Paper to be presented at the

35th DRUID Celebration Conference 2013, Barcelona, Spain, June 17-19

Idea-centered, dynamic knowledge network analysis: Tracing the unfolding of innovation through time and space

Oliver Ibert
Leibniz Institute for Regional Development
Dynamics of Economic Spaces
iberto@irs-net.de

Felix Claus Müller
Leibniz Institute for Regional Development
Dynamics of Economic Spaces
felix.mueller5@gmx.net

Abstract

The paper presents a framework for the time-spatial analysis of innovation processes. Using qualitative case-study data from innovation biographies in law services and biotechnology research and development services the presentation develops a phase model of innovation ? induction, validation, mobilization and concretization ? that applies to both sectors and allows synchronizing the longitudinal time-spatial data. It then identifies relevant relations within knowledge networks that have been critical for the creation and unfolding of the core idea and positions them into the phase model. The notion "relational distance" is employed to explore the quality of each of these relations by depicting how they combine proximity and distance along multiple dimensions. The proposed framework affords the in-depth analysis of each relation using the multidimensional understanding of proximity/distance. Moreover it allows a phase-specific horizontal analysis of how different relations work together at specific stages of the innovation processes and a vertical analysis of the changing nature of relations throughout innovation processes.

Jelcodes:O31,-

Idea-centered, dynamic knowledge network analysis: Tracing the unfolding of innovation through time and space

1 Introduction

Innovation is relational. The concept of 'proximity' has been employed frequently to qualify relationships in innovation processes along various dimensions (Boschma 2005; Torre and Gilly 2000; Knoben and Oerlemans 2006; Mattes 2011). Proximity, both spatial and relational, is treated as a necessary prerequisite for successful innovation. This paper presents the concept of 'relational distance' as an open heuristic, which allows studying the multiplex nature of innovative relationships more fully, including elements of conflict, friction, separation and distanciation. In doing so the paper aims to connect the more recent thinking in economic geography with the general discourse on innovation networks: Rather than with spatial or territorial manifestations of knowledge creation (see: Howells 2012) it is concerned with exploring the process knowledge creation as it unfolds in time and space simultaneously. Empirically the paper analyses qualitative interview data that was collected in seven case studies; three of them conducted in law services and four of them in biotechnology. These case studies represent "innovation biographies" (Strambach 2012) with longitudinal data that document seven innovation processes. Each innovation biography is approached by employing a qualitative, dynamic and idea-centered network analysis.

In contrast to foregoing research on network dynamics (e.g. Glückler 2007) deep qualitative understanding of network relations is given priority over a quantitative overview of structural network dynamics. The analysis is thus selectively focused on those few ties that are regarded as crucial in pushing knowledge creation towards an innovative end by the involved actors. The quality of the respective relation is assessed by adopting the concept of "relational distance" (Ibert 2010) to delve deeper into each relation's multiplex (Uzzi 1997) nature. This heuristic regards every kind of relation as a multidimensional phenomenon, in which the involved participants are at the same time proximate to each other in some respect and distanced in other respect. For instance, in a relation of mentorship, as the following analysis will demonstrate, the participants are proximate to each other in terms of belonging to the same knowledge domain or being members of the same organization, whereas they are distanced in terms of hierarchical position and accumulated reputation. Each combination of relational proximity and distance also has a material manifestation in physical space. Proximity and distance here are treated as categories with the same epistemological value (Grabher and Ibert 2012) and as equally important driving forces in innovation endeavors.

The research questions addressed by this paper are: Which recurring kinds of relations can be observed throughout innovation processes and what is their nature in terms of

proximity/distance combinations? What is their relevance in particular phases of the innovation process? What kind of physical distances do these relations enact? How do they interact with each other and how do they evolve in the course of an innovation process?

In the following two sections a number of key notions are introduced and methodological decisions are explained. In the subsequent main chapter the empirical findings are presented. This chapter is organized along the logic of a phase model of innovation that distinguishes four phases – induction, validation, mobilization and concretization. These phases apply to both analyzed sectors and allow synchronizing the longitudinal, historically idiosyncratic time-spatial data collected in the case studies.

## 2   Dynamic idea-centered knowledge network analysis: inter-cohesion and relational distance

The attributes "idea-centered", "dynamic" and "knowledge" specify the particular focus of the empirical investigation of networks presented in this paper and thus need to be scrutinized in some detail. Formally , a network consists of nodes (=actors) and ties (=relations) (e.g. Kenis and Oerlemans 2008). An *idea-centered* network is a "focal network" (Glückler 2012, pp. 5f.) flourishing around a selected idea. It is important to note that "idea-centered" is not tantamount to "ego-centered" (Burt 1992), even though some individuals, or egos, like, for instance, an entrepreneurial inventor, might be closely associated with an idea throughout their entire existence. An idea-centered network can thus be defined as a focal network that encompasses all egos who contributed to the emergence and unfolding of an idea and who have pushed the creative process.

