studies looked at the role of clusters for achieving ambidexterity. Cluster ambidexterity can have different meanings which we analyze in this paper: Cluster cooperation can contribute to competitiveness of individual firms either by promoting exploitation or exploration. As firms closely cooperate in a cluster, their patterns of ambidexterity also influence the degree of ambidexterity of the total cluster. Cluster initiatives and – more

specifically – cluster managements that are promoted by cluster policies can contribute to cluster ambidexterity. Our empirical analysis contributes to this literature and explores the influence of cluster management on the ambidexterity of a cluster and among cluster firms.

The clusters that host cluster initiatives which were successful in the LECC are well suited for the analysis of cluster ambidexterity in respect to individual cluster firms, clusters and to the role of cluster initiatives. The LECC required the cluster actors to develop a common cluster strategy that also addresses the development of disruptive innovations. Consequently, a substantial share of the R&D cooperation projects that were funded by the programme aimed at developing completely new products.

When we take a deeper look at the *contribution of cluster activity to the ambidexterity of individual firms*, several common activities are related either to exploitation or to exploration. Parallel to production along the value-added chain, a constant effort to improve existing products and production processes is part of the common cluster activities. This relates to different kinds of activities as improving existing products and processes, coordination of innovation activities along the value added chain and searching for common solutions that come up in production processes.

At the same time, activities that relate to exploration can be part of common cluster activities. Firms may use cluster activities to scan their environment for new technological possibilities (either by gaining information from cluster organizations, by holding contact with universities and research institutes or by looking for the success of high-tech ventures in the cluster regions. Also R&D cooperations within the cluster could be important for developing completely new products by joining knowledge with other actors within the cluster.

In respect to cluster ambidexterity, different concepts have been discussed. Especially, it was not clear, which individual strategies were followed by the individual firms. Our analysis shows, that cluster firms use cluster R&D cooperation for pursuing both exploitation and exploration. Different patterns emerge which indicate, that cluster firms partly search for new ideas within the cluster, partly use cluster cooperation in looking for new technological and market trends, and partly for probing new solutions. A substantial share of all R&D projects funded by the program (ten per cent totally and another 20 per cent partly) address R&D topics that relate to exploration. All leading-edge clusters we analyzed are ambidextrous in the sense that most individual firms pursue both strategies and thereby also contribute to cluster ambidexterity.

While cluster management agencies do not have the core task to address the relationship of cluster activities that relate to exploitation and exploration, they influence both kinds of activities in their role as service providers who orient their activities at the needs of their customers, namely the cluster firms. In this respect, they can develop into a supporter both for exploitation and exploration. We find that different R&D strategies influence the demand for

different services of the cluster management. Especially, firms focusing at exploration use cluster management services that aim at cross-cluster contacts which can give impulses for cluster development. In addition, we confirmed our expectation that the cluster management is orienting its work on the needs of its customers, namely the firms. In single clusters, exploitation was addressed in the development of cluster service instruments.

