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Micro-dynamics of knowledge: actors, processes and territorial organization

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Abstract:

By applying the evolutionary economic geography approach and focusing on the organizational dimension of the knowledge-based theory of the firm the paper intends to make both a conceptual and an empirical contribution to understand the ways in which knowledge dynamics unfold in time and space and lead to innovative change. The article focuses on the connections of cumulative and combinatorial knowledge dynamics at the micro level of firms and other organizations. The empirical results base on the quantitative and qualitative meta-analysis of case studies in Europe that were obtained by the instrument of innovation biographies.

Keywords: Micro-dynamics of Knowledge, Innovation, Institution, territorial Organization

JEL Codes: D83, O4, O31, O32, R11.

1 Introduction

The concept of Territorial Knowledge Dynamics (TKDs) developed in the Eurodite project focuses on the territorial organization of knowledge interaction processes. It is argued that a qualitative shift from 'cumulative' to 'combinatorial knowledge dynamics' is under way (CREVOISIER and JEANNERAT, 2009). While the former former place emphasis on knowledge creation within firms, sectors and regions, the latter come into existence by the unification of originally separated knowledge bases spanning over distinct organizational, sectoral and territorial contexts.

Investigating the territorial shaping of knowledge dynamics is challenging since it requires an integrated view to grasp trajectories of knowledge as a result from simultaneous and interacting dynamics at both the micro and macro level. A major reason for that is that knowledge does not easily flow like information due to its inherent tacit dimension, its process character and its context dependence. The production of knowledge is fundamentally grounded in complex social processes embedded in institutional contexts. Knowledge interactions generally are localized but not limited to certain territories. Geography does play an important role as a platform to organize knowledge interactions due to proximity economies facilitating especially tacit knowledge exchange (BOSCHMA, 2005; GERTLER 2003). Furthermore geography influences knowledge dynamics not only through the mechanism of proximity but also through the mechanism of path dependency and place specific institution building. From a dynamic perspective, it can be assumed that the claimed growing importance of combinatorial knowledge also brings about new or transformed territorial shapings. However, how knowledge dynamics unfold in time and space and how both cumulative and combinatorial modes are connected at the micro level has not been fully explored.

The paper aims to deepen the understanding of the modes in which different forms of knowledge dynamics are connected and unfold in time and space in conceptual and empirical terms. By using the biographical methods as special approach for the empirical investigation, the Eurodite project investigated in knowledge interactions underlying innovation at the micro level without making an explicit distinction of different modes in advance. The paper derives to take advantage from this research procedure. Based on a suggested conceptual distinction between different forms of cumulative and combinatorial dynamics the empirical analysis will explore what kind of insights can be gained from these empirical findings on the spatial organization of micro dynamics of knowledge (MKD). The ways in which cumulative and combinatorial knowledge dynamics are connected and shaped by proximity economies and the institutional embeddedness of actors, and in turn reshape territory and territorial configurations of actors, as a part of the social process is investigated in the article.

By applying the evolutionary economic geography approach (BOSCHMA and FRENKEN, 2006) and focusing on the organizational and institutional dimension of the knowledge-based theory of the firm (DOSI et.al., 2008; TEECE, 2010; NOOTEBOOM, 2010), the paper intends to make both a conceptual and an empirical contribution to understand the ways in which knowledge dynamics unfold in time and space and lead to innovative change.

2 Shift in Knowledge dynamics

The notion 'knowledge dynamics' - applied to both the micro and the macro-level - is recently used in the field of research focusing on 'knowledge economics'. Knowledge dynamics are unfolding from interaction processes of the creation, use, transformation and diffusion of knowledge. Innovations in products, services or processes are the visible results of these driving forces. Firms and other organizations are important actors in knowledge using and knowledge generation processes leading to innovation. The rich theoretical and empirical research strands dealing with knowledge and innovation from a micro or macro perspective clearly brought out the multi-level nature of knowledge dynamics.

Following CREVOISIER and JEANNERAT (2009)'s focus on the macro level of territorial knowledge dynamics (TKDs), knowledge circulates to a greater extent and is continuously mobilized and combined within interacting firms and regions. Traditional cumulative learning processes within firms, sectors and regions lose importance. *Combinatorial knowledge dynamics* taking place between technological and non-technological resources as well as between firms, sectors and regions have given rise to new territorial shapes and new research challenges.

A parallel scientific debate also occurred on the micro-level of firms and organizations starting in the 2000s. Several approaches in innovation research acknowledge and underline the growing importance of knowledge external to the firm and the changing nature of innovation (OECD 2010). This is particularly reflected in the debate on distributed innovation (COOMBS et.al, 2003), on more open innovation environment (CHESBROUGH, 2006; COOKE, 2005) and the organizational decomposition of innovation (SCHMITZ and STRAMBACH, 2009). As response to an increasing market fragmentation, more individual and divergent customer requirements as well as shorter innovation cycles in the globalization processes, the openness of firms to source outside knowledge stocks is underlined. The dynamic organizational capabilities to integrate, build and reconfigure internal and external knowledge are emphasized as essential competencies of the knowledge-based firm (TEECE et. al. 1997: 516). Additionally the growing importance of user involvement (V. HIPPEL, 2010) and the co-creation of values together with customers point also towards the increase of non-technological knowledge as a driving force for innovation. Even though these literature strands in innovation research do not focus on cumulative and combinatorial knowledge dynamics, the arguments at the micro level of firms and organizations coincide partly with the ones underlying the debate of the TKDs concept (CREVOISIER and JEANNERAT 2009).