A *dynamic* network analysis puts particular emphasis on the changes in a network in the course of time. The most elaborated studies on network dynamics so far focused on structural features of networks. The evolution of these networks has been traced by registering newly established ties and the dissolution of existing ties in a given period of time. This approach has been highly influential in evolutionary economic geography (Glückler 2007; Ter Wal and Boschma 2009). This paper is concerned with the quality of network relations and the ways in which these relations connect otherwise separated socio-material practices (Grabher and Ibert 2006; Pachucki and Breiger 2010; Bathelt and Glückler 2011).

The notion of a *knowledge network* is closely linked to our understanding of relationality in knowledge creation. Interactive learning is not merely an exchange of knowledge in an objectivist sense, but a process of connecting and negotiating divergent cultures of knowing in practice (Ibert 2007). This involves primarily professional networks (Rajagopal et al. 2012), which frequently also employ seemingly private forms of interaction to achieve the involved actors' ends (Wittel 2001; Grabher and Ibert 2006). Vedres and Stark provide a 'blueprint' for the conceptual integration of networks and qualitative difference between actors.

Following them we use the notion "inter-cohesion" (2010, p. 1156ff.) for ties that connect actors who at the same time belong to two or more internally cohesive groups.

Fig. 1: The structure of inter-cohesion in contrast to brokerage and closure
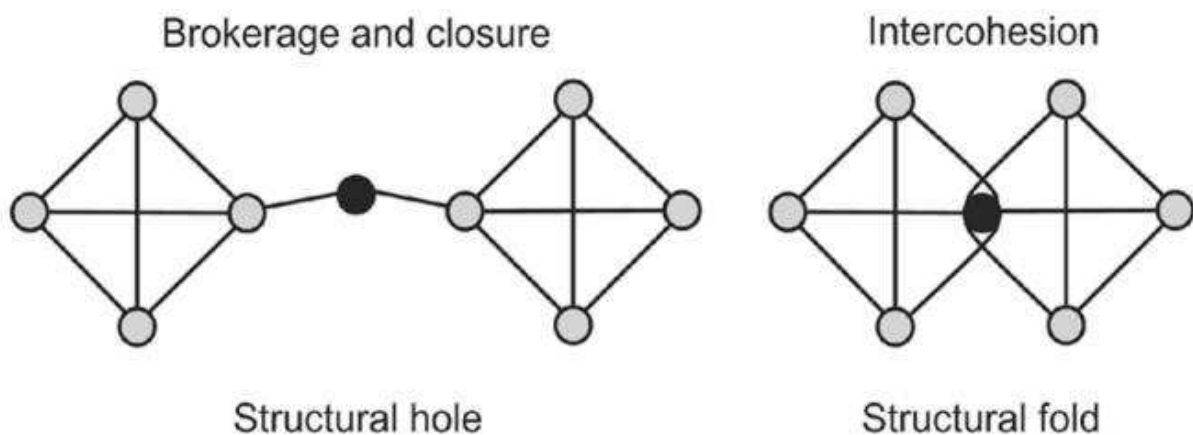
Source: Vedres and Stark 2010, p. 1157

In structural terms, these actors occupy the position in a "structural fold" (see fig. 1):

> "Actors at the structural fold are multiple insiders, participating in dense cohesive ties that provide close familiarity with the operations of the members in their group. Because they are members of more than one cohesive group, they have familiar access to diverse resources. This combination of familiarity and diversity facilitates the work of recombining resources" (Vedres and Stark 2010, p. 1156).

Entrepreneurial work is thus not adequately understood in just taking advantage of information asymmetries but as the active generation of new associations between elements that so far have been separated as they belonged to different practices used by internally cohesive groups. In the following we will discuss the concept of "community of practice" as a way to identify cohesive groups in terms of knowledge practice and culture, as well as its commonalities and differences vis-à-vis knowledge network links (for a detailed discussion see: Ibert and Stein 2012).

In very general terms, a community is an informal group of people who share a common practice, mutually engage each other and voluntarily adhere to common rules (Lave and Wenger 1991). Communities emerge as practitioners frequently ask their colleagues for advice in challenging professional situations. As an unintended by-product of collaboration, the negotiation of practical problems and the ongoing exchange of mutual advice, communities constantly cultivate a pool of shared knowledge which is permanently updated and variegated.

Within communities the governance mechanism for exchanging resources is "sharing" (Belk 2010). Sharing circumscribes a mode of resource allocation in which all members contribute to a common pool of resources without the expectation of reciprocity, while every member can legitimately use this pool according to his or her demand (ibid.). In contrast networks are frequently theorized to rest upon the expectation of reciprocity as a core governance mechanism (e.g. Grabher 1993). Furthermore, while wider network structures emerge through numerous dyadic ties employed by the partners for mutual benefit, communities resemble groups in which the involved participants enroll each other in a more interactive manner (Grabher, Ibert and Flohr. 2008). In contrast to communities, networks involve a greater degree of strategic and instrumental consideration (Burt 1992; Grabher and Ibert 2006), whereas communities are also confronted with these kinds of aspirations but are frequently reported to suffering from them (e.g. Lerner and Tirole 2002; Grabher et al. 2008).

