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The territorial shaping of knowledge dynamics in Baden-Württemberg. Inter-organizational relations in the sectoral knowledge domain of the automotive industry

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Abstract:

The paper focuses on the territorial shaping of knowledge dynamics as one of the driving forces for innovation. Knowledge dynamics are unfolding from processes of creation, use, transformation and diffusion of knowledge. Due to both the ongoing restructuring of global value chains and the changes in the organization of innovation 'combinatorial knowledge dynamics' gain a more prominent role in innovation. Firms are facing an increasing need to combine heterogeneous knowledge sources spread over organizational, technological, sectoral and spatial boundaries in innovation processes. Combinatorial knowledge dynamics imply to cope with many different cognitive, technological, intra- and inter-organizational and institutional interfaces.
Deeper empirical investigation in the connected organizational and institutional change linked with knowledge dynamics is still missing, but is indeed necessary to better understand the spatio-temporality of knowledge dynamics behind innovation. Addressing the connection of space as a scope of action and space as being generated as a part of the social process, the paper chose a biographical method to explore knowledge dynamics.

Keywords: Innovation, territorial knowledge dynamics, automotive industry, Baden-Württemberg.

JEL Classifications: D83, L62, O32

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1 Introduction

Although the knowledge perspective on innovation has markedly gained interest in the industrial-innovation literature, the larger issues of knowledge dynamics and knowledge trajectories are still underexplored (Meeus/Haage 2006). Crevoisier and Jeannerat (2009: 1224) argue to broaden the traditional paradigm based on innovation trajectories to include knowledge dynamics. This implies focussing on the transformation and shift of knowledge itself as one of the driving forces for innovation and as a source of novelty. Knowledge dynamics are unfolding from processes of creation, use, transformation and diffusion of knowledge (Strambach 2008: 153). Innovations in products, services and processes are the visible results of knowledge dynamics. The subject of investigation of this approach is the dynamic processes of interaction in their socio-institutional embeddedness, which create and transform individual knowledge stocks, integrate and combine them.[1]

A change in the way scientific, social and cultural knowledge is produced was already acknowledges in the mid-1990s. New knowledge is increasingly produced by a variety of actors in complex problem-oriented situations in a transdisciplinary way (Gibbons et al. 1995). Moreover, it is argued, that this new mode of knowledge production is replacing or reforming established institutions, disciplines, practices and policies. However, the implications of that change for the territorial organization of knowledge dynamics have not been examined and analyzed in detail yet.

We argue that a qualitative shift in knowledge dynamics towards combinatorial knowledge dynamics is under way. Apart from cumulative knowledge dynamics which are either based on or are directly related to existing knowledge, 'combinatorial knowledge dynamics' gain a more prominent role in innovation. This shift is triggered by the ongoing restructuring of global value chains and modifications in the organization of innovation (Schmitz/Strambach 2009). Thus, the processes of knowledge production itself are affected by changes towards modularization, standardization and externalization. These processes lead to an increasing complexity of both horizontal knowledge domains related to business functions such as marketing and vertical knowledge domains related to sectoral contexts. Actual knowledge dynamics therefore are often characterized by the need of bringing together highly specialized and heterogeneous knowledge bases, which at the same time are organizationally and spatially distributed across different actors within and outside the firm

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Analysing the territorial implications of such combinatorial knowledge dynamics poses new challenges for research, since this focus so far has rarely been used in innovation research. Obviously, this shift also brings about new or transformed territorial shaping and inter-organizational relations, since knowledge interactions generally are localized but not limited to certain territories. The main aim of this paper is to contribute conceptually and empirically to the understanding of the territorial shaping of knowledge dynamics. How are firms and other economic actors using cumulative knowledge bases and place-specific institutional endowments in innovative change processes? What are the spatial patterns unfolding from interactions in the use of different types of internal and external knowledge resources? We are using the term territory to both address space as a dependent and independent variable to find out about the influence of regional knowledge bases on firms as well as the set up of multi-scalar knowledge processes. Moreover, we ask how a connection between both perspectives on the territoriality of knowledge dynamics can be established.

Since these aspects of knowledge research are conceptually underexplored so far, our reasoning is strongly based upon empirical observations and the application of the grounded theory approach (Glaser/Strauss 1967). We draw upon a series of case studies from the sectoral knowledge domain of the automotive industry in Baden-Württemberg. To get a deeper insight into the territorial shaping of knowledge dynamics determined by both the specific type of knowledge base and the context, we focus therefore on one vertical knowledge domain. The Baden-Württemberg automotive industry is an especially interesting case to be studied, because it recovered extraordinarily fast from economic downturn during the 1990s. Additionally, the automotive industry is typified as both a multi-technology and a multi-actor industry today, which is characterized by highly diversified knowledge creation processes (Jürgens et al. 2008, MacNeill/Chanaron 2005). We chose a biographical method to explore knowledge dynamics by capturing various sources of external knowledge located at different geographical scales and in different sectoral contexts.

2 Knowledge dynamics and their territorial shaping

Conceptualizing the interplay of knowledge dynamics and territory

Perceiving knowledge as the key resource for innovation shifts the focus from the innovation process itself to the processes of knowledge creation, using, transformation and diffusion. This is what we comprehensively define as knowledge dynamics. They can be seen as the driving force behind innovation.

Analysing the spatial shaping of knowledge dynamics is not an easy task, and needs some further conceptual clarification. Scientific literature utilizes differing approaches which are rarely congruent and thus frequently capture different aspects of a complex phenomenon. Even within economic geography the notion of space is grasped in different ways. By

investigating the interplay of knowledge dynamics and space, we can draw upon substantial results of interdisciplinary innovation research in theoretical and empirical terms. Especially the streams of research based on evolutionary and institutional economics as well as economic geography put emphasis on knowledge in the analysis of organizational and economic change and the emergence of novelty.

We are using the term 'territory' in the following analysis to integrate two opposing but not conflicting views in the way the 'space' dimension is conceived in interdisciplinary innovation research. Firstly, space can be perceived as the scope of action for actors within a given territory which is made up of institutional configurations or endowments. Space as the socio-institutional context limits economic opportunities and actions by providing place specific resources for actors. Particularly innovation research in economic geography pointed to the institutional and cultural characteristics of a territory which are formed over time. Moulaert and Sekia (2003) summarized such models in the generic notion of "Territorial Innovation Models" (TIMs). In these approaches, space is considered as fixed geographical piece of space, typically in guise of a 'region', where political competence and a specific institutional endowment can be found (Maskell/Malmberg 1999). In the words of Lorenz/Maurer/Staber (2010) this view conceives space as the independent variable in the analysis, which constitutes the knowledge capabilities and options of the actors like firms within the region respectively located in this bounded space.