Figures and Tables

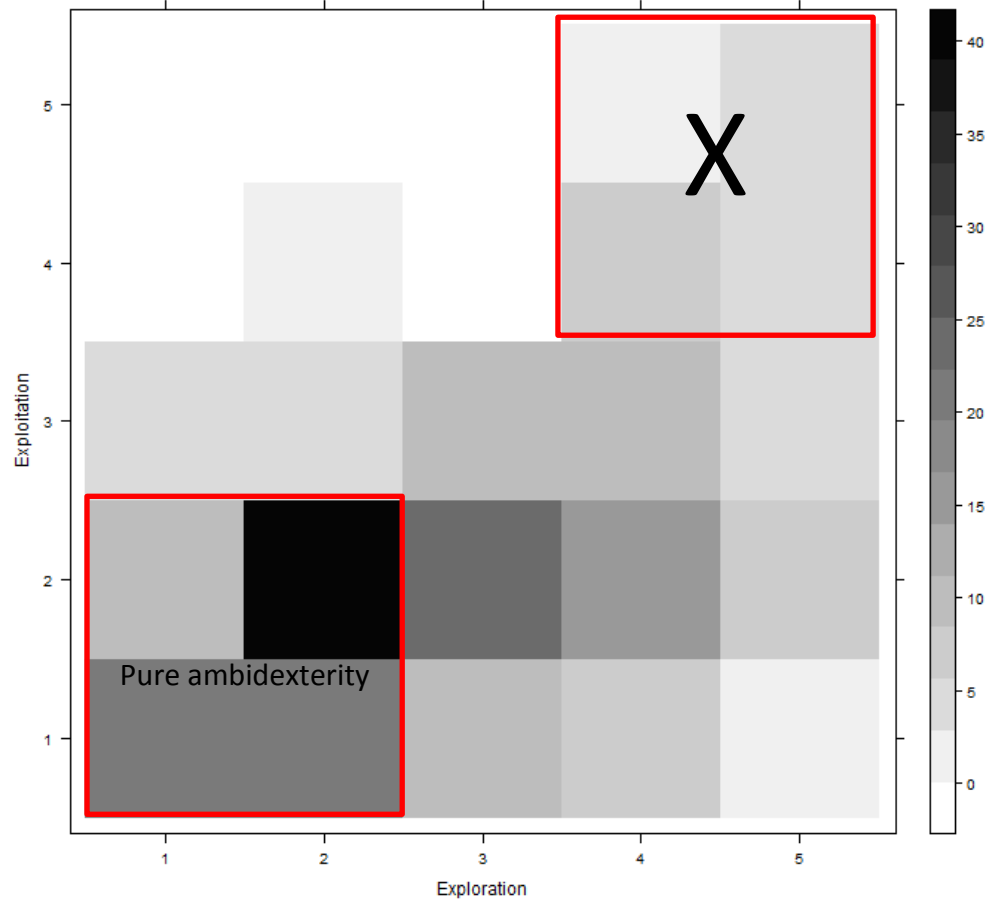


Figure 1 The two ends of the ambidexterity continuum. Levelplot based on the cross-tabulation of exploration and exploitation. Lower left area defines the variable PureAmbidexTech. Top right area "X" is excluded in the calculation of ContAmbidex.

Table 1 Descriptive overview on the services as provided by the cluster management

	Number of cluster managements providing this service	Mean strategic importance of this service as evaluated by the cluster managements that offer this service	Mean percentage of cluster actors that states to have a demand for the respective service
Common R&D infrastructure for the actors (<i>R&D Infrastructure</i>)	5	2.20	59.53%
Qualification/Education for the employees of the actors (<i>Qualification/Education</i>)	9	1.56	67.68%
Events/common activities of the cluster actors (<i>Events for cluster actors</i>)	10	1.50	92.93%
Public relations (<i>Public relations</i>)	10	1.60	87.20%
Consulting with regards to R&D funding (<i>Consulting R&D funding</i>)	9	1.56	74.91%
Networking within the cluster/connecting cluster actors (<i>Networking within the cluster</i>)	10	1.40	90.26%
Providing an IT-Platform for the exchange of information and knowledge within the cluster (<i>IT Platform</i>)	9	2.11	81.36%
Contact to the funding agency of the Leading Edge Cluster Competition (<i>Contact to funding agency of LECC</i>)	9	1.78	81.23%
Networking outside the cluster/connecting cluster actors to external actors (<i>Contact to external actors</i>)	10	1.90	81.05%
Networking with other clusters with similar technological focus (<i>Networking with other clusters</i>)	10	2.10	88.76%
Establishment of international contacts (<i>International contacts</i>)	9	1.56	77.58%

Table 2 Distribution of Ambidexterity in Clusters

Cluster	Obs								Shares						
	-2	-1	0	1	2	3	4	Total	-2	-1	0	1	2	3	4
BioRN	0	0	6	5	0	1	0	12	-	-	0.50	0.42	-	0.08	-
CoolS	0	2	1	5	1	2	0	11	-	0.18	0.09	0.45	0.09	0.18	-
FOE	0	3	3	2	0	0	0	8	-	0.38	0.38	0.25	-	-	-
LogistikRuhr	1	1	21	13	14	4	0	54	0.02	0.02	0.39	0.24	0.26	0.07	-
Luftfahrt	0	0	5	3	3	0	0	11	-	-	0.45	0.27	0.27	-	-
MedicalValley	1	1	9	5	4	3	0	23	0.04	0.04	0.39	0.22	0.17	0.13	-
MicroTEC	1	4	18	11	5	2	2	43	0.02	0.09	0.42	0.26	0.12	0.05	0.05
Software	1	1	3	4	2	1	0	12	0.08	0.08	0.25	0.33	0.17	0.08	-
Solar	1	0	4	4	0	2	0	11	0.09	-	0.36	0.36	-	0.18	-
m4	0	3	5	5	2	1	0	16	-	0.19	0.31	0.31	0.13	0.06	-
Total	5	15	75	57	31	16	2	201	0.02	0.07	0.37	0.28	0.15	0.08	0.01

Note: *ContAmbidex* is defined by the difference exploration and exploitation. A negative (positive) value indicates specialization in exploration (exploitation).