Furthermore a general change in the way scientific, technological, social and cultural knowledge is produced was already acknowledged in the mid-1990s. New knowledge is increasingly created by a variety of actors in complex problem-oriented contexts in a transdisciplinary way. GIBBONS et. al (1994) labeled this new way 'Mode 2' for differentiating it from traditional knowledge production within a disciplinary, primarily cognitive context. Without using the term they point to 'combinatorial knowledge dynamics' in broader, transdisciplinary social and economic contexts. It has been argued that this new mode of knowledge production is replacing or reforming established institutions, disciplines, practices and policies. After a decade of the scientific discourse, there is a broad consensus that the notion 'Mode 2' made an important contribution to the visibility and understanding of the contemporary change. The focus of criticism is however still on the low conceptual foundation and on the ambiguity of notion. Both make it difficult to capture empirical processes in systematic and comparative ways that allow practical interventions (HESSELS

and VAN LENTE, 2010; RIP, 2010). One must add that these both aspects are to some extent mutually dependent. Moreover, the implications of that change for the territorial organization of knowledge dynamics have not been examined in more detail.

In summary, despite all differences in the analytical levels and theoretical approaches of these scientific debates, they point to a qualitative shift towards more complex and distributed knowledge interaction processes in organizational and spatial terms leading to innovative change. Using TKDs as an epistemological concept that focuses explicitly on the territorial organization and consequences of the claimed shift deserves a deeper conceptual foundation to facilitate empirical investigation. Evolutionary theory of knowledge and organization as well as evolutionary economic geography could be helpful when thinking about the nature and connection of cumulative and combinatorial knowledge dynamics.

3 Time and institutions in knowledge dynamics

Relating knowledge to innovation, based on SCHUMPETER (1934), it can be argued that innovations are always new combinations of existing knowledge and learning. Accordingly, combination is considered in general as an essential source for novelty, innovation and technological change. Making the case that a qualitative shift from 'cumulative' to 'combinatorial knowledge dynamics' is under way (CREVOISIER and JEANNERAT, 2009), begs the question what the specific characteristics which differentiate combinatorial knowledge dynamics from cumulative ones in theoretical terms are. From an evolutionary perspective two dimensions – *time and institutions* – can be used to differentiate both types conceptually.

In evolutionary economic theory the cumulative nature of knowledge that leads to the formation of specific knowledge bases, often synonymously called stocks of knowledge, is widely acknowledged. Socio-economic development has been seen as reflecting path-dependent cumulative knowledge dynamics and the co-evolution of technological innovation and social institutions that result in new developments. The cumulativeness of knowledge is understood as the degree to which the generation of new knowledge builds upon current knowledge (MALERBA and ORSENIGO 2000: 290). ANTONELLI (2005: 230) specifies that knowledge cumulability is found when different vintages of knowledge are necessary for new knowledge to be both acquired and enriched. Accordingly, *time* is a distinct dimension to differentiate cumulative and combinatorial knowledge.

Focusing on the emergence of new technology, ARTHUR (2011: 20-22) argues that the stock of existing technologies provides the parts for combination. The inventions are built cumulatively from earlier inventions. Slowly in time existing technologies beget further technologies due to the fact that more complex ones use simpler ones as components. He calls this mechanism 'combinatorial evolution'. Following this reasoning it can be stated that there is a connection between cumulative knowledge bases and the possibilities of combination. Or in other words new combinations are limited by the cumulative knowledge bases built previously in time. Only on their basis, more complex combinations may evolve, which can explain why some technologies were not developed hundred years ago. The institutional dimension plays an important role for the cumulativeness of knowledge by contributing to certain continuity in time. The co-evolution of institutions and complementary institutional arrangements are central for the continuity of cumulative

knowledge trajectories and the specific profile of cumulative knowledge bases in present time.

Beyond the level of technology it is pointed out on several analytical levels - ranging from the individual to nation states - that cumulativeness determines knowledge production. Drawing on these largely separated scientific discourses direct as well as indirect impacts of the *institutional context* are indicated in which knowledge interaction processes are embedded.

At the **micro level of firms** substantial research has shown that cumulative knowledge provides options to expand in new but uncertain markets in the future. What an organization has done before tends to predict the type and direction of innovation processes as well as the ability to absorb new knowledge (COHEN and LEVINTHAL, 1990; KOGUT and ZANDER, 1992; PATEL and PAVITT, 1997). Knowledge creation and firms' modes of innovation are strongly shaped by their specific cumulative knowledge base(s). Organizational routines and organizational capabilities are essential institutions that coordinate and integrate knowledge using and exploring processes among individuals and communities at the firm level (NELSON and WINTER, 1982; DOSI et. al, 2008; TEECE, 2010). By referring to organizational path dependence, the knowledge and competence-based theory of the firm (KOGUT and ZANDER 1992; NONAKA and TAKEUCHI 1995; TEECE et. al. 1997) underline that routines and organizational practice are based on localized learning processes over time, which explains why they cannot easily be replicated and transferred to other contexts (TEECE 2010) and therefore contribute to organizational competitiveness.