But space can also be understood in a second way - as socially constructed part of space unfolding in interaction processes among agents. Amin (1998: 153f.) emphasizes, that in a globalized world it is no longer useful to think of "separate [territorial] spheres of social organization and action [...]". Instead, he argues that "in any location […] of activity, layers of proximate and distant logics and influences are likely to be at work". In search for a conception of space, which allows for versatile knowledge dynamics to be captured, the notion of territory reveals clear advantages. In contrast to 'regions', 'territories' as specific spheres are flexible as far as their spatial extent is concerned and thus can refer to varying geographical scales (Dicken/Malmberg 2001: 345; Storper/Walker 1989: 183). Especially in the light of obvious changes in the organization of innovation, we argue that the spatial dimension is of relevance in both ways for a deeper understanding of knowledge dynamics.

What is widely acknowledged about innovation processes is a shift towards more open innovation environments and the growing importance of complementary knowledge external to the firm. Schmitz/Strambach (2009) place emphasis on the organizational decomposition of innovation processes which implies the increasing integration of heterogeneous actors from inside and outside the firm in knowledge production. The involvement and cooperation of

internal decentralized R&D departments and subsidiaries, with external suppliers, knowledge-intensive business services (KIBS) or public/private research organizations embedded in spatially distributed networks, has two main consequences: It led to a higher degree and complexity of labour division in knowledge production underlying innovation. Along with the coordination and integration of heterogeneous knowledge bases, the creation of 'combinatorial knowledge' thus gains a more prominent position for firms in innovation development. In contrast to 'cumulative knowledge', that is knowledge which builds on or is directly dependent on already existing stocks of knowledge, 'combinatorial knowledge' comes into existence by the unification of originally separate knowledge bases. It is characterized by bringing together formerly separate knowledge bases spanning over distinct organizational, sectoral and territorial contexts.

Equally, the restructuring of value chains is increasing the complexity of vertical and horizontal knowledge domains related to sectors and business functions. It generates new distance-proximity relations in both organizational and spatial terms and. In parallel, knowledge-intensive service activities and – as the internationalisation of R&D activities shows – the process of knowledge production itself, are affected by shifts towards modularisation, standardisation and of externalisation. The dynamic growth of knowledge-intensive business services (KIBS) is closely connected with the rising need for combinatorial knowledge. Research on KIBS provided substantial theoretical and empirical evidence that these firms contribute in an essential way to knowledge dynamics in firms, sectors and territorial contexts through the attributes and production of their knowledge products. Three processes – the contextualisation, de- and re-contextualisation of knowledge – can be seen as main mechanisms through which KIBS shape knowledge dynamics beyond their own sector boundaries.

A change in the way scientific, social and cultural knowledge is produced was already acknowledged in the mid-1990s. Gibbons et. al (1995) pointed out that new knowledge is increasingly produced by a variety of actors in complex problem-oriented situations in a transdisciplinary way. However, the spatial dimension and the implications of that change for the territorial organization of knowledge dynamics have not been examined in more detail. Though, the question of the territorial shaping of knowledge dynamics associated to innovation under these new conditions remains in many respects an open one. In line with Meeus/Hagen (2006) and other authors we claim the need of a much more complex theory of innovation and knowledge production.

Combinatorial knowledge dynamics, institutional change and proximity

Much research and many organizational and institutional approaches refer to the cumulative character of knowledge and to the development of specific knowledge bases over time through path-dependent learning processes of actors (Antonelli 2006). In contrast, knowledge generation processes of combinatorial knowledge have received little attention so far, despite the fact that they are becoming more important for the development of innovation (Crevoisier/Jeannerat 2009).

The significance of cumulative knowledge dynamics has been acknowledged at different analytical levels: at the organizational, the sectoral and the territorial level. It has been shown at the firm level that the existing knowledge base influences the type and the direction of innovation processes as well as the ability to absorb new knowledge (Patel/Pavitt 1997, Cohen/Levinthal 1990). Comparably, sectors differ largely in the way innovation and knowledge exploration processes are organized and in their specific institutions, despite changes and transformations of vertical and horizontal knowledge domains (cf. Malerba 2005). On the basis of the synthetic, analytic and symbolic typology of knowledge bases the understanding of distinct sector differences in the organization of innovation has made substantial progress (Asheim & Coenen, 2006, Asheim 2007). The three knowledge bases are defined by distinct learning processes through which knowledge is developed as well as by the criteria applied for evaluating the usefulness of knowledge. It is argued that they differ with regard to the relevance of geographical distance and proximity, and with regard to mixes of tacit and codified knowledge.

Sectors with a mainly analytical knowledge base dominate in industries in which science based knowledge is highly important such as biotechnology and nanotechnology. The production of analytical knowledge is based to a large degree on formal models and codification is essential. A synthetic knowledge base refers to industrial sectors in which innovation takes place mainly through the application or novel combination of existing knowledge. Accordingly, synthetic knowledge is more sensitive to distance than analytical knowledge, because it is often formed in response to the need to solve specific problems through interactions between customers and suppliers. Thus experienced based and tacit knowledge play a more important role. Industries which draw upon a symbolic knowledge base are mainly active in the cultural or creative fields such as service industries like film making, music, fashion, publishing or advertising and design (Scott 1997). Firms in these industries are dealing with the creation of meaning, symbols and socially constructed commodities and the ‘value of sign’. The cultural embeddedness of interpretations, habits and norms is made responsible for the strong tacit component, the high context specificity and the sensitivity to distance that characterises this symbolic type of knowledge base (Mariussen/Asheim 2003). Although the differentiated knowledge base approach characterizes ideal types, the concept underlines the importance of

organizational forms and institutional differences in the production of different types of knowledge. Also meso and macro level approaches like the National System of Innovation (NIS) (Lundvall et. al 2002) or Varieties of Capitalism (VOC) use the perspective of space as the scope of action for individual and collective actors. Likewise they place emphasis on the connection between the behaviour of agents in innovation processes on the micro level and their embeddedness in a specific geographical context (Hall/Soskice 2001, Whitley 2002).

Summarizing, we make the point that the co-evolution of institutions and complementary institutional arrangements are central for the emergence of specific cumulative knowledge bases over time. Organizational routines, competences at the firm level, sectoral and region-specific institutions as well as institutional configurations at the national level contribute to the cumulative development of competences and knowledge at different analytical levels. Agglomeration and localisation economies and dynamic localized learning processes are assessed as main mechanisms leading to region-specific characteristics, localized knowledge bases and capability building. Untraded interdependencies and idiosyncratic context conditions evolve over time, fostered by knowledge spillovers and proximity economies, which are assumed to be especially important for tacit knowledge transfer (Cooke 2005, Gertler 2003, Malmberg/Maskell 2006, Storper 1995). These mechanisms and processes give explanations for institutional variation at the territorial level and within a distinct territorial institutional environment.