Table 3 Logistic regression on the influence of a firms R&D strategy on its demand for cluster management services

	(i) general services								(ii) internal networking								(iii) external networking							
	<i>Need_R&D infrastructure</i>		<i>Need_Qualification / Education</i>		<i>Need_Public relations</i>		<i>Need_IT Platform</i>		<i>Need_Events for cluster actors</i>		<i>Need_Consulting R&D funding</i>		<i>Need_Networking within the cluster</i>		<i>Need_Contact to funding agency of LECC</i>		<i>Need_Contact to external actors</i>		<i>Need_Networking with other clusters</i>		<i>Need_Inter-national contacts</i>			
	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z		
<i>Exploration</i>	-0.234	0.31	0.059	0.79	0.970 **	0.02	0.337	0.23	0.201	0.59	0.503 **	0.05	0.318	0.36	0.798 ***	0.01	0.239	0.35	0.986 ***	0.01	1.197 ***	0.00		
<i>Exploitation</i>	0.051	0.81	-0.073	0.72	0.346	0.31	-0.448 *	0.06	-0.007	0.98	-0.119	0.58	0.165	0.57	-0.143	0.53	0.333	0.15	-0.226	0.44	-0.202	0.39		
<i>PureAmbidexTech</i>	1.234 **	0.04	0.520	0.38	-0.951	0.45	0.249	0.73	0.010	0.99	-0.859	0.18	-0.121	0.90	-1.103	0.12	-0.891	0.18	-2.011 *	0.06	-1.357 *	0.08		
<i>SME</i>	-0.004	0.99	-0.042	0.91	1.052	0.18	0.355	0.44	1.065	0.11	0.869 **	0.03	0.400	0.54	0.112	0.80	0.743 *	0.09	0.645	0.27	1.278 ***	0.01		
<i>Clusterdummies</i>	yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes			
<i>Benefits/Costs LECC</i>	-0.104	0.16	-0.009	0.90	-0.154	0.19	0.001	0.99	-0.148	0.18	0.004	0.96	-0.081	0.44	-0.155 **	0.05	-0.020	0.80	-0.034	0.74	-0.105	0.23		
<i>Member of other cluster</i>	0.012	0.98	0.768 *	0.05	2.371 ***	0.01	1.163 **	0.02	0.000		0.299	0.45	2.140 ***	0.01	0.355	0.41	0.342	0.44	0.767	0.20	0.734	0.13		
<i>Experience in cooperation</i>	0.945 **	0.04	0.976 **	0.03	-0.092	0.91	1.078 **	0.03	0.959	0.15	0.157	0.74	1.717 ***	0.01	0.010	0.98	0.665	0.17	0.365	0.57	0.278	0.60		
Obs	166		181		157		161		83		181		166		172		170		142		175			
Wald chi2(15)	26.44		31.06		39.38		42.76		24.33		38.84		46.83		41.90		44.56		44.21		49.46			
Prob > chi2	0.0336		0.0196		0.0003		0.0002		0.0114		0.0019		0.0000		0.0004		0.0002		0.0000		0.0000			

Table 4 OLS regression of the firms' demand on the cluster management's perceived relevance of services