3   Methodology

To access network dynamics in innovation process we conducted case studies in the form of innovation biographies. These case studies have been inspired by the empirical strategy of "follow the things" (Cook 2004). However, in this case the "tracking strategy" (Marcus 1995) was not focused on objects but on core ideas. An innovation biography starts with identifying innovative products or services in the present. Then we identified a core idea that expresses the qualitative difference established through that innovation, traced back in time and space its origins and re-constructed *ex-post* through qualitative expert interviews its unfolding. "By tracing back an innovation event in its biographical development, the instrument concentrates on the distributed knowledge activities and their evolvement over time" (Strambach 2012, p. 62).

We selected law services and research and development services as promising fields for case study selection[1] as both knowledge domains represent business-oriented services and thus appear to be comparable. Furthermoreover, law and biotech could be observed in the same regional context. As both represent comparatively strong sectors in the Berlin region we did not only had a relatively easy access to both empirical fields, it was also possible to compare different stories under rather similar local contextual conditions. However both domains also deviate in theoretically relevant ways. For instance, while law services epitomize "pure" services biotechnological research and development blends the ideas of service provision and technology development. The sectors also differ with respect to the underlying knowledge practices. While law exemplifies the knowledge dynamic in "professional communities", the biotech cases represent knowledge practices that have be ascribed to

---

"epistemic communities" (Amin and Roberts 2008). Both knowledge domains thus are different with respect to the role of scientific knowledge (lawyers are educated in academia but complement this codified knowledge with practical experiences whereas biotech-engineers remain more or less within academia) the relationship to users (law: direct interaction; biotech: no direct interaction) and their positions vis à vis other communities (law: corresponding practices at the periphery of one's own practice; biotech: strong overlap with related epistemic practices).

Table 1: Overview about selected cases

Case study	Core idea	Additional remarks
L1 – Juridical project management for building	To offer a service for large building projects to anticipate and avoid conflict in front of the court	Four interviews, Start of biography: late-1980ies
L2 – Compliance	To offer a consulting service for multi-national firms to change internal routines in a way that internalizes the organization's awareness for issues of compliance and misbehavior.	Five interviews, Start of biography: 2005
L3 – Public transport privatization	Privatization offers unique juridical challenges and opportunities for a better provision of transport services.	Five interviews, Start of biography: early 1990ies
B1 – Drug delivery	Encapsulating active ingredients in peptides in order to deliver them directly to the affected parts of the body and thus to increase their effects.	Five interviews, Start of biography: late 1990ies
B2 – Synthesizing of biological molecules	Creating DNA chips that allow high-volume synthesizing of biological molecules by using peptides for the first time worldwide	Five interviews, Start of Biography: late 1980ies
B3 – Experimental analysis of genetic functions	Genes' functions are not predetermined but have to be examined in context and experimentally.	Three interviews, Start of Biography: late 1990ies
B4 – Analysis of gene regulation	Cancer can be diagnosed through the detection of	Four interviews, Start of biography: late

	enzymes that regulate carcinogenic growth	1990ies

Data was collected mainly in form of semi-structured expert interviews, between three to six interviews per case. The interviews lasted between 45 and 120 minutes with an average duration of 90 minutes. Interviews have been tape-recorded and transcribed verbatim. In the majority of cases the interviews have been conducted in German language. For the purposes of this paper, cited passages from the interview transcripts have been translated into English[2].

In each case study, the first interview was the most critical one. The challenges here were to achieve a shared understanding about the core idea represented by the respective innovation and to establish such a trustful relationship on the basis of which the interviewee would be willing to give us recommendations about additional involved participants. If one of the two challenges could not be met, we were forced to drop the potential case.

In each interview we asked for information to answer the following questions: How would you subdivide the process in retrospect? What persons played significant roles, and what kinds of relations existed between them? In how far have these relations been "proximate" or "distanced"? What places and workarounds have been involved in the innovation effort? What modes of interaction have been established between these places (temporary co-presence; virtually mediated communication, circulating objects)? By combining and comparing the accounts from multiple perspectives we were able to generate more comprehensive stories of each innovation biography. Thereby the interviewees complemented each other's accounts (e.g. often interviewees did witness only particular phases of the process) but it was also possible to triangulate the interviews by comparing individual accounts on identical instances.

4   From conditions to opportunities: Network dynamics and relational tensions

To frame comparison across single cases and across sectors we developed a phase model inductively from the empirical material. We use the suggested phase model to synchronize rather idiosyncratic accounts of innovation process that covered different times, different places (apart from orbiting around Berlin), topics and actors. With this framework we do explicitly not insinuate that innovation always follows a predefined sequence of events in a linear fashion. Rather on the contrary, we registered feedback loops, iterative learning and

---

[2] Interviews and cases have been made anonymous. To enable readers to relate interviews to cases each interview has been coded. In this code the letters signify the analyzed knowledge domain (with capital B denoting biotech and capital L denoting law services). The first number refers to the consecutive number of the case (see table 2), the second number refers to the consecutive number of interview within each case (for example: "B43" is biotech case study 4, interview # 3).

major interruptions in our innovation biographies. However, these phenomena usually occurred within the proposed framework and did not contradict it.