The way in which combinatorial knowledge dynamics reshape territory and territorial configurations of actors as a part of the social process is an interesting question which innovation research has not addressed in detail so far. As argued above, innovation processes increasingly need to bring together separate knowledge bases, which are distributed across different actors within and outside the firm. Consequently, combinatorial knowledge dynamics imply to cope with many different cognitive, technological, organizational and institutional interfaces. At the same time, such knowledge interactions have to bridge various intra- and inter-organizational institutions and are therefore closely connected to institutional change processes.

Even though knowledge is increasingly a kind of commodity that can be traded and priced, the production of knowledge is fundamentally grounded in complex social processes. Knowledge creation and its transformation into economic value require learning; it does not easily flow due to its tacit dimension, its process character and its context sensivity/dependence. In interdisciplinary innovation research it is widely acknowledged that effective communication, mutual understanding and the absorptive capacity of actors is determined by the degree of their cognitive proximity. The learning dimension is essential and it affects the perception and

interpretation of actors, the knowledge exchange between them, and their potential to create new knowledge together. Concerning the relationship between cognitive distance and its impact on innovation it is pointed out, that cognitive distance must be sufficiently small to allow understanding – but at the same time sufficiently large to actually bring new knowledge (Boschma 2005, Nooteboom 2009). It is assumed that spatial proximity affects cognitive proximity insofar as physical proximity is often combined with other types of proximity such as institutional, organizational or social proximity. This assumption is supported by the argument, that since actors are co-located and share the same context, other kinds of proximity are simultaneously present in between them which reduce uncertainty, the risk of opportunistic behaviour, lower transaction costs and foster interactive learning. Even though it is not clear in what way the different dimensions of proximity are related to each other, it is meanwhile widely acknowledged that it is not spatial proximity per se which is decisive for the emergence of knowledge dynamics (Lorenz 2005, Torre/Rallet 2005, Boschma 2005).

Following this reasoning we argue, that compared to cumulative knowledge production, the development of organizational routines and governance structures directing combinatorial knowledge creation processes seem to be far more complex. Due to the complexity and variety of actor constellations and the different composition and integration of separate knowledge stocks, cognitive, organizational, and institutional distance have to overcome. There is, in other words, a crucial difference between cumulative and combinatorial knowledge dynamics with regard to organizational forms and institutional arrangements. Additionally, there has been little detailed exploration of their territorial shaping. What needs to be investigated in more depth hence is the connection between geographical proximity and other forms of proximity. Understanding this interplay in the creation of combinatorial knowledge and the impacts of territory thereon is an essential challenge for research due the importance of the time dimension and the interconnection of multi-level institutions. How do firms and other organizations use cumulative knowledge bases embedded in place-specific institutional endowments and combine these with organizationally and spatially distributed knowledge sources in innovative change processes? What are the territorial patterns unfolding in interaction in the use of different types of internal and external knowledge resources? And how do they in turn change existing organizational forms which, over time, have the potential to provide the impetus for new institutionalization? Connecting the view of space as a scope of action and space as being generated in knowledge interactions, promises to gain new insights into the mutual interdependence of institutional and organizational change in innovation processes.

3 The automotive industry in Baden-Württemberg – institutional change and knowledge dynamics at the regional level

Due to the location of the OEMs Daimler, Porsche and Audi as well as a multitude of suppliers and engineering service providers, one of Europe's largest automotive regions, profiled in the vehicle segment of the premium class, has developed in Baden-Württemberg. In line with the highly specialized industrial setting the regional knowledge base is strongly related to the vertical knowledge domain aligned to automotive engineering and to mechanical and electrical engineering. In the course of the long-lasting success story of the automotive industry of the region a strong cumulative knowledge base mainly in the synthetic knowledge fields (cf. Asheim/Gertler 2005) was formed. Numerous regional studies identify a significant, though indirect contribution to maintain the technological innovative capacity of firms through synergy effects and the reciprocal support of the co-evolved institutional set up. Complementary institutional configurations in the scientific system furthermore provide the great potential of highly skilled human resources in the technological fields of synthetic knowledge bases through occupational training and further education, technology transfer and the labor market.

In spite of this, the automotive industry of the region faced severe crisis at the beginning of the 1990s. In course of the global flexibilization of production systems the region's industry had lost its competitiveness by maintaining its so far proven, but then outdated organizational structures. What has been stated as causal factors was the slow adjustment to new forms of knowledge production and non-technological innovations like organizational and service innovations characterized by a higher importance of symbolic knowledge bases. The established institutional environment did not appear to be favorable for innovations in these knowledge fields. Such innovations tend to be short lived and market oriented; they depend to a lesser degree on technological knowledge and competences, but instead far more on the context of application and a combination of numerous economic, social, and cultural competences. It became obvious that the stable, well established, institutional relationships have caused rigidities and lock-in effects. The economic downturn could not simply be regarded as a sectoral adjustment problem (cf. Cooke/Heidenreich/Braczyk 2004; Fuchs/Wassermann 2005, Strambach 2002).

From the 1990s onwards the automotive industry generally is characterized by substantial restructuring processes of the value chains. Accordingly, considerable impacts on the organization of knowledge creation processes towards more complex forms of product and process development, showing a high degree of division of labor can be observed (cf. Sofka et al. 2008). A responding process of economic and institutional restructuring to meet the pressures of globalized markets could be observed in the region on different levels - in the private business economy as well as in political processes, institutions and the formation of

new public and semi-public agents. Remarkably, it was neither a complete break with the well established structures of the cumulative knowledge bases which had proven to be successful nor a rise of completely new actors, but a reorganization of existing structures and knowledge creation processes which helped to regain competitiveness. Thereby, the combined knowledge formation and the incorporation of symbolic knowledge gained importance.