Comparably, at the aggregated level of **industrial sectors** the specific knowledge bases determine the organization of knowledge exploration and exploitation processes (ASHEIM and GERTLER, 2005; MALERBA, 2005). At the aggregated level of industries, sector specific institutions or established practices and organizational forms differ considerably (MALERBA, 2005). In some industries, as for instance the pharmaceutical or the automotive industry, knowledge exploration and exploitation processes have been separated in time and space for a long time. In other sector context with a dominant symbolic knowledge base however, these processes are more tightly coupled in time and space. On the basis of the synthetic, analytic and symbolic typology of knowledge bases the understanding of marked sector differences in the organization of innovation has made substantial progress (ASHEIM and COENEN, 2006; ASHEIM, 2007).

At the **regional and national levels** cumulative knowledge bases developed over time are made responsible for the competitiveness of territories. Especially territorial innovation models (TIMs) (MOULAERT and SEKIA, 2003) put emphasis on the local institutional environment and its impact on innovation processes. Cumulative knowledge bases embedded in complex institutional ecologies/configurations generate the need for firms of 'being there' to have access to these specialized knowledge bases (GERTLER, 2003; GERTLER, 2010). Furthermore macro level approaches like the National System of Innovation (LUNDVALL et. al, 2002), the Varieties of Capitalism (HALL and SOSKICE, 2001) or the Social Systems of Innovation and Production (AMABLE 2003) point in the same direction. They explain the relative stability of specific innovation profiles and the comparative innovation strength of national economies by distinct differences in the institutional configurations and mechanisms of institutional complementarities. The systemic context conditions developed over time affect innovation processes and new knowledge creation at the micro level.

Coming back to both modes of knowledge dynamics an important conclusion can be drawn out of these different scientific debates. The special feature of knowledge interactions of the *cumulative type* is that the production of new knowledge is directly dependent or builds mainly on previously generated knowledge bases structured over time by co-evolved functionally specialized institutional settings. In cumulative knowledge interactions leading to innovation actors may combine several specialized knowledge bases, too. However, for this kind of combinations the functional institutional settings in which the respective knowledge stocks are embedded are similar or have at least a very high degree of overlapping. Even though the knowledge bases, in cumulative knowledge dynamics are divided on different actors or distributed in space, they are not 'dispersed' in the sense of being unorganized or 'unrelated'.

Given the transversal nature of combinatorial dynamics, they come into existence by the unification of originally separated knowledge bases located in distinct institutional environments (CREVOISIER and JEANNERAT, 2009, HALKIER et al 2012). From an evolutionary point of view it can be argued that the scope of variety in combinatorial knowledge dynamics is wider compared to the cumulative ones. Developed institutional settings by no way determine behaviour of actors. However, they impact selection process in the exploration of knowledge complementarities and facilitate the exploitation by supporting connectivity and retention processes. Institutional overlaps affect cognitive proximity between the actors due to shared norms and values which in turn facilitate mutual understanding, learning and the generation of new knowledge (NOOTEBOOM 2010, BOSCHMA 2005). Correspondingly, a low degree of institutional overlaps - as characteristic of combinatorial knowledge interactions - implies a wider range of variety among the involved actors and a greater extent of cognitive distance in these kinds of knowledge dynamics.

Meanwhile substantial insights exist in the dynamics of cumulative knowledge development and the self-reinforcing mechanisms which lead to knowledge accumulation and competence building over time in a path dependent way. Regarding the mechanisms and processes of combinatorial knowledge dynamics several theoretical, methodological and empirical questions are still open. The micro-level of actors is an important analytical level to deepen the understanding of combinatorial knowledge dynamics and the territorial shaping discussed in the following section.

4 Micro dynamics of knowledge and institutional change

Micro dynamics of knowledge emerge and are founded in interactions processes of actors within firms and other organization or between networks of firms and organizations. Having defined the key feature of combinatorial knowledge dynamics as action contexts with the participation of a variety of different actors who belong to different organizational and sectoral contexts or are located in different places, this type of knowledge production has to cope with many different institutional interfaces. Compared to cumulative knowledge production both a high degree of cognitive diversity and a low level of common knowledge between the actors can be considered as characteristic attributes of combinatorial knowledge production (table 1).

Table 1: Characteristics of cumulative and combinatorial knowledge dynamics at the micro level

Dimension **Actors**	**Cumulative knowledge dynamics**	**Combinatorial knowledge dynamics**
Cognitive distance	Low	High
Institutional overlaps	High	Low
Interaction process		
Existing knowledge base(s)	Broaden/Deepen	Unification with others
Variety of contexts to be integrated	Low	High
Required investment in mutual understanding	Low	High
Required bridging of organizational, technological and sectoral interfaces	Low	High

Source: STRAMBACH and KLEMENT 2012, modified

At the individual level knowledge interaction processes are strongly influenced by cognitive distance and proximity between actors (BOSCHMA 2005, NOOTEBOOM 2010, IBERT 2010) since knowledge and sense making are embedded in action contexts. Cognitions[1] determine perceptions and interpretation and judgments of situations. They are influencing mutual understanding and therefore the absorptive capacity of individual actors and their potential to jointly create new knowledge. Building upon the knowledge based view of the firm and its focus on organizational capabilities it is obvious that the development of organizational routines and governance structures which are capable to coordinate and govern combinatorial knowledge creation processes seems to be far more complex.