Table 2: Phase model of innovation

	Definition	Turning Points
Induction	Actors are confronted with practices that they perceive as deficient or problematic.	Ability to express a novel idea in few sentences and in simple words
Validation	Actors try to grasp the idea by enacting a practical context within which the idea works.	Proof of concept
Mobilization	Actors try to extend the practical value of the idea beyond the context of valuation	Proof of feasibility
Concretization	Actors focus their efforts on the spot in which market penetration appear most promising.	Successful market entry

Source: own design

The main reason for retaining elements of linear thinking (Balconi, Brusoni und Orsenigo 2010) was the observation that throughout innovation processes the dynamic of knowledge generation takes fundamental turns, each of which entail a completely new direction and internal logic for subsequent processes of collective learning (see also Latour 1987). The leading criterion for the separation of phases was the way the central ideas changed in their manifestation, validity and utility. For instance, at the beginning of an innovation biography actors were usually not aware of the fact that they are generating a new idea. Some of them felt that their practices were somehow inappropriate, however, they were not yet realizing that this gut feeling already was part of a search activity (Stark 2009). This perception changes fundamentally when actors realized that they identified a major problem that underlies their impression of inappropriateness and when they acquire the ability of expressing this problem in simple words. From this moment onwards it became impossible for the involved actors to regain the former status of naïve ignorance again. In this example, the change in the direction of knowledge dynamics is irreversible and the underlying process thus exhibits characteristics of linearity.

4.1   Induction: interrupted routines and complicity

In all selected case studies the innovation biographies started in a phase we called "induction". Typically, at the beginning of this phase, our respondents have been involved in practices they experienced as somehow deficient or problematic. However, for a longer or shorter period of time, they were not able to make explicit what exactly the problem was they were experiencing. The induction phase typically ended in a situation in which the participants acquired the ability to explicate the core problem addressed by the innovation for the first time in simple words. Respondents usually recall the situation in great detail (J22), in which their awareness awoke seemingly from one moment to the other. Interviewees report of moments of great clarity and almost ridiculous simplification.

We registered one form of relation within knowledge networks which we termed **interrupted routines** which occurred in all seven analyzed case studies and thus seem to epitomize the "perplexed and trying situation" which predominates the induction phase. Within an interrupted routine the participants were on the one hand integrated into a practice, for instance as members of an organization or participants in a particular markets, on the other hand, however, unlike other participants they were also involved in a different practice. For instance, in case study B1, a physicist who worked in the research and development department of a large pharmaceutical firm, was responsible for developing dilutions for new active ingredients. Unlike all his colleagues, who were trained pharmacists, he felt uncomfortable with straightforwardly applying physical knowledge as it was presented in the pharmacists' text book:

> „And everybody told me, you have to do this and you have to do that. And I reproduced and reproduced, but it did not work. […] At some point I said: I refuse to do that, it's shit, it's frustrating, it doesn't work" (B11).

The physicist began to question text book knowledge and surprisingly, found out that something was wrong. He then started to modify the underlying formulae and eventually generated a new approach for the delivery of active ingredients (B11). The other case studies show similar constellations of interrupted routines. In L1, for instance, a lawyer discovered the limitations of his juridical perspective on large building projects when he realized that even in those cases in which he won a trial, his customers still were unsatisfied with the solution proposed by the judges. Against the background of these experiences he radically reconceptualized his approach. Instead of defending his customers' interests in front of the court he now started to think about a consultancy service to help customers to avoid legal conflicts (L12). Both examples illustrate that actors occupying a position of inter-coherence seem more prepared than their ordinary peers to experience inappropriateness and to detect solutions beyond the established routines.

Interrupted routines are frequently accompanied by a second kind of relation, **complicity**. Complicity refers to relations between the inner circle of idea generators and another

person not directly involved in the respective practices. The nature of the tie usually is personal and often long-standing and highly trustful. In other words, social proximity predominates. In professional terms, by contrast, accomplices seem to be rather distanced. They are often not involved in the organizations and their expertise is only indirectly related to the practice that is under revision due to interrupted routines. For instance, in case study L2 one of the early participants raised his awareness about his so far poor understanding of possible reasons why members of multinational firms might behave not according to the rules when discussing the issue with a close family member, a trained sociologist.

Complicity, in other words, partly reflects the constellation of inter-cohesion – being closely related to diverse, otherwise unrelated practices. More importantly, however, this relation to someone not directly involved in a practice but supportive to views that deviate from the practice's norms and conventions turned out to be helpful to maintain cognitive distance (see also Hautala 2011, p. 618). In other words, complicity prevents actors caught in situations of interrupted routines from assimilating to the dominant norms and views. It thus stabilizes the "troubled, perplexed and trying" (Dewey 1933 cited in Stark 2009, 14) situation and increases the chances of identifying novel problems (and at the same time of reframing ideas about possible solutions).