With regard to the territorial shaping of network structures a new allocation of tasks and a strong trend to outsource not only production activities, which are mainly focused on knowledge using, but also of innovative tasks, could be observed. Network structures and the quality of inter-organizational exchange therefore have intensified significantly in order to adapt to the new modes of knowledge production. In view of the organizational decomposition of innovation the role of suppliers in the region has been revalued significantly and the model of modularized production evolved. This resulted in suppliers like Bosch, Mahle, and Behr becoming so-called 'system suppliers' by taking over more responsibility for knowledge creation processes and creating specialized technological competences in innovation. Thereby the OEMs make use of knowledge inputs which are complementary to their own knowledge base. Induced by this restructuring, the formation of a dense cluster around the OEMs Daimler, Porsche and Audi could be observed. It is estimated that within Baden-Württemberg alone between 3.000 and 3.500 enterprises are integrated over the whole range of the value chains (vehicle construction, mechanical and electronic engineering, rubber and plastic processing and business services) (cf. Prognos 2008). The KIBS sector, which is rather under-represented in Baden-Württemberg, was in connection able to grow particularly in the field of technical KIBS.

Within these networks a large range of analytical and synthetic knowledge fields for instance in mechanics, software, electronics, chemistry, plastics and engineering are available, provided by various actors located regionally or beyond the regional scale. Furthermore, symbolic knowledge can be regarded more and more as elementary part of technologically advanced products. Like in many other industries a growing influence of design, marketing and cultural aspects of the demand side can be observed.

Political processes to support the regional economy have obviously moved away from hierarchical structures of government to more open forms of governance in multi-actor and multi-level institutional setups (cf. Kaiser 2007) which better fit to benefit and support the more open forms of innovation described above. New policy aims were directed to open up network relationships between different sectors and mobilizing existing competences in different knowledge stocks. Like for example from 2006 on cluster policy was introduced not only in sectoral but also in technology and cross-sectoral competence areas to promote

combinatorial knowledge dynamics. Furthermore, an increasing policy attention accorded to the support of extra-regional knowledge processes. This is reflected in the establishment of international policy networks and the growing international cooperation of public and semi-public organizations in applied European research projects or experience based knowledge transfer initiatives. It is worth mentioning that changing knowledge dynamics have also impacts on regional educational and further educational institutes, which reacted to the situation by developing and offering new courses of study to match the changed demand of the corporations.

Summarizing these structural changes, we observe a continuity of the basic actors and network structures while the breaking up of value chains and the stronger integration of external actors brings in new momentum and new structural elements into the territorial shaping of knowledge dynamics.

In spite of these changes, the region specific knowledge base and the specific institutional setting which had emerged over decades still shapes actual knowledge processes. In the following chapter we will go into details of how inter-organizational relations in knowledge processes unfold in space and how the cumulative knowledge base is used therein.

4 Inter-organizational relations and innovative change in the sectoral knowledge domain of the automotive industry – empirical insights

4.1 Methodology

Our qualitative research followed the methodological approach of the grounded theory (Glaser/Strauss 1967) which appears to be suitable to extend knowledge in a field that is under theorized so far. To get empirical insight into the nature of knowledge dynamics of innovative change processes and how these unfold in space and time, established instruments of data collection are of limited use. We studied these processes from a new perspective and chose a biographical method to explore knowledge dynamics. In the focus of the biography is the innovation event itself or in other words a change processes in the sectoral knowledge domain of the automotive industry in Baden-Württemberg. By examining the entire life-span of an innovative change process, a biography captures the actors involved, their relationships, their knowledge contribution and their institutional and geographical settings. The biography tries to understand how internal knowledge of actors is related to the various sources of external knowledge located at different scales and how this evolves over time. One of the main advantages of such an approach is to grasp the dynamism without being limited to a certain territory. Knowledge interactions can be mapped regardless of geographical or sectoral scales.

In the empirical selection process we applied theoretical sampling in combination with the snowball procedure. At the beginning an important selection criteria for the theoretical sampling was the participation of KIBS firms as focal actors in the events. Subsequently we made use of the snowball procedure to follow actors and interactions processes in the knowledge production of the innovation event. In total we followed 12 events conducting multiple qualitative and semi-structured interviews dependent from the actors involved in the cases. The number of interviews per event ranged between 2 to 8 interviews with a duration of 1 till 2 hours. Additionally, several qualitative interviews with political actors and with representatives of various public and semi-public organizations engaged in either regional development or in the sectoral knowledge domain of the automotive industry were carried out.

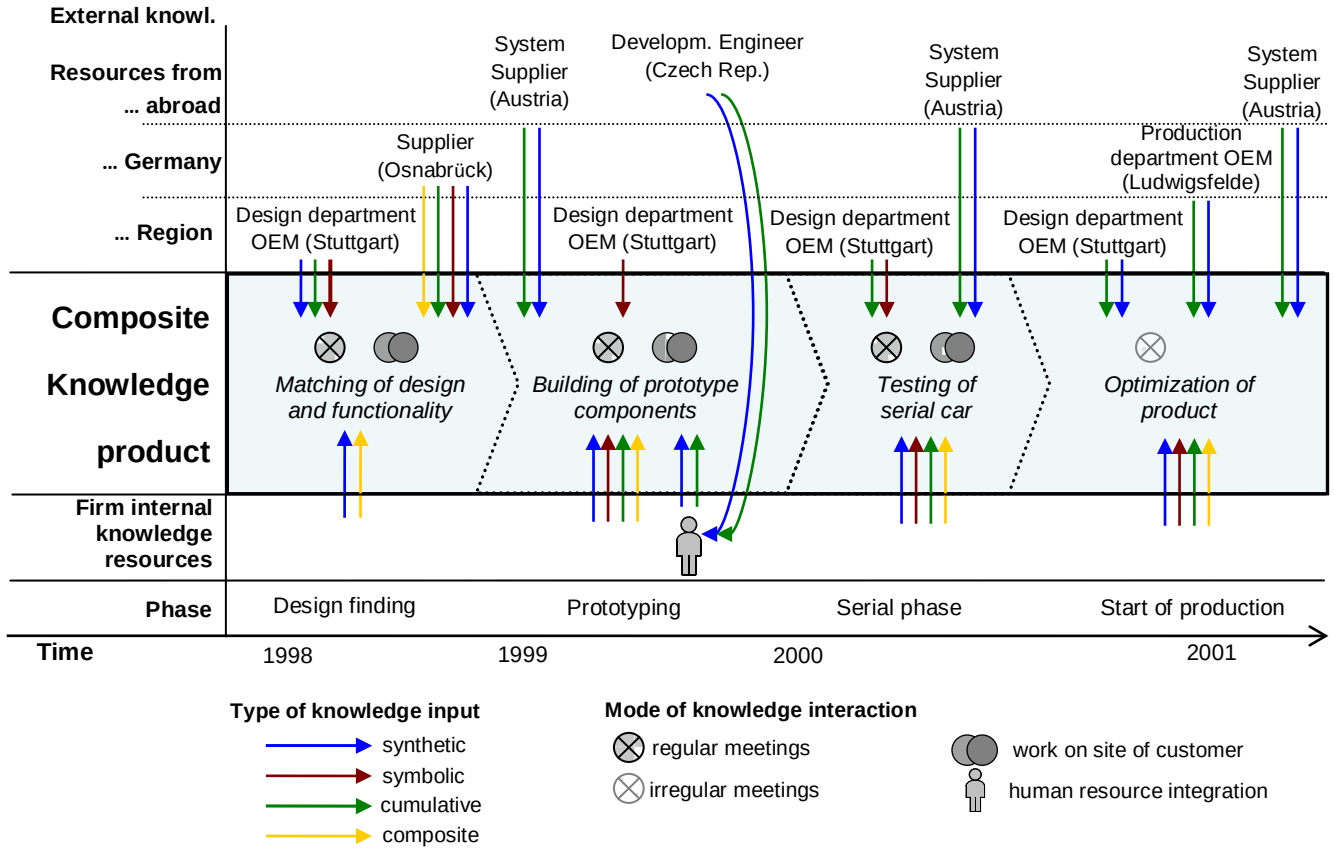
In this chapter four of these cases are chosen to be reviewed in depth. The objective is to provide empirical insights into inter-organizational relations involved in innovation events and the role of space in knowledge production. Since KIBS firms were identified in theoretical and empirical research as central actors contributing to knowledge combination and knowledge dynamics two contrasting cases will be presented in depth. Both are characterized by the need to combine synthetic with symbolic knowledge bases to give birth to the innovation, but they differ in the types of actors involved and the actor constellations. They are distinct in terms of different dominant knowledge bases. In the first innovation biography an 'Engineering KIBS' with its cumulative knowledge base being mainly located in synthetic knowledge fields is the focal actor. Whereas in the second innovation biography the focal actor is a 'Media KIBS' firm operating in the field of media, whose cumulative knowledge base is strongly biased towards symbolic knowledge. As further case studies innovation biographies of a politically induced cluster in visual computing as well as a project initiated by private firms to combine competences in simulation technology are chosen.