	<i>CM offer of the respective service</i>		No	Pseudo	Prob >	LR
	Coef.	P>z	Obs	R2	chi2	chi2
<i>Fit_Need_R&D infrastucture</i>	-3.0156 **	0.05	77	0.0459	0.0396	4.23
<i>True/Fit_Need_R&D infrastucture</i>	0.2487	0.66	125	0.0009	0.6622	0.19
<i>Need_R&D infrastucture</i>	0.1024	0.78	125	0.0004	0.7792	0.08
<i>Fit_Need_Qualification/Education</i>	0.1686	0.84	170	0.0001	0.8402	0.04
<i>True/Fit_Need_Qualification/Education</i>	0.3831	0.44	215	0.0013	0.4410	0.59
<i>Need_Qualification/Education</i>	0.1124	0.42	215	0.0004	0.6762	0.17
<i>Fit_Need_Events for cluster actors</i>	-3.3055 *	0.08	83	0.0388	0.0511	3.8
<i>True/Fit_Need_Events for cluster actors</i>	-2.4529 ***	0.01	229	0.0307	0.0019	9.61
<i>Need_Events for cluster actors</i>	-0.9127 *	0.06	229	0.0122	0.0503	3.83
<i>Fit_Need_Public relations</i>	1.6856	0.1	157	0.0109	0.1255	2.35
<i>True/Fit_Need_Public relations</i>	0.4452	0.5	229	0.0015	0.4900	0.48
<i>Need_Public relations</i>	0.2191	0.6	229	0.0008	0.6283	0.23
<i>Fit_Need_Consulting R&D funding</i>	-4.8868 ***	0.00	170	0.0737	0.0000	20.37
<i>True/Fit_Need_Consulting R&D funding</i>	-1.8943 ***	0.00	215	0.0297	0.0012	10.44
<i>Need_Consulting R&D funding</i>	-0.4993 *	0.09	215	0.0080	0.0941	2.8
<i>Fit_Need_Networking within the cluster</i>	3.3344 ***	0.00	166	0.0412	0.0022	9.41
<i>True/Fit_Need_Networking within the cluster</i>	0.5043	0.45	229	0.0019	0.4433	0.59
<i>Need_Networking within the cluster</i>	0.2034	0.63	229	0.0007	0.6258	0.24
<i>Fit_Need_IT Platform</i>	-0.3303	0.72	161	0.0003	0.7150	0.13
<i>True/Fit_Need_IT Platform</i>	-0.6915	0.23	215	0.0026	0.2257	1.47
<i>Need_IT Platform</i>	-0.1912	0.52	215	0.0007	0.5234	0.41
<i>Fit_Need_Contact to funding agency of LECC</i>	-2.4142 *	0.06	161	0.0200	0.0521	3.77
<i>True/Fit_Need_Contact to funding agency of LECC</i>	-1.8993 **	0.02	215	0.0217	0.0138	6.07
<i>Need_Contact to funding agency of LECC</i>	-0.5291	0.20	215	0.0061	0.1903	1.72
<i>Fit_Need_Contact to external actors</i>	-3.8538 ***	0.00	170	0.0357	0.0004	12.4
<i>True/Fit_Need_Contact to external actors</i>	-1.4130 **	0.02	229	0.0127	0.0163	5.78
<i>Need_Contact to external actors</i>	-0.4013	0.20	229	0.0036	0.2002	1.64
<i>Fit_Need_Networking with other clusters</i>	-3.5182	0.29	142	0.0214	0.2309	1.44
<i>True/Fit_Need_Networking with other clusters</i>	-0.2944	0.75	229	0.0004	0.7554	0.1
<i>Need_Networking with other clusters</i>	-0.1018	0.86	229	0.0001	0.8550	0.03
<i>Fit_Need_International contacts</i>	-1.2985 **	0.05	164	0.0123	0.0509	3.81
<i>True/Fit_Need_International contacts</i>	-0.5139	0.27	215	0.0030	0.2719	1.21
<i>Need_International contacts</i>	-0.2209	0.47	215	0.0013	0.4712	0.52

Appendix

Description of the data sources

The analysis in this paper is based on different sources of information that have been collected during the evaluation of the LECC. Different survey methods have been applied to projects, firms, research institutes and the cluster managements (see Rothgang et al., 2015 for the project report).

Each year, standardized questionnaires were sent to the cluster managers, cluster firms and to the managers of the R&D projects that have been funded within the LECC. For the analysis in this paper, we use the 2011 and 2012 surveys among the 10 winning clusters of the first two competition rounds. Structured expert interviews were conducted twice a year with the cluster managers and selected firm representatives of the clusters. The cluster strategy papers were prepared as part of the application procedure for the LECC and were made available to the evaluation team by the BMBF.