Knowledge generation in situations of interrupted routines resembles "the kind of search when you don't know what you are looking for, but will recognize it when you find it" (Stark 2009, p. 11). As long as one does not know what exactly to look for, it does not make much sense to travel far. A striking evidence throughout all our cases was, that this kind of serendipitous search during challenging situations of interrupted routines almost always took place at rather ordinary places of the involved knowledge practices such as laboratories (B1; B2; B3) seminar rooms (B1; B4; L1; L3), offices (L2), political gatherings (L3), court rooms (L1). In other words, search during the induction phase resembled an undirected, open-ended, sometimes even unconscious process that connected places of everyday practice located along the paths of everyday mobility. Learning is thus strongly shaped by the opportunities for recombination offered by the immediate surrounding physical context of the involved actors.

The relation of complicity has a slightly different logic in terms of its unfolding in the physical space. As it seems to be critical that one of the partners should not be involved directly in the situation of interrupted routines, it is more likely though, of course, not necessary that this partner might also reside at a place far away (e.g. case L1, L2). However, it is part of the nature of this relation that partners have to frequently meet each other personally, hence despite physical distance they have to be mutually accessible in order to build up and sustain this quality of the relation.

4.2 Validation: mentors and rivals

The moment of insight abruptly changes the dynamics of knowledge generation and the innovations biographies shifted from induction to validation. One interviewee used the word "lead project" (B41) the identification of a problem is at the same time the identification of a corridor for possible solutions (Rittel and Webber 1973, Stark 2009). As a consequence, the so far rather undirected dynamics of learning became more goal-oriented and also more purposeful.

Across our case studies the first step was to find ways to make the idea more concrete and to acquire the ability to more systematically explore its practical consequences. One interviewee vividly recalls a car trip during which he felt the desire to test a new aspect of his idea:

> „It was three o'clock in the night and I said to myself: Man, I cannot drive to [name of place…]. I have to go back into the laboratory in order to test. Does it work, or not? It worked so easily, it couldn't be simpler. […] I was ashamed: It is that easy, it can't be true. There must be some idiot who had this idea before. No, no one" (B11).

This quote illustrates that validation requires a concrete socio-material context to be carried out. While during induction the mere reflection of inappropriate practices would suffice, during validation the idea has to be grounded at a particular place and requires the personal presence of the inventor to be manipulated ('I have to go back to the laboratory').

In the biotech context validation took place in laboratory contexts, in which an arrangement of machines, laboratory equipment and handmade parts configures a material context. Within this context the analytical and synthetical steps suggested by the main idea are combined to a working procedure for the first time, which can be reproduced and iteratively variegated involving a high degree of creative experimentation and manual work. Typically the number of epistemic entities (genes, substances) used in the procedure is very small, necessitating steps towards a generalization (the whole genome of an organism, an entire class of substances) further down the road (B1-4). In the law sector, laboratories in which causalities can be tested in a controlled environment are not available. Rather than *in vitro*, the participants here have to experiment *in vivo*. Examples for such *in vivo* test environments are an academic lecture (L1) in a technical university, in which the idea (juridical project management) was tested in front of potential customers (advanced students of building engineering), a newly established department within a firm handling a compliance crisis and in need of consulting (L2) or a new part-time position (L3) within an organization concerned with the topic of the new idea (privatization of public transport). If validation was successful, the participants are able to present a *proof of concept*. The idea did work, at least under the very particular conditions as represented by the experimental context.

In vivo and *in vitro* experimentation share in common that resources, like personnel, money, equipment, time and attention have to be mobilized to a lesser or larger degree to enact the

organizational and socio-technical contexts for validation. This phase is thus strongly shaped by two types of relations that both are strongly linked to the necessity of mobilizing resources; mentorship and rivalry.

Mentorship is a dyadic, rather close relationship between one of the actors closely associated with the idea on the one hand and a supportive more experienced person on the other hand. The relation is proximate in the sense that both involved actors usually share the same practice and/or knowledge domain and often belong to the same organization and almost always share the broader institutional setting. In this relation distance unfolds along the divergent degree of seniority, access to resources and acquired reputation. When successful, mentorship can have elevating effects for the mentee as the mentor helps to acquire reputation, get access to resources and get promoted to high-ranked positions. In our case studies two forms of mentorship became effective, scientific mentorship (L1) such as, for instance, the relationship professor-PhD-student (L3) but also intra-organizational mentorship (B1; B2; B3; L2; L3).

Almost all our case studies give evidence that mentorship was a key factor for mobilizing organizational and institutional resources for idea validation by the mentees. Typically actors who identified the core problem were not in a position to allocate own resources to the validation of the idea. They were forced to persuade directors of research institutes and heads of research departments to provide laboratory equipment to situate the idea for the first time in a concrete context or department managers and CEO's to allocate personnel and give access to organizational slack to experiment with the new idea. Mentors usually enable others to act. They often supported their mentee's ideas because they had an own interest in introducing fresh or irritating ideas into their field of responsibility, but did not want to be the person to do so:

> „I am not a lawyer and in those days juridical issues have been key. Also, I am not the revolutionary guy. It is not in my nature. However, I covered that mission as a member of the board. I let him [mentee] surge ahead with his abilities and at the same time had an eye on him from the senior position that he did not behave like a bull in a china shop " (L34).