Cognition as a mental activity by definition cannot apply to aggregates such as firms or organization (NOOTEBOOM 2010: 29). However, actors located in similar institutional contexts as in organizations can share views, interpretations, values and norms of behaviour which are not shared outside the organization. Based on organizational routines firms provide cognitive orientation and foster cumulative knowledge dynamics. As GRANT (1996) points out, routines provide a mechanism for coordination which does not require the communication of knowledge in explicit form. The physical, social, cultural and resource-allocation structures allow knowledge resources to be shaped into competences based on experiences and expertise of individuals to create economic value (TEECE, 2008, NONAKA and TAKEUCHI, 1995; GRANT, 1996).

As research on the knowledge-based theory of the firm points out, the efficiency of knowledge integration is influenced by the level of common knowledge, the frequency and

[1] Here broadly understood as mental activities including perceptions, interpretations, sense making, knowledge and skills, norms and values which are developed by people in interaction with their social and physical environment (Cf. BERGER and LUCKMANN 1966).

variability of the activity and the structure, which economizes on communication (GRANT, 1996; KOGUT and ZANDER 1992). The wider the span of knowledge being integrated, the more complex is the creation and management of organizational capabilities. Accordingly, in actor constellations of combinatorial knowledge production, barriers might be caused by cognitive distance, a low degree of institutional overlaps and the required overcoming of several organizational, technological and sectoral interfaces. Actors coming from a variety of backgrounds have to cope with many different technological, organizational and institutional interfaces in order to explore complementarities of originally separated knowledge stocks. To bridge the diverse interfaces and develop a common knowledge base that supports decision-making and choice in the course of the innovation process, actors have to invest much more in cognitive coordination and establishing sufficient mutual understanding compared to cumulative knowledge production. The plasticity of institutions understood as their interpretative flexibility (STRAMBACH, 2010) and the low degree of institutional coherence open up a wide room for interpretations and perceptions. In turn, that generates the need for complex communication processes to convert the variety of different actors' meanings into shared views. The latter enable the ability to collaborate and influence the willingness and commitment to do so (NOOTEBOOM, 2010: 77). While overlapping institutional contexts in cumulative knowledge production facilitate the integration of knowledge by providing a level of common knowledge grounded in the intersection of different types of proximities like organizational, technological or the sectoral one, combinatorial knowledge production lacks such focussing mechanisms to a large extent.

HAYEK (1945: 520-522) already denoted the fundamental problem of the economic organization how to make the large body of very important but unorganized and 'dispersed' knowledge widely available. He put emphasis on the question of appropriate institution building as one of the main problems of designing efficient economic systems. Dispersed knowledge is understood as systems where the knowledge of the relevant facts is initially dispersed among many people due to its generation in the particular circumstances of time and place. Geography might play an import role as platform for the coordination and integration of combinatorial knowledge production. In economic geography it is widely acknowledged that spatial proximity facilitates knowledge exchange and creation in particular, when the knowledge being produced and exchanged is highly specialized and has a strong tacit component, or is highly novel and economically very valuable (HOWELLS 2002; GERTLER 2003). However, it is not the spatial proximity per se which is considered as an important mechanism that may bring together actors within and between organizations. It is most likely the intersection with other forms of non-geographical proximities such as cognitive, organisational, social and institutional proximity that provide solutions to the fundamental problem of knowledge coordination (BOSCHMA 2005). Temporary (spatial) proximity plays an important role to establish forms of proximities particularly in long-distance knowledge interaction processes (TORRE 2008). 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. From an evolutionary perspective combinatorial knowledge dynamics have the potential to generate variety within an established path and contribute to institutional dynamics. Given the transversal nature of this mode of knowledge interactions they may often involve the transfer of institutions to different contexts, or rearrangements or re-combinations of institutional principles and practices in new and creative ways for new purposes. By becoming further institutionalized this may lead to gradual institutional change over time (STREECK/THELEN 2005).

The analysis of the empirical case studies investigated in *EURODITE* seeks to contribute to a deeper understanding of different types of knowledge dynamics at the micro level and their territorial organization.

5 Methodology

The Eurodite project followed a qualitative methodological research design to gain insights into knowledge dynamics of innovative changes and how these unfold in space and time. Based on the methodological approach of the grounded theory (GLASER and STRAUSS, 1967) the project intended to derive theory building in an inductive way rather than testing existing theories. The empirical meta-analysis in this paper has an explorative nature and uses quantitative and qualitative methods. As data sources the written reports on the innovation biographies and the quantitative data of the timeline reports were analyzed. The latter contain basic information on the knowledge interaction processes in the course of every innovation event. The actors including their spatial and sectoral location and the knowledge types were noted in a systematic manner through each of the different research teams. The empirical investigation on knowledge interactions in Eurodite were carried out without distinguishing between modes.

Table 2: Proxies for cumulative and combinatorial knowledge dynamics at the micro level

Indicators	**Cumulative knowledge dynamics**	**Combinatorial knowledge dynamics**
SAS Knowledge Base	Within the same Knowledge Base	Between Knowledge Bases
Knowledge Domain	Within the same Knowledge domain	Between Knowledge Domains
Stability of relationship of Actors	Long term relationship	Totally new Actors
Geographical Distance	National/Regional Interaction	International Interactions

Therefore different indicators are used in the analysis as proxies for cumulative and combinatorial knowledge production. Based on the theory-led distinct features of both modes, mainly associated with cognitive distance and heterogeneity between actors and institutional distance, respectively overlaps the *SAS knowledge bases, knowledge domains related to the value chain, the stability of the relationship and the location of the interacting actors* are applied (see table 2).