4.2 Combining synthetic and symbolic knowledge – inter-organizational relations in the design process for the interior of a new car type

The case of the Engineering KIBS, an engineering service provider mainly working for the automotive sector in Baden-Württemberg, starts to give us an insight into the complex nature of knowledge interactions. Starting point of this event was the assignment between a Baden-Württemberg based OEM with an Austrian system supplier to design and produce the whole interior for a planned new type of vehicle. Most interestingly, the Austrian system supplier redistributed the design and prototyping part of this assignment to the Engineering KIBS from the Stuttgart region. Our subsequent analysis of knowledge dynamics better makes us understand the territorial shaping of labour division in knowledge production and the reasons for such a decision.

Figures 1 and 2 map the central elements of the innovation biographies in the generation of the combinatorial knowledge product as they appeared a posteriori. The chosen type of depiction should not mislead us to think of innovation as a predefined linear sequence of events. Instead, in each case we found decisions which were subject to uncertainties and challenges, leaving open the continuance and success of the project.

Figure 1: Innovation biography of the interior of a new car model



The first challenge in this interactive knowledge creation process was to match design and functionality. The OEM's design department brought in its cumulative symbolic knowledge by creating templates as a basis for further development. Additionally, their cumulative synthetic knowledge about internal processes, technological requirements and production parameters was important in order to meet the technological specifications for the design. The supplier located in the north of Germany – being responsible to match the interior design to the specification of the body shell construction – also contributed cumulative synthetic knowledge. The Engineering KIBS had the role of absorbing the external knowledge stemming from the knowledge bases of the OEM and the suppliers and consequently combining it with its own cumulative synthetic knowledge about vehicle engineering.

The inter-organizational transfer of knowledge was institutionalized by the Engineering KIBS' engineers working on site of the OEM and by weekly team meetings, allowing for better team learning. By the work on site of the OEM, the Engineering KIBS was able to familiarize with the OEM's organization and routines with tacit knowledge being transferred much easier. Frequent

face-to-face contact and the high degree of physical proximity facilitated the spontaneous and flexible knowledge sharing which was necessary in various situations characterized by a high degree of uncertainty. Additionally, face-to-face communication fostered the exchange of implicit knowledge and increased the trust among the actors involved in this phase.

After the specifications were set in the first phase, in the second phase the prototype – a digital computer image of the interior – was constructed. Knowledge exchange thereby happened mainly in between the Austrian system supplier in charge of production, holding specific cumulative knowledge about plastic materials, to match the prototype with production requirements. Besides, to meet the tight production schedule of the OEM a critical situation had to be solved by increasing personnel capacities. Due to the German skill shortage the CEO was only able to solve the situation by using his personal contacts to poach 20 engineers from the design department of the car manufacturer Skoda in Czechia. Human resource integration worked smoothly since they shared the same technological and sectoral context – they had been trained to work with the same CAD-tool the OEM and the Engineering KIBS use. This point is remarkable, since the software platforms in use and the organizational routines in connection therewith create an important kind of non-geographical proximity. For example the CAD software platform CATIA is the standard software tool in the fields of construction and design of OEMs in Baden-Württemberg. Accordingly, KIBS as well as suppliers use this tool. Companies which do not meet this standard are hampered in knowledge exchange, like for example the ones working for Ford using a different standard CAD software tool. Consequently, the CATIA skills were a key to quickly match and make accessible the knowledge of the Czech engineer to the knowledge of the firm.

In the phase of converting the prototype into a serial model, the weekly meetings involving the Engineering KIBS and the OEM were still in use and the KIBS's engineers still worked on site of the OEM, so implicit knowledge and face-to-face communication remained important. When production had started in the last phase only minor adjustments needed to be coordinated with the production department of the OEM at Ludwigsfelde in the northeast of Germany. Knowledge exchange was not intensive any more since partners only met monthly or else used distant ways of communication.

The knowledge dynamics unfolding in this innovation event reflect knowledge interactions in proximal and distant inter-organizational relations with changing actor constellations. Concerning the spatial dimensions of knowledge interactions of this innovation, the main actors of the OEM and the Engineering KIBS can be found in Baden-Württemberg. Physical and organizational proximity in between these central actors and learning opportunities by work-on site and weekly meetings were essential to combine diverse synthetic and symbolic knowledge bases. It was a prerequisite for the Engineering KIBS to get the contract. The combination of both types of proximities allowed for mutual, flexible and spontaneous learning. It proved to be helpful that the modes of interaction could be adapted flexibly to unforeseen situations. This facilitated mutual understanding by reducing cognitive distance among the actors, especially in the knowledge intensive first and second phase when the detailed specification of the knowledge product was missing.