Rivalry is a second and related kind of relationship that becomes prominent during validation. The term denotes relations between practitioners who belong to the same knowledge domain and field of expertise. Rivals thus are proximate in terms of cognitive patterns and disciplinary enculturation. However, rivals are also distant to another as they have different, even contradictory opinions about the value of the new idea for the shared practice. Rivalry can be more or less intensive and frequently unfolds between "schools" and "currents" within communities of practice. However, particularly in law, rivalry can also be highly personalized and thus highly conflict ridden.

Rivalry is a non-cooperative relationship that at a first glance mainly has negative impacts on the aspirations of validating a new idea. Rivals do their best and use all their influence (e.g. when obtaining the role of a peer reviewer) to prevent that institutional resources are

invested into the idea. However, an effective mentorship can protect the unfolding of the idea to a considerable extent against these inhibiting forces. Interestingly, some interviewees also expressed productive contributions made by rivals. As these rivals often are the most reputable and gifted representatives within a community their contributions to the discussions are valued for showing convincingly and very clearly the limitations of the traditional approach. The following quote illustrates that when generating new knowledge it can be very helpful to have a precise idea about what *not* to aspire (similarly L22):

> „I heard him [a prominent rival] one or two times. Highly intelligent! It was real fun […]. And then I read one of his articles and I said: terrific! … but bullshit. With his bright intellect he formulated a number of postulations, all completely correct, per se correct … but not practicable" (L13).

The spatial patterns unfolding during the validation phase blend interaction in constellations of permanent co-location with professional mobility to enact constellations of temporary co-presence. Mentorship almost automatically implies permanent co-location of mentor and mentee, at least for some time. As the mentee usually works within the mentor's organization and uses these organization's resources to improve validity, both usually collaborate closely and meet each other personally within the same workaround. Rivalry by contrast is typically enacted between members of professional or epistemic communities. Hence, it is often located in the same institutional contexts but often unfolds between organizations. Rivalry is not an inter-personal affair alone, it is also about occupying physical and symbolic spaces (e.g. space in the curriculum of a university or on conference programs). Typically rivalry needs temporary co-presence in order to become effectual:

> „One year ago I really experienced […] pure hatred on a conference in Berlin […] of about 20, 30 experts on building law, among them myself. By the way, I felt really shabby. I don't want to show off. I did perform poorly, most likely. But why did I perform poorly? Because before me, four or five speakers talked more or less disrespectful about what we made " (L13).

4.3   Mobilization: pioneer customers, build-up partners and grey eminences

The logic of knowledge generation in the mobilization phase is to critically test the general applicability of the main idea against the background of a greater diversity of so far new contexts. Starting from the certainty that the idea works at least in one context (the context of validation), the main search dynamic now is to ask, in how far it also works elsewhere, and if so, what are the critical conditions that need to be fulfilled to make the idea work. In order to be able to abstract from one concrete context of knowledge application to general conditions of application, it is important to test the validity of the idea in contexts in which unknown local factors might interfere and necessary supportive conditions might not be fulfilled (von Hippel 1994; von Hippel and Tyre 1995). This phase will be successfully completed when the idea has emancipated from the socio-material context of origin and proved validity in at least one further context. In short, mobilization denotes the evolution of an idea from *proof of concept* to *proof of feasibility*. Three relations within the knowledge

networks become most influential during this phase, in which high priority is given to the emancipation of the idea from one specific, mainly supportive context of validation; pioneer customers, build-up partnerships and grey eminence.

The practical usefulness of an idea apart from the context of validation is mainly negotiated in relations with **pioneer customers**. The involved segments of the knowledge network embrace key members of the development team on the one hand and newly enrolled potential customers on the other. In biotech these relations usually connect the researchers who developed the idea with major producers of pharmaceuticals or from agro-business. In law by contrast, the pioneer customers represent the sectors in which the law service is envisaged to be provided in the future. In our cases these clients are from the building and public transport sectors as well as multinational organizations.

Given the relative instability of the idea in this phase of development the pioneer customers need to fulfill several criteria and are thus difficult to identify. Typically, in this relation proximity exists with respect to a shared general belief in the usefulness of the main idea. Furthermore, pioneer customers have an own interest in the unfolding of the main idea and are thus willing to take parts of the risks of knowledge generation (von Hippel 1988). Once the pioneer customer is identified and willing to join the learning trajectory, the relation is additionally enforced through formal arrangements: In the law case studies and in one biotech case (B1) this enforcement took the form of a contractual arrangement of a service project. In the three remaining biotech cases pioneer customers from industry co-founded a joint venture enterprise. In both sectors organizational proximity is absent initially, but is created subsequently. Moreover this organizational proximity typically has an "institutionalized ending" (Lundin and Söderlund 1995). Temporary organizational proximity stabilizes the relation, makes explicate responsibilities of the involved partners and distributes possible wins and losses among participants.