Table 5 Variable description

	Variable	Meaning	Obs	Mean	Std. Dev.	Min	Max
R&D Strategy	<i>Exploration</i>	Orientation towards 'search for new technological fields' in a firms research cooperation. 5 is the best, while 1 is the lowest possible value.	217	2.73	1.26	1	5
	<i>Exploitation</i>	Orientation towards 'deepening of existing competences' in a firms research cooperation. 5 is the best, while 1 is the lowest possible value.	217	2.04	0.97	1	5
	<i>ContAmbidex</i>	Continuous variable from -4 to +4, where -4 stands for specialization in exploration and +4 stands for specialization in exploitation. The values in between show ambidexterity from different degrees.	217	0.70	1.16	-2	4
	<i>PureAmbidexTech</i>	Dummy variable which becomes 1 if a firm allocates the two highest values (1 or 2) to <i>exploration</i> and <i>exploitation</i> .	217	0.45	0.50	0	1
True/reported demand for cluster management services	<i>Need_R&D infrastructure</i>	Dummy variable, indicating, whether the firm has a need of Qualification/Education offered by the cluster management.	229	0.59	0.49	0	1
	<i>Need_Qualification/Education</i>	... need of R&D infrastructure ...	229	0.67	0.47	0	1
	<i>Need_Events for cluster actors</i>	... need of events for cluster actors ...	229	0.90	0.31	0	1
	<i>Need_Public relations</i>	... need of public relations ...	229	0.90	0.30	0	1
	<i>Need_Consulting R&D funding</i>	... need of consulting in R&D funding...	229	0.72	0.45	0	1
	<i>Need_Networking within the cluster</i>	... need of networking within the cluster ...	229	0.89	0.32	0	1
	<i>Need_IT Platform</i>	... need of an IT-platform...	229	0.79	0.40	0	1
	<i>Need_Contact to funding agency of LECC</i>	...need of contact to funding agency of LECC ...	229	0.78	0.41	0	1
	<i>Need_Contact to external actors</i>	... need of organized contacts to external actors ...	229	0.79	0.41	0	1
	<i>Need_Networking with other clusters</i>	... need of networking with other clusters ...	229	0.87	0.33	0	1
<i>Need_International contacts</i>	... need of international contacts ...	229	0.76	0.43	0	1	
Fitted demand for cluster management services	<i>Fit_Need_R&D infrastructure</i>	Probability of the need of R&D infrastructure offered by the cluster management, dependent on the firms strategy and other control variables.	166	0.57	0.21	0.06	0.96
	<i>Fit_Need_Qualification/Education</i>	... need of Qualification/Education ...	181	0.66	0.16	0.16	0.94
	<i>Fit_Need_Events for cluster actors</i>	... need of events for cluster actors ...	83	0.77	0.17	0.26	0.95
	<i>Fit_Need_Public relations</i>	... need of public relations ...	157	0.90	0.15	0.15	1.00
	<i>Fit_Need_Consulting R&D funding</i>	... need of consulting in R&D funding ...	181	0.72	0.15	0.23	0.95
	<i>Fit_Need_Networking within the cluster</i>	... need of networking within the cluster ...	166	0.88	0.15	0.20	1.00
	<i>Fit_Need_IT Platform</i>	... need of an IT-platform ...	161	0.76	0.16	0.23	0.97
	<i>Fit_Need_Contact to funding agency of LECC</i>	... need of contact to funding agency of LECC ...	172	0.74	0.17	0.20	0.99
	<i>Fit_Need_Contact to external actors</i>	... need of contact to external actors ...	170	0.76	0.14	0.31	0.97
	<i>Fit_Need_Networking with other clusters</i>	... need of networking with other clusters ...	142	0.84	0.14	0.38	1.00
<i>Fit_Need_International contacts</i>	... need of international contacts ...	175	0.75	0.22	0.07	0.99	
Fitted demand for cluster management services filled with the reported value if the fitted one is a missing	<i>True/Fit_Need_R&D infrastructure</i>	Probability of the need of R&D infrastructure offered by the cluster management, dependent on the firms strategy and other control variables or real value (Dummy variable, indicating, whether the firm has a need of this service offered by the cluster management).	229	0.59	0.31	0	1
	<i>True/Fit_Need_Qualification/Education</i>	... need of Qualification/Education ...	229	0.67	0.25	0	1
	<i>True/Fit_Need_Events for cluster actors</i>	... need of events for cluster actors ...	229	0.90	0.20	0	1
	<i>True/Fit_Need_Public relations</i>	... need of public relations ...	229	0.90	0.21	0	1
	<i>True/Fit_Need_Consulting R&D funding</i>	... need of consulting R&D funding ...	229	0.72	0.24	0	1
	<i>True/Fit_Need_Networking within the cluster</i>	... need of networking within the cluster ...	229	0.89	0.20	0	1
	<i>True/Fit_Need_IT Platform</i>	... need of IT Platform ...	229	0.79	0.23	0	1
	<i>True/Fit_Need_Contact to funding agency of LECC</i>	... need of contact to funding agency of LECC ...	229	0.78	0.22	0	1
	<i>True/Fit_Need_Contact to external actors</i>	... need of contact to external actors ...	229	0.79	0.21	0	1
	<i>True/Fit_Need_Networking with other clusters</i>	... need of networking with other clusters ...	229	0.87	0.20	0	1
	<i>True/Fit_Need_International contacts</i>	... need of international contacts ...	229	0.76	0.27	0	1