All collaborating actors shared common knowledge related to organizational routines in the automotive industry to a certain degree, which facilitates collective learning in the joint creation of new knowledge. The cumulative knowledge base of the Engineering KIBS in both synthetic and symbolic knowledge fields of the vertical domain of the automotive industry enabled this firm to take over the boundary spanning role in the combinatorial knowledge production process. The Austrian System Supplier itself obviously lacked both the automotive design competences as well as the necessary high degree of organizational proximity to the OEM, so that the decision to outsource this task was reasonable. In the following, the System Supplier drew upon the resources which had been developed by its cooperation partners in former interactions as points of contact. This can be observed from the proceeding of the system supplier, who selectively exploits the proximities in the vicinity of KIBS firms by choosing a partner who is integrated into the suiting knowledge context. Additionally, the innovation biography shows the sourcing of highly specialized synthetic knowledge modules in distant inter-organizational relations. An important condition for such a labour division in knowledge production seems to be the possibility to specify the necessary knowledge modules and to define the interfaces for its integration.

What is also remarkable about this case is that we can identify a strong agreement on organizational routines of how to handle knowledge production in such a project. The defined temporal milestones of the project and the institutionalized knowledge transfer and sharing in meetings and work on site of the customer shows a large process experience which all partners obviously share or at least are able to take over easily.

4.3.1 Combining symbolic and synthetic knowledge – inter-organizational relations in the process of a service product innovation

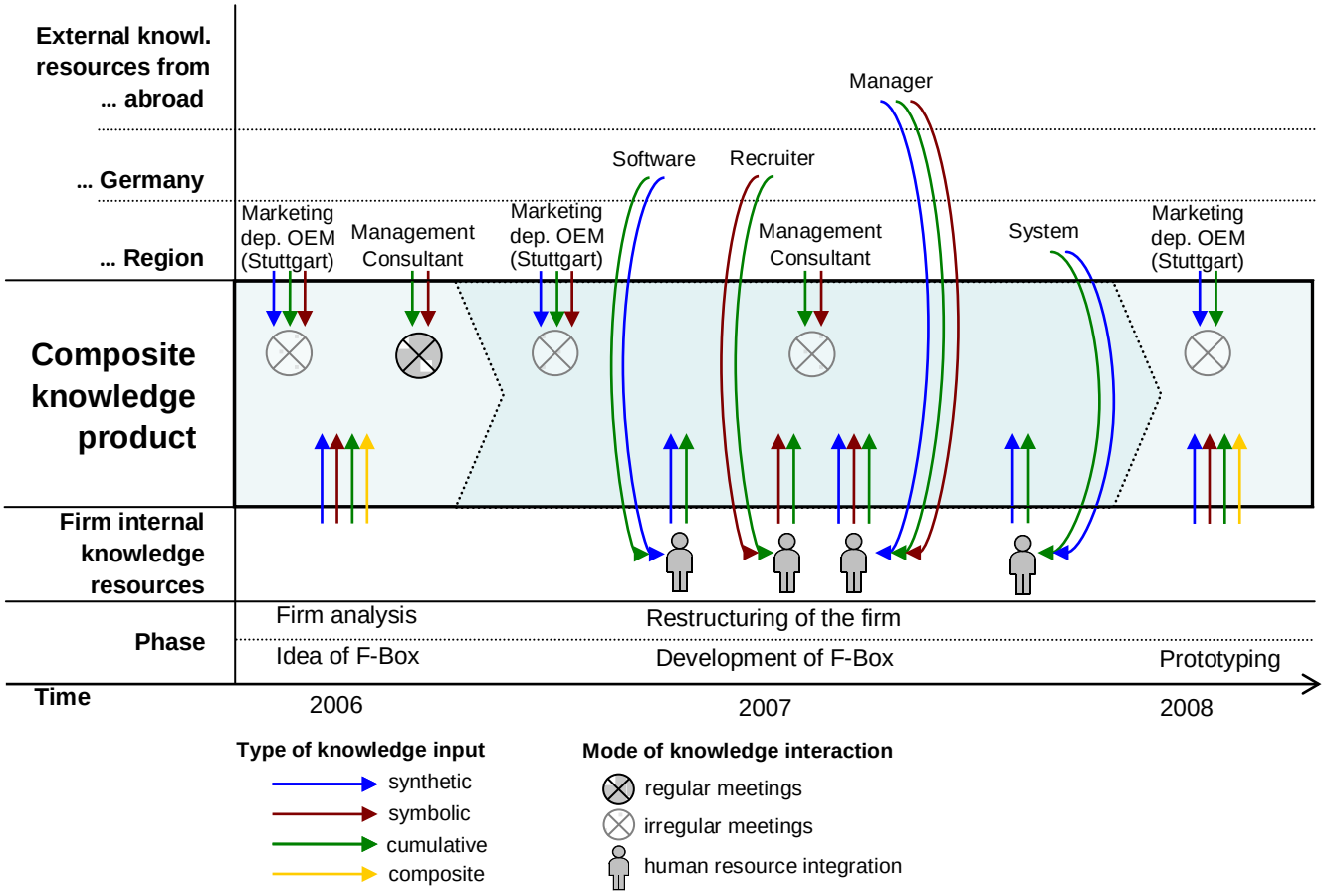
The second case of a Media KIBS illustrates how the development of the innovative output of a firm is closely linked to intra-organizational change processes. Starting point for this innovative event was the search of an OEM for a media partner to provide graphical material for a marketing campaign for the global launch of a new type of car. Due to personal contacts between the CEO and the marketing department of the OEM the Media KIBS got the chance of being awarded this large scale contract. The Media KIBS had pronounced competences in graphic animation, digital post-production and 3D-visualization from successfully carrying out tasks within the sectoral knowledge domain of the automotive sector.

However, the firm previously produced pictures and films, individually manufactured by 3D-artists which passed through the whole production process without any division of labour. Thus, the large scale project could not be mastered by this mode of production. Consequently an internal search was set off, to find a technological solution to upscale production on the one hand, and a way of creating suitable internal structures and work routines for the project on the other hand. The technological solution was to create an automated content management tool and to completely depart from manufacturing images.

The coordination between the marketing department and the Media KIBS took place on occasional meetings. Since the tool is a relatively independent module, which is handed over to the customer, there are not as many interfaces to other participating actors to be considered as for example in the previous case. Occasional project meetings thus sufficed to agree on product requirements and on a time schedule.