In total, 62 case studies, each comprising one innovation event, were analyzed. *EURODITE* investigated innovation events at the firm level in seven sectors: food & drink; automotive; biotechnology; ICT (information and communication technology); Knowledge Intensive Business Services (KIBS); new media; and tourism in 22 European regions. In summary, 693 knowledge interaction processes form the foundation of the empirical findings reported here. Knowledge interaction processes are hereby defined as knowledge using, transforming and creating processes occurring in interaction of several actors during an innovation event. The first part the quantitative cross-cutting analysis of the empirical data focuses on the

structural dimension of knowledge interactions and does not take into account the time dimension. Initial insights on modes of knowledge dynamics at the micro level and their territorial organization can be gained even though being descriptive.

The second part is led by a process view and analyses the knowledge interactions related to innovation events over time. The analysis concentrated on 'innovation biographies' of three industrial sectors: tourism, automotive and knowledge intensive business services (KIBS). The criteria for sector choice are both their distinct knowledge bases and marked differences in their respective industrial organizations. The selection of the specific sectors is led by the assumption that sector contexts influence knowledge interaction processes, especially due to differences in the dominant knowledge bases (ASHEIM 2007) and the co-evolved sector-specific institutional arrangements and organizational routines.

The instrument of innovation biographies was developed within Eurodite. By tracing back an innovation event in its biographical development, the instrument concentrates on the distributed knowledge activities and tries to understand how the internal knowledge of actors is related to the various sources of external knowledge located at different scales and their evolution over time. It uses secondary research and a combination of different types of qualitative interviews connected with a snowball sampling strategy to investigate the sequences and distributed knowledge activities of innovation events (for detailed information see BUTZIN and WIDMAIER in this special issue). What makes biographical research in social science (FISCHER-ROSENTHAL & ROSENTHAL 1997: 411) particularly interesting to transfer and adapt to research on innovation are three attributes: its concern to link macro and micro level of analysis; its epistemological intention to uncover the general from within the particular; its consideration of reciprocal effects among the past, the present and the future. Just as the individual life encompasses experiences that draw on a multiplicity of forms of thoughts and actions (WENGRAF et al 2002: 262), every innovation is unique and the biographical method can reveal to cover the hidden knowledge paths.

The written innovation biographies were analyzed by means of a qualitative content analysis (MAYRING, 2000: 1). Central for the qualitative analysis are the use of categories deductively or inductively built to identify text passages that are relevant for the analysis. While the material was examined mainly by deductive theory-led coding, these were supplemented by inductive ones formulated directly out of the material. Such a proceeding increases the openness and flexibility to grasp and discover new aspects which so far had not been considered theoretically.

However, drawbacks have to be taken into account to approaching innovation processes by qualitative analysis. The empirical findings may be of limited representativeness due to the relatively small number of analyzed cases, the idiosyncrasy of innovation processes and the limited, possibly arbitrary selection of cases. The international nature of the research project means that empirical material from many cultural contexts was collected by several researcher teams from a variety of (research) cultures and disciplines. Even though the cultural distance between researchers and interview partners was rather low, the transfer of empirical material throughout the research consortium across language barriers and cultural contexts was subject to individual interpretations of the researchers (cf. ZALAN & LEWIS 2004).

6 Empirical insights in cumulative and combinatorial knowledge dynamics – a cross-sectoral analysis

The labor division in knowledge production and the significance of external knowledge sources become evident by pursuing the knowledge interaction processes of innovation events in case studies of different industries. Over two-thirds of the 693 analyzed knowledge interaction processes involve actors who are external to the focal firm or organization. The result is clearly underlining the changing nature of innovation processes, its organizational decomposition and the involvement of spatially distributed knowledge. However the high amount of external knowledge sourcing does not simultaneously imply an increase in the combinatorial type of knowledge dynamics as conceptually defined. By applying indicators for both modes of knowledge dynamics initial insights can be gained.

Table 3: Actors and relationships in knowledge interactions

		Type of relationship							
		All		Totally new actor		Known actor intermittent contact		Long term continous	
Sectors		No.	%	No.	%	No.	%	No.	%
Automotive	PKI	77	100%	23	30%	22	29%	32	42%
	DKI	13	100%	3	23%	4	31%	6	46%
Bio technology	PKI	102	100%	21	21%	53	52%	28	27%
	DKI	43	100%	7	16%	24	56%	12	28%
Food & drink	PKI	62	100%	15	24%	18	29%	29	47%
	DKI	14	100%	2	14%	3	21%	9	64%
ICT	PKI	61	100%	23	38%	18	30%	20	33%
	DKI	32	100%	15	47%	8	25%	9	28%
KIBS	PKI	53	100%	22	42%	18	34%	13	25%
	DKI	11	100%	5	45%	2	18%	4	36%
New media	PKI	38	100%	10	26%	16	42%	12	32%
	DKI	19	100%	14	74%	4	21%	1	5%
Tourism	PKI	141	100%	44	31%	25	18%	72	51%
	DKI	20	100%	10	50%	5	25%	5	25%
All sectors	PKI	534	100%	158	30%	170	32%	206	39%
	DKI	152	100%	56	37%	55	36%	46	30%

Table 3 first provides an overview of all knowledge interactions analyzed in the case studies of the Eurodite project. They are assigned on the one hand to the sector in which the corresponding innovation event took place and on the other hand to the type(s) of the actors and their relationships. Based on theoretical debates it is assumed that actors with long-term relationships may have a lower degree of cognitive distance compared to knowledge interactions between totally new actors. In long-term relationships due to previous interaction processes a common knowledge base or even social proximity are already established. Spatial proximity stands for institutional overlaps. In cross-border knowledge interaction processes taking place in long-distance relations (DKI) actors are facing a lower degree of institutional overlaps as those who are involved in national or regional knowledge interactions. The later are named proximal knowledge interactions (PKD).