Table 5 continued

	Variable	Meaning	Obs	Mean	Std. Dev.	Min	Max
	<i>SME</i>	Dummy variable which is one if the firm is a small and medium sized company and 0 if it is a large firm.	225	0.61	0.49	0	1
	<i>Solarvalley</i>	Dummy which is one if the firm belongs to the cluster SolarValley Mitteldeutschland	229	0.05	0.21	0	1
	<i>m4</i>	... cluster m4.	229	0.08	0.27	0	1
	<i>BioRN</i>	... cluster BioRN	229	0.06	0.23	0	1
	<i>CoolS</i>	... cluster CoolSilicon	229	0.06	0.24	0	1
	<i>FOE</i>	... cluster Forum Organic Electronics	229	0.03	0.18	0	1
	<i>LogistikRuhr</i>	... cluster LogistikRheinRuhr	229	0.27	0.45	0	1
	<i>Luftfahrt</i>	... cluster Hamburg Aviation	229	0.06	0.24	0	1
	<i>MedicalValley</i>	... cluster Medical Valley	229	0.12	0.32	0	1
	<i>MicroTEC</i>	... cluster MicroTEC Südwest	229	0.21	0.41	0	1
	<i>Software</i>	... cluster Software-Cluster	229	0.06	0.24	0	1
	<i>Benefits/Costs LECC</i>	Variable received from the question: How do you evaluate the benefits as compared to the costs of the participation of your firm in the LECC? A value of 1 means 'costs are considerably high as compared to the benefits'; a value of 5 means 'benefits are considerably high as compared to the	159	3.64	1.09	1	5
	<i>Member of other cluster</i>	Dummy variable, indicating, whether a firm is member of an other cluster, except the LEC	217	0.36	0.48	0	1
	<i>Experience in cooperation</i>	Dummy variable, indicating, whether the firm experienced cooperation before the LECC	220	0.75	0.43	0	1
	<i>IT Platform</i>	CM's priority of offering IT Platform	215	2.52	1.10	1	4
	<i>R&D infrastructure</i>	CM's priority of offering R&D infrastructure	125	2.26	0.57	1	3
	<i>Qualification/Education</i>	CM's priority of offering Qualification/Education	215	2.40	1.70	1	5
	<i>Events for cluster actors</i>	CM's priority of offering Events for cluster actors	229	1.57	0.50	1	2
	<i>Public relations</i>	CM's priority of offering Public relations	229	1.59	0.49	1	2
	<i>Consulting R&D funding</i>	CM's priority of offering Consulting R&D funding	215	1.49	0.57	1	3
	<i>Contact to funding agency of LECC</i>	CM's priority of offering Contact to funding agency of LECC	215	1.87	0.58	1	4
	<i>Networking within the cluster</i>	CM's priority of offering Networking within the cluster	229	1.51	0.50	1	2
	<i>Contact to external actors</i>	CM's priority of offering Contact to external actors	229	1.83	0.67	1	3
	<i>Networking with other clusters</i>	CM's priority of offering Networking with other clusters	229	2.02	0.38	1	3
	<i>International contacts</i>	CM's priority of offering International contacts	215	1.62	0.64	1	3

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