In the cognitive dimension the relation is again initially dominated by distance. As the pioneer customers often represent sophisticated experiences in the respective field of usage, they are likely to pose significant new challenges to the so far validated knowledge but also to demonstrate novel ways of coping with practical problems. Even though some believes are shared the practices of knowledge creator and potential knowledge user are and remain significantly different. In Biotech this cognitive distance unfolds between the logics of researching scientists on the one hand and industrial producers on the other. In law services the difference is between the practices of lawyers and those within the respective fields of application.

In the case of **build-up partnership** the network encompasses members of the development team and further members from an external supplier who contributes expertise that is regarded as indispensible for the mobilization of the idea, but cannot be generated by the so far involved parties alone. Build-up partnerships compensate for lack of expertise but also

allow the research teams to solve pragmatic problems without losing focus. In two of the analyzed innovation biographies, build-up partnerships played a dominant role (B2 and J2).

In a build-up partnership proximity exists with respect to a shared interest in co-developing new insights in the respective fields of expertise. The partners concerned with the innovation biography need a sophisticated supply that might not yet be present on the market. The delivering partner is interested in using the innovation biography as an occasion to expand own core competencies. These shared interests are underpinned by contractual arrangements that formalize the relationship and explicate the shared expectations: "Both partners have to benefit at eye level. And both have to believe to benefit at eye level" (B31).

These dimensions of proximity afford interpenetration of practices that are different in functional, cognitive and technological respect. In the case B3 (experimental analysis of genetic functions), for instance, a build-up partnership was necessary to develop a software to detect patterns in huge masses of genetic data. Together with two partners the team members developed further software initially developed for secret services to screen telephone calls for fragments of sentences (B31). In the law case study L2 (compliance) the involved lawyers enrolled specialists from a management consulting service provider. Complementary to juridical expertise the envisaged service also required knowledge about how to change the pioneer customer's organizational structures and procedural routines to avoid compliance problems in the future (L24).

Finally, the mobilization phase is also characterized by relationships that we termed **grey eminence**. Involved are one or more members of the core team who are closely and personally associated with the core idea and a mentor. Like the mentor (see above), the grey eminence is proximate in terms of the shared knowledge domain. Differences with respect to organizational influence, control about institutional resources and acknowledged reputation from within the domain of the shared knowledge still exist, though they are not that pronounced anymore. Apart from that, the dominant logic for grey eminence is one of purposeful mutual disengagement during which the relation increasingly becomes dominated by distance along several dimensions. For instance, in the biotech cases (B1-4, also L3), the involved actors founded their own enterprises during the mobilization phase. With leaving the mentors' organizations the founders increase the organizational distance between both parties and the decrease the dependence on institutional resources controlled by the mentor. This emancipation from a mentor reflects the dynamics of knowledge generation which increasingly is oriented towards demonstrating the usefulness of the core idea in a practical context different from the context of validation.

In the physical space all the three relations that predominate in the mobilization phase are enacted across larger distances. In the case of pioneer customers and build-up partners the search focus is at the same time narrow with respect to the desired expertise, and wide with respect to where to find the partner. For instance, both build-up partners that have been enrolled to develop the biotech application of a data-screening software have been

ultimately identified in the US. Similarly, pioneer customers are usually not located in the home region of the innovation (Grabher et al 2008). In two cases (B1, B4) the pioneer customer was located in a foreign country more than a day trip away. Also, the grey eminence transforms a relation of close co-location into a relationship across physical distance. Physical distance is at least helpful to unfold the true nature of grey eminence, as it underlines at the symbolic level that the idea and its proponents are independent from specific local conditions and the help of powerful supporters.

However, the increasing dominance of relations across physical distance does not mean that physically 'being there' (Gertler 1995) is completely irrelevant. Rather on the contrary, increased professional mobility is used to enact frequent situations of temporary co-presence in law and biotech. These personal encounters usually took place at the customers' sites, which seem to promote the process of most effectively generating what one interviewee referred to as a new "mixed culture" (B21, similar B15). The case L1 exemplifies a strategy in which the law firm created new organizational units and set them up in physical proximity to pioneer customers in order to create new constellations of permanent co-location. The respective innovation – a juridical project management for large building projects that anticipates and helps avoiding conflicts – requires frequent personal presence (according to interviewee L11 three days a week) on the construction site in order to be able to really appreciate the nature of conflicts that arise in these occasions. However, in another law case study (L2) the requirement of temporary co-presence was fulfilled through enhanced professional travelling.

4.4   Concretization: users, shareholding and competition

Concretization denotes the final major turnaround in the dynamics of knowledge generation. Unlike the other phases the magnitude of possible applications of the core idea is re-focused in order to identify a spot in which market entry is most promising and least risky. Concretization entails the freezing of the main idea:

> „It is good to have one thousand ideas but it is not enough. We also need to channel ideas. To select the best one and to go through with it " (B11).