Nonetheless, the Media KIBS was driven to incorporate industrial routines into the design processes to get compatible to serve a project on this scale. In contrast to the previous case of the engineering KIBS, this firm could not revert to organizational routines of how to handle larger projects. As the CEO lacked competencies for managing the organizational change process himself, he called in a management consultant to find a new business model and implement new work routines. This cooperation again was established by using personal networks as a coordination mechanism. Only due to the operating experiences from both automotive and media industry, the management consultant was able to create a usable organizational structure which is compatible to the required more industrial mode of production. Hence, the Media KIBS could also profit from localized knowledge in the Stuttgart region. The consultant accompanied the Media KIBS in finding new structures and work processes in regular meetings over many months and also in implementing the new structures for another year.

Figure 2: Innovation biography of an automated content management software tool



Taking over this project was highly risky for the Media KIBS since it involved so many innovation related uncertainties. During the life-span of this innovative event many critical situations emerged, which could not be solved by internal resources. What appeared to be critical for the ability to overcome problems was the good functioning of personal networks and the ability to mobilize suiting new employees. As we can see in Figure 2 knowledge base of the firm was mainly extended by hiring external professionals with highly specialized knowledge. Thereby the needed competences came in which enabled the development of procedural and organizational routines for handling larger projects. They took over newly created leading management positions using their experience knowledge from former jobs in the game and media industry. Within only one year the Media KIBS extended its capacities from only twelve to 60 employees. Due to the human resource integration the firm was enabled to advance development of the tool and the internal restructuring using internal knowledge. This aspect is remarkable because it reveals that knowledge can be integrated and used even if it is not anchored in any of the firm's cumulative or composite knowledge-bases. On the other hand we can assume that this absorption of external knowledge only worked well because of its complementarity to the firm's existing competence in the field of 3D-computing.

We can learn from this case that changing the field of competence – from a service provider to a technology provider – requires an adaptation of intra-organizational structures and processes. It was crucial in this case to include an external business consultant, since he had to link between symbolic knowledge about marketing-related symbols and representation with the synthetic knowledge about industrial production procedures and software technology. Another important aspect is that social proximity appears to be important for the sourcing of highly specialized knowledge connected with complex application contexts. The access to external knowledge via human resource integration was only facilitated by the CEO's, and other manager's personal networks. As far as the spatial dimension is concerned, the whole knowledge involved in the first phase was obtained from actors located in Baden-Württemberg. The human resource integration later on, in contrast, drew on national and international sources.

4.4 Initiating combinatorial knowledge dynamics – the case of the visual computing cluster and the automotive simulation center

Policy initiated "Cluster Visual Computing"

As regional policy in Baden-Württemberg intends to stay abreast of changes in knowledge dynamics, the Innovation agency for ICT and media initiated a platform for knowledge exchange in visual computing technologies (MFG Medien- und Filmgesellschaft Baden-Württemberg 2007). The cluster aimed at opening up new innovation potential by bringing together the strong cumulative knowledge bases in simulation and visual computing, which can be found in several sectoral knowledge domains. Visualization and simulation techniques have become indispensable applications in many fields like the automotive industry,

mechanical engineering, architecture, medicine and the media industry. The knowledge about simulation and visualization techniques in different application contexts was expected to be congruent in large parts, thus a huge potential of cross-sectional knowledge exchange was assumed. However, to this day political actors have not succeeded in achieving self-supporting combinatorial knowledge dynamics within the visual computing cluster yet, despite the verifiable high competences in network policy in Baden-Württemberg.

This case illustrates well the limits of knowledge integration, especially in the generation of combinatorial knowledge, involving a very high degree of knowledge exchange from heterogeneous actors and located in diverse synthetic and symbolic knowledge bases. Sharing experiences and knowledge in the use of the same technology, which on the first sight appear to have many commonalities, still vary significantly according to the application context. In engineering for example, attention is turned on accuracy and measurable aspects of the simulation whereas in media applications aesthetic properties are much more important. Thus, even similar knowledge bases cannot be randomly combined. Knowledge exchange between involved institutions only gained momentum, when a certain degree of cognitive proximity in the sense of mutual understanding was present and the knowledge pieces which could be obtained externally were of value to solve the highly context specific problems. Spatial and technological proximity alone did rarely suffice to induce knowledge dynamics.

Industry initiative "Automotive Simulation Centre Stuttgart (ASCS)"

In contrast to the poor performance of the cluster visual computing, the dynamic in the knowledge field of simulation is better reflected in a bottom-up industry initiative to build up the Automotive Simulation Centre Stuttgart (ASCS). The aim of this cooperation between firms and science institutes is research and development in basic and applied fields of simulation technology and visual computing for the automotive industry.

It was the Innovation and Development Department of Porsche which gave the impulse for the development. Internally the OEM is in need of competence in advanced simulation technologies to deal with pressing issues like CO2 reduction, respirable dust reduction, light construction and a fast realization in industrial software tools (University of Stuttgart - Referat für Presse und Öffentlichkeitsarbeit 2008). Together with the High Performance Computing Centre (HLRS) Stuttgart, which brought in the high-performance computing resources, the idea grew to win over more partners with cumulative synthetic knowledge bases related to simulation technology, to master such a project on a grand scale. After a two years stimulation and networking process, the ASCS was founded in 2008 by the OEMs Porsche, Daimler and Opel, the supplier Karmann, service engineering firms, companies of the IT sector like hardware manufacturers and software companies but also the University of Stuttgart, the High Performance Computer Centre Stuttgart as well as semi-public organizations as the Virtual Dimension Centre in Fellbach. Thus partners from almost all parts of the automotive value chain have their share in bringing in synthetic knowledge from basic research to application development to the generation of combinatorial knowledge. Subsequently, the research in the

centre is conducted on a project basis. Members can apply for projects, which in turn are realized in temporary project teams on site of the ASCS.

The main purpose of the center is knowledge exploration and knowledge creation in a pre-competitive stage. In contrast to the aforementioned political cluster initiative, the cooperation within the ASCS is a demand led industry initiative and well-directed action to bring together specialized cumulative knowledge bases in simulation techniques from within the automotive sector. With the common sectoral background of the automotive industry, heterogeneity and distance of knowledge bases was limited and a certain cognitive proximity given, which proved to be helpful to create the trust needed and facilitate mutual learning.

In the initial phase before the official foundation of the Centre, it were mainly regional actors who joined forces and helped to reach a critical mass of knowledge input and reputation to attract further project partners on a pre-contractual basis. The regional endowment in the concentration of a multitude of potential project partners and knowledge readily available at an arm length helped to stimulate knowledge dynamics. On the one hand, the ASCS in principle is based on the institutional endowment of its location. At the same time this endowment is altered by the emergence of a new institution. The availability of new networks and inter-organizational forms of knowledge exchange, namely the accessibility to basic research and computing power in turn changes the scope of action for other actors. Thus, new possibilities and new points of departure for knowledge dynamics emerge and the regional endowment is enriched by the localized learning processes.