Analyzing the kind of actors involved in knowledge production and their relationships, the cross-sectoral results underline that the sourcing of external knowledge from well-known actors with long term trust-based relationships is as important as the involvement of new actors or those with contacts of an intermittent nature (table 3). Going in more detail into proximal and distant relationships, around a fifth of the investigated knowledge interactions are international relationships (DKI). Over a third of the distant knowledge interaction processes take part amongst actors who are new to each other. These interaction processes

indicate combinatorial knowledge production. However, regarding the territorial organization of knowledge dynamics the high degree of established long term trust-based relationships to distant actors who are involved in innovation events is remarkable. Furthermore, even in knowledge interactions in regional and national contexts (PKI) a high share of new actors (30 %) is involved. In the course of the innovation event it is not only necessary to acess distant knowledge sources held by new actors, it also appears to be of importance to open up specialized knowlege bases of new actors located in regional and national contexts and to integrate them in innovative problem solving processes.

Table 4: Knowledge types and their combination in knowledge interactions

	Knowledge types			Combinations of knowledge types			Total	
Sector	Analytic (1) %	Synthetic (2) %	Symbolic (3) %	Analytic / Synthetic (1,2) %	Synthetic / Symbolic (2,3) %	A / S / S (1,2,3) %	%	
Automotive	13%	**64%**	13%	4%	4%	0%	100%	89
Bio technology	**24%**	18%	18%	14%	26%	0%	100%	145
Food & drink	13%	41%	37%	4%	5%	0%	100%	78
ICT	10%	**54%**	5%	31%	0%	0%	100%	87
KIBS	0%	**88%**	3%	0%	9%	0%	100%	66
New media	14%	14%	**53%**	0%	16%	4%	100%	57
Tourism	0%	10%	**76%**	0%	14%	0%	100%	171
All	11%	**35%**	34%	8%	12%	0%	100%	693

Barriers in combining and integrating types of knowledge were significant by using the SAS-taxonomy (ASHEIM, 2007) as indicator for cognitive distance and institutional overlaps. Combinations of knowledge types occur rather rarely, only amounting to 20% of all knowledge interaction processes. Furthermore, the dominating knowledge bases of the sectors (according to ASHEIM 2007) are reflected in the shares of knowledge types involved (table 4, marked cells). Beyond that the results underline, that not all types of knowledge can be equally combined in interaction processes. The analytic/symbolic combinations in the knowledge interaction processes were not found at the micro level. Presumably cognitive distance and institutional heterogeneity between actors in such constellations are extremely high. In the transformation process of knowledge into economic value added the analytical type of knowledge can be characterized by a major distance to the application and market context.

Considering combinatorial knowledge at the aggregated sectoral level, sector-specific modes of sourcing different knowledge types have to be acknowledged. Additionally outside the dominating knowledge base of a sector, the empirical figures (table 4) show that all three types of knowledge are present in innovation events. Symbolic knowledge, in particular, appears to contribute a lot to the innovation processes, not only in those sectors dominated by a symbolic knowledge base (such as tourism or new media), but also in those sectors usually depicted as analytical or synthetic industries, such as biotech or food & drink (ASHEIM 2007). Overall, industry differences indicate the impact of both the sector-specific organization of knowledge formation and of sector-related institutions in knowledge dynamics at the micro-level.

In summary, the quantitative findings clearly underline the growing labor division in knowledge production involving different internal and external actors in innovation processes. However it is rather difficult to clearly determine distinct differences in the territorial organization of both modes of knowledge dynamics. Hence, combinatorial knowledge dynamics are not necessarily associated with spatially distant knowledge interaction processes. To open up specialized knowlege bases of new actors located in regional and national contexts and to integrate them in innovative problem solving

processes seems equally important. On the other hand long term trust-based linkages to actors facilitating the exchange of tacit knowledge are present in all sector contexts. However, these are embedded in both regional institutional environments as well as in international contexts. Overall the quantitative results indicate that the importance of cumulative knowledge is not diminished. Both processes, the further cumulative specialization of knowledge and the combination of separate knowledge bases seem to complement, not substitute each other in innovation events.

Apparently, the sectoral domain still plays an important role in the integration of knowledge from various actors. Although it is acknowledged that sectoral boundaries are becoming blurred, specific institutional settings are still important in the coordination of knowledge integration in learning processes across organizational boundaries. However, the territorial organization of knowledge interactions leading to successful innovation over time seems far more complex as the global-local debate points to. Knowledge interactions involve local, regional, national and international actors in mixed patterns of interactions at close and great distances. The structural and aggregated analysis is undervaluing the procedural and organizational dynamics of knowledge interactions behind innovation. By taking on a process-based view, knowledge interactions associated with organizational changes turned out to be of a multi-scalar nature.