In other words, knowledge generation does not strive at further unfolding the idea, but becomes increasingly directed towards robustness, usability, repeatability, profitability and legality. The concretization phase ends with successful market penetration. The abstract and clear idea which emerged during the induction phase ultimately has taken the shape of a new service that can be provided routinely and with profitable returns. In comparison to the cases from the law sector, the biotech actors experienced the concretization as a far more conflicting development phase. In three of the four observed cases, key scientists left the firms during this phase and thus disconnected themselves from the innovation biography – in two cases even the initiators of the idea ceased participation.

"And we had a [personnel] turnover. People who said, 'no, that is not fun anymore. I'd prefer to do more research'. And then these people went somewhere, where they could do more research and less product development. [...] We purposefully brought in people into the organization with exactly these [product development related] experiences within the molecular diagnosis" (B43).

Reflecting the importance attributed to profitability, usability and repeatability in this phase three relations become most prominent within the knowledge networks; user-relations, shareholding and competition.

User relations more or less organically evolve from pioneer user relations. These networks encompass manifold members within the organization providing the new service and a slowly growing number of additional market participants who are potentially interested in acquiring the service for their particular benefits. In other words, 1:n networks that step by step enroll additional users replace the close 1:1 relation to pioneer customers.

Compared to pioneer users, user relations are much more dominated by distance. For instance, in order to collaborate within a user-relationship it is not necessary anymore to establish a joint venture or to explicate in detail the distribution of risks and benefits of a new solution. Rather, in formal terms it is sufficient to enact these relationships as ordinary market relations, in which payments and deliverables are contractually specified. However, unlike market relations in these cases the market relationship is primarily enacted to learn from users, not to earn money with serving them.

In terms of knowledge generation the specific contribution of the user relationship is that on the side of the partners ordinary users predominate who are neither willing to take innovation related risks nor can be expected to be competent above average. This expansion of the knowledge network creates a series of confrontations of the idea with additional "single cases, each of which pushed the main idea forward" (L12). Ordinary users, in a sense, stress the idea in manifold unanticipated ways (von Hippel 2005, 94) and thereby pose a cascade of new problems that need to be addressed before the service will be provided on a routine basis. Addressing these problems makes the idea robust and more independent from particular local conditions and thus also more mobile. Moreover, ordinary users can be sub-classified into groups, each of which epitomizing a particular market segment. For instance, in biotech the service has to be adapted to different territorialized institutional regimes. Also user relations can be used to get a more comprehensive impression of the user contexts in which the innovative service is supposed to work.

Shareholder relations are more visible and more explicit as an additional logic in the biotech cases, mainly because compared to law services innovation in biotech is significantly more capital intensive . This relation connects members of the development team with investors or representatives of institutional investors. A shareholder relation bases on proximity in terms of a shared believe in the market potential of the core idea. However, apart from this general believe, the involved parties enact a significant distance with respect to the ways in

which the idea has to be valued. The longer the innovation biography lasts the more explicit become these expectations by shareholders to have a return on investment.

Shareholders in a sense turn into stakeholders. They become involved into the formulation of strategies to bring the service onto the market and they frequently strengthens the pragmatic view that development endeavors have to come to an end and costs have to be limited in order to reach profitability sooner. Whereas in former phases relations tended to foster the exploration of new development trajectories, this relation is in essence focused on exploitation of knowledge (March 1991). Concretely, shareholders would argue in favor of freezing technical solutions on a satisfying level (instead of optimizing the service), limiting the costs in order to achieve a competitive market price (rather than further improving the service). Moreover, shareholder relations strengthen also the user relationship as they reiteratively remind the technical specialists that user requirements deserve high priority.

The more successful the concretization and the more ordinary users become enrolled into market relations the more a third type of relation becomes important: **competition**. Competition embraces relations within a knowledge network between the developing team on the one hand and other entrepreneurial actors who try to penetrate the same market. Competitors are proximate to each other in terms of the underlying cognitive models, and general interests in developing up a market. However, actors are distanced to one another as they try to conquer the same market. However, all in all relations of competition seem less hostile than the notion connotes. As long as the market develops the competitors share the general interest of developing this market, while the interest in competing against each other about market shares is rather limited. In this sense, one interviewee referred to a competitor as a "social partner" (B43). However, in law services, a sector in which knowledge asymmetries cannot be protected by patents, this form of friendly relations between competitors could not be observed within our sample of case studies.

As competitors are not only engaged in the same knowledge practice but additionally also share the belief that the new idea is valuable enough to warrant a revaluation of the common epistemic rules they are helpful to additionally cover the appreciation of the idea among fellow peers within the own knowledge domain. In other words, the closer the idea comes to market penetration the less influential become relations of rivalry.

All three kinds of relations that increasingly dominate the knowledge network during the concretization phase do not require permanent co-location in order to be sustained and in order to unfold their effects on knowledge generation. Competition, for instance, does not only reside in the home regions of the respective innovative ideas. The same holds true for users and financiers of the idea.