The successful realization of the project on the other hand, draws upon knowledge resources from specialized cumulative knowledge bases also located outside the region. They are even distributed internationally to facilitate access to missing pieces of specialized knowledge. From 2008 onwards, it is particularly regional and national companies which are members of the ASCS next to some foreign establishments of internationally operating IT companies, like the US company Cray Computer which equips and cooperates with the high Performance Computer Centre of the University of Stuttgart for a long time.

5 Discussion and Conclusion

Investigation of the ways in which knowledge dynamics are territorially shaped is challenging. Addressing the connection of space as a scope of action and space as being generated as a part of the social process, it takes us back into the central debate in social science concerning the relationship between structure and agency. On a macro level, knowledge dynamics are underpinned by the institutional characteristics of a territory which have formed over time. Substantial theoretical and empirical research underlines the importance of place specific institutional regimes for knowledge exchange and innovation development. However, to what extent different types of innovation rely on distinct kinds of institutional arrangements is still unclear. A major reason is that the embeddedness in specific institutional set-ups has by no

means a deterministic impact. Instead, it provides both exogenous constraints and resources for firms and organizations involved in knowledge production.

In the paper we suggest to take on a dynamic perspective and investigate knowledge interaction processes which underlie innovation events. Dynamics of knowledge unfold at the micro level of actors, therefore a key issue is how firms and other organizations, embedded in place-specific institutional endowments, use such localized resources in knowledge interactions. This question is particularly interesting in the light of the dynamic restructuring of global value chains and the increasing internationalisation of knowledge-intensive activities. Both developments, enabled by new technologies, contribute to the growing complexity of vertical and horizontal knowledge domains. In innovation processes firms are facing an increasing need to combine heterogeneous knowledge sources spread over organizational, technological and spatial boundaries. While the consequences of these developments were discussed controversially as mirrored in the global-local debate (Cooke 2005, Bathelt et al. 2004), the far more complex modes of labour division related to innovation, were rarely taken into account in detail. Insights into the implications of coordination and governance of the complex division of labour in knowledge production are scarce. Deeper empirical investigation in the connected organizational and institutional change linked with knowledge dynamics is still missing, but is indeed necessary to better understand the spatio-temporality of knowledge dynamics behind innovation.

The empirical findings provide substantial evidence for the mulit-scalar nature of knowledge interaction processes. Characterisitic for their territorial shaping is a mixed pattern of interactions at close and great distances. During the analyzed knowledge production processes, actors on a local, regional, national and international scale were included in the interorganizational relations. The decisive factors for the selection of cooperation partners were their specialized cumulative knowledge and the trust in their useful potential to the innovation, regardless of the geographical scale.

During the life-span of an innovation we can observe different emphases in the intensity of the location of interactions. The biographical approach has proven to be useful to gain insights into the variable composition of interaction partners during whole innovative event. Even though the knowledge value chains of the automotive industry in Baden-Württemberg have become highly complex, diversified and spatially enhanced due to reorganization processes, the vertical knowledge domain seems to form a focal point to explore local as well as distant knowledge. For example the long lasting cooperation between the University Stuttgart and the US firm Cray computing contributed to build up localized competences in high performance computing over many years. This cumulative knowledge base is used and explored in new inter-organizational relations in the large scale cooperation project ASCS.

Additionally, it became obvious that innovative events are often closely linked to organizational change, respectively the emergence of new institutions. Micro dynamics of knowledge in inter-organizational relations themselves reshape the territorial configuration of economies in creating new forms of organization as part of the innovation process. This can be the

emergence of new organizational bodies like in the case of the ASCS. A common organizational framework can probably be regarded as a prerequisite for trust-building and knowledge sharing, in cases where actors fear the risk of knowledge loss or usually encounter each other as competitors and not as partners. Another reason for the creation of new organizational entities is the issue of representation. In this case an organizational representation of the new purpose was necessary to acquire further financial funds from the public sector to realize the new knowledge production. In the case of the visual simulation cluster also the emergence of new network structures could be observed. So it needs to be noted, that the global-local dichotomy (cf. Bathelt et al. 2004) misses the complexity of knowledge interactions over time in innovative change.

The comparison of the empirical cases supports exisiting findings which point out that synthetic and symbolic knowledge production differs in distinct ways (cf. Asheim 2007). The organizational processes of knowledge production among the Media KIBS and the Engineering KIBS are different even both KIBS firms operate in the same vertical knowledge domain of the automotive industry. For the coming through of a successful innovation based on combinatorial knowledge dynamics, organizational proximity, the flexible deployment of temporal geographical proximity and the development of appropriate organizational routines in inter- and often intra-organizational relations seem to be crucial.

As the Media KIBS show only by combining the logic of the organizational routines used in the industrial sector of the automotive industry with its own existing internal processes, the firm achieved the necessary scaling of the symbolic knowledge output. Following the spatial and temporal set up of the innovation events, due to the biographical method, we could observe the dynamic use of temporal and geographical proximity in the change process in very distinct ways. In the synthetic knowledge field of the automotive industry the separation of knowledge exploration and exploitation (production and R&D) in place and time has already practiced for long time. Organizational routines to govern knowledge creation, like the product development process or product design process are well established. They facilitate coordination and interaction processes and reduce uncertainties in knowledge production. As the interaction processes with the German and Austrian suppliers show, knowledge can also be sourced over larger distances. The established routines in the vertical knowledge domain support mutual understanding within the process of knowledge production. The physical proximity which is produced on a regular basis and institutionalized by the actors in advance to structure the uncertain process in time seems sufficient.

As long as only one knowledge base is involved in knowledge creation, the specification of knowledge modules and the definition of interfaces appear to be much clearer and easier for the actors involved. But as soon as different knowledge bases need to be integrated, the necessity for multiple forms of proximity being simultaneously in use among the actors gets stronger. The interaction processes of the OEM and the Engineering KIBS show that physical proximity in the form of punctual meetings in time seem not enough, to integrate and combine synthetic and symbolic knowledge. Although the actors shared the same vertical knowledge domain, working on site over a longer time period was necessary.

Summarizing our findings about the territorial shaping of combinatorial knowledge dynamics, the place-specific institutional endowment and cumulative knowledge bases provide a rich repertoire for variation that can be used by actors to achieve innovative solutions. But the results mirrored obstacles in the production of combinatorial knowledge which still need more in-depth research.

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