7 Innovation in tourism, automotive and KIBS industries – the territorial organization of knowledge dynamics

Reconstructing the knowledge trajectories behind innovation events in time and space provides empirical insights into the way these shape territories as a part of the social learning processes. The quantitative analysis found inter-industry differences in knowledge interactions across organizations proved to be larger as intra-industry differences. Comparing innovation events in three sector contexts with distinct knowledge bases and marked differences in their respective industrial organizations helped to understand similarities and differences in the territorial organization.

By exploring the time dimension in the analysis of the innovation events the biographies showed not only that both proximal and distant knowledge interactions are apparently present in knowledge dynamics, but also that they are not separated in the course of the innovation event. Across the three sectors one cannot identify particular phases of the innovation process that are only characterized by proximal or distant relationships. In many phases knowledge interactions at more than one spatial scale are interwoven at the same time (STRAMBACH and STOCKHORST 2010). Furthermore, knowledge dynamics do not appear to develop in a linear way; for example from proximal to distant relations. A notable finding is that temporary geographical proximity (TGP) was used in a dynamic way during the course of all observed innovation events as an essential mechanism for knowledge coordination and integration. Reconstructed from the empirical material a posteriori different forms of TGP can be indentified, ranging from working on-site over the whole project to workshops lasting one week as well as one day meetings. In knowledge creation processes different forms of TGP were often practiced in one innovation event. Even though milestone meetings were fixed in advance among the involved actors to structure knowledge coordination, spontaneous and flexible knowledge sharing in various situations

were characterized by a high degree of uncertainty, required temporary spatial proximity and co-location.

Following the innovation biographies in time and space, it turns out that organizational change and institutional dynamics are significant features of knowledge trajectories. In many cases new organizational forms emerged which have not existed prior to the innovation event. Three kinds of organizational forms could be identified comparing the empirical cases across the different sector contexts:

- The emergence of **new organizations** which were created in the course of the knowledge dynamics defined as organizational bodies, respectively new actors, with own strategic goals and with the ability to operate.
- The establishment of new organizational forms represented by **internal restructuring processes** and the creation of new organizational units (e.g. departments) within the boundaries of a firm or organization itself.
- **New networks** were identified as a third kind of organizational structures which occurred during knowledge dynamics where each member to a large extent remains independent from the other actors.

The creation of **new organizational bodies** took place in all three sector contexts. In the automotive sector new organizations were established over time in innovation events combining several analytical and synthetic knowledge bases. In Lower Saxony regional actors from universities and the industry started with a loose cooperation. Later on a new research centre for vehicle technology was established with the task to create a platform for the integration of the highly specialized analytical and synthetic knowledge of research organizations, universities and firms and to motivate them to use their expertise for a new purpose (BLÖCKER and JÜRGENS 2009).

In Baden-Württemberg a firm based initiative started to bring together specialized cumulative analytical and synthetic knowledge bases related to simulation technology to explore and generate knowledge in a pre-competitive stage. In a two-year long communication process a network was build involving heterogeneous private and public partners located at the regional, national and international scale who were willing to share and combine specialized cumulative knowledge and expertise in a collaborative effort. Private firms from almost all parts of the automotive value chain as well as service engineering firms, companies of the IT sector like hardware manufacturers and software companies, but also semi-public organizations and public partners from the university and research institutes engaged in applied as well as in basic research, commited to invest in the exploration of knowledge complementarities. Later on the decision was taken to transform the loose network in a formalized independent organizational entity, named Automotive Simulation Centre Stuttgart (ASCS). The intersecting institutional contexts of the vertical knowledge domain of the automotive industry and the knowledge domain of simulation technology proved to be helpful to create a level of cognitive proximity needed to achieve sufficient mutual understanding in such a variety and diversity of heterogeneous synthetic and analytical knowledge bases from actors with previously intermittent or long term relations as well as unknown partners in proximal and distant locations.

In tourism in innovation events which combine specialized symbolic and synthetic knowledge bases the establishment of new organizational bodies took place as well. In the case of “Jutland All Year Tourism”, for instance, diverse actors started with a decentralized

network for the development of a new joint booking system in North Jutland, later on the loose relations were integrated into a private limited company. Even though it was not structured very hierarchically, it seemed that the integration of various heterogeneous actors from different spheres (e.g. municipalities, tourism offices, travel agencies) in one organization was a decisive prerequisite for an intensified knowledge exchange (HALKIER et. al. 2009)

Following the sequences of the innovation events over time, it can be concluded from the case of ASCS and many other cases that the formation of new organizational bodies was a decisive step in creating a new quality in the constellation of actors on their way to combinatorial knowledge production. The foundation of a formal organization that operates as a collective actor for the partners equipped with resources, seems contributing to a narrower coupling, enhances trust-building and reinforces the commitment between the involved actors. However, the establishment of these organizational forms was the visible outcome of complex and time-consuming communication processes taking place previously in time. These processes do not always end up in a common understanding on how to proceed and structure the uncertain innovative change process, as the case of "Jutland Mariagerfjord" shows in which some actors' incompatible interests and escalating conflicts could not be overcome (HALKIER et. al. 2009).

Besides the foundation of new organizations, organizational change could also be observed on a firm-internal level. To combine specialized accumulated knowledge bases in order to exploit these for new purposes, internal resources and capacities of firms often had to be rearranged. Organizational change and the establishment of new organizational units, represented by **internal restructuring processes** (e.g. departments), within the boundaries of a firm itself could be observed in all sector contexts. Taking the case of a Media KIBS in the Stuttgart region as an example in the course of this innovative problem solution the combination of symbolic and synthetic knowledge bases took place. The development of new graphic animations for a marketing campaign for the global launch of a new type of car generated the need to implement new working routines and find a new business model in the course of the innovative problem solution. 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. For scaling symbolic knowledge production, the firm combined industrial routines from the manufacturing industry and adapted these to the own organizational structures. Without a massive intra-organizational change realized with the support of external expertise, success would not have been possible. During the life-span of this innovative event many critical situations emerged which could not be solved by internal resources. It was crucial in this case to include an external business consultant with specialized synthetic knowledge about industrial production procedures and software technology. Additionally, by hiring external professionals with expertise from the related game industry, required competences were acquired which enabled the development of procedural and organizational routines for handling larger projects.

Even for multinational KIBS, organizational change in the form of new department building is an important basis to explore and exploit knowledge complementarities spatially and functionally distributed within the corporations as the two case studies in Bratislava show (REHAK et al. 2009). To create new generic solutions in the field of information and personal data security, de-contextualized, cumulative, experienced-based knowledge, gained in former client projects in other countries and regions, had to be combined and integrated for

new purposes. Knowledge sharing and the combination of different kinds of competences occurred in complex learning processes within diverse 'knowledge communities' (GERTLER 2008, NOOTEBOOM 2008) in several places in Europe through organized temporary proximity. For the product innovations, in both cases the co-evolving organizational change in form of new department building was an important means for the anchoring of available intra-organizational knowledge bases and their combination with external localized competences.

The findings also highlight **new networks** as an important type of organizational structure which emerged in the course of knowledge dynamics where each member to a large extent remained independent from the others. Firms and organizations were enabled to exploit parts of their respective knowledge resources for innovative problem solutions within networks of new actor constellations. In the case of the "Skane Film Route" a development of a tourism route in Southern Sweden, different regional municipalities and museums built up a cooperative network in order to share complementary knowledge and to develop different attractions and places of interest (DAHLSTRÖM ET AL. 2009). Another example was the tourism case in Antalya where new cooperation networks among hotels were established which participate in the new service product development of a professional football camp (DULUPÇU et al. 2009). Crucial for the building of new networks seems the fact that the actors have overlapping interests, sufficient cognitive proximity and a common understanding of the objective and economic value of the future cooperative outcome. Apparently, these conditions foster a level of certainty on which a form of organization with loose coupling is enough to integrate the knowledge bases.

Insights into the implications of coordination and governance of the complex division of labour in cumulative and combinatorial knowledge production are scarce. The innovation biographies provide a great deal of empirical evidence that micro dynamics of knowledge themselves reshape the territorial configuration of economies by creating new forms of organization as part of the innovation process. The case studies highlight that the co-evolving organizational forms in innovative change processes fulfil an essential function for the bridging of interfaces and for the integration and the anchoring of combinatorial knowledge. In turn the availability of new networks, organizations and inter-organizational forms of knowledge exchange change the scope of action for other actors and thus, open up new possibilities and new points of departure for the emergence of future knowledge dynamics. 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.

8 Conclusions

The shift in knowledge dynamics driven mainly by technological change, the restructuring of global value chains and the internationalization of innovation brings about new challenges equally for both corporations and regions. Micro-dynamics of knowledge offer significant empirical evidence that distributed knowledge production is an important feature of the knowledge economy. Time turned out to be an essential dimension to understand business interactions leading to innovation at the micro level, due to the fact that time defines the nature of interaction as a process in which sequential events are related to each other. The empirical results indicate that previous interactions and future expectations of the firms and

organizations involved in innovation events influence each other profoundly, and therefore, the output of the knowledge interaction processes.

Taking into account the time dimension the debate on the global-local dichotomy does not do justice to the complexity of the territorial organization, particularly the dynamic processes in which space and place shape knowledge interactions. The knowledge trajectories behind innovation evolve in a multi-scalar way, as the findings clearly underline. Moreover the dynamic utilization of different forms of temporary geographical proximity in the course of the innovation event was obvious. Organized temporary proximity is an essential mechanism for the coordination and integration of distinct knowledge bases, as well as for the flexible and spontaneous adaption to unforeseen situations.

In the innovation-oriented economic change processes, cumulative as well as combinatorial dynamics were found. The results emphasize that knowledge combination is a challenging process. Even though sector contexts are associated with more blurry boundaries, sector specific institutions have a major impact on the organisation of knowledge interaction processes. Institutional overlaps based on sector specific knowledge sharing apparently reduce cognitive distance between firms and organizations. In their action guiding function such institutions are often taken for granted which may explain why knowledge combination across sectors implies obstacles and barriers.

By applying the biographical method, co-evolving organizational changes and institutional dynamics emerge as significant features of knowledge trajectories. To coordinate knowledge integration processes, actors collectively develop their own governance structures. These may result in internal restructuring, the establishment of new, loosely-coupled networks and even the establishment of new organizational bodies through the integration of resources from independent organizations. Particularly innovation events involving combinatorial knowledge production are characterized by dynamic organisational changes and the sequencing of different organizational forms in time. Knowledge interaction processes are not only territorially shaped by place specificities, but also reshape these places. Whether in a long term perspective these gradual institutional changes lead to accumulated transformative change of institutions (STRECK and THELEN 2005) at the aggregated level of industries or region, deserves further investigation.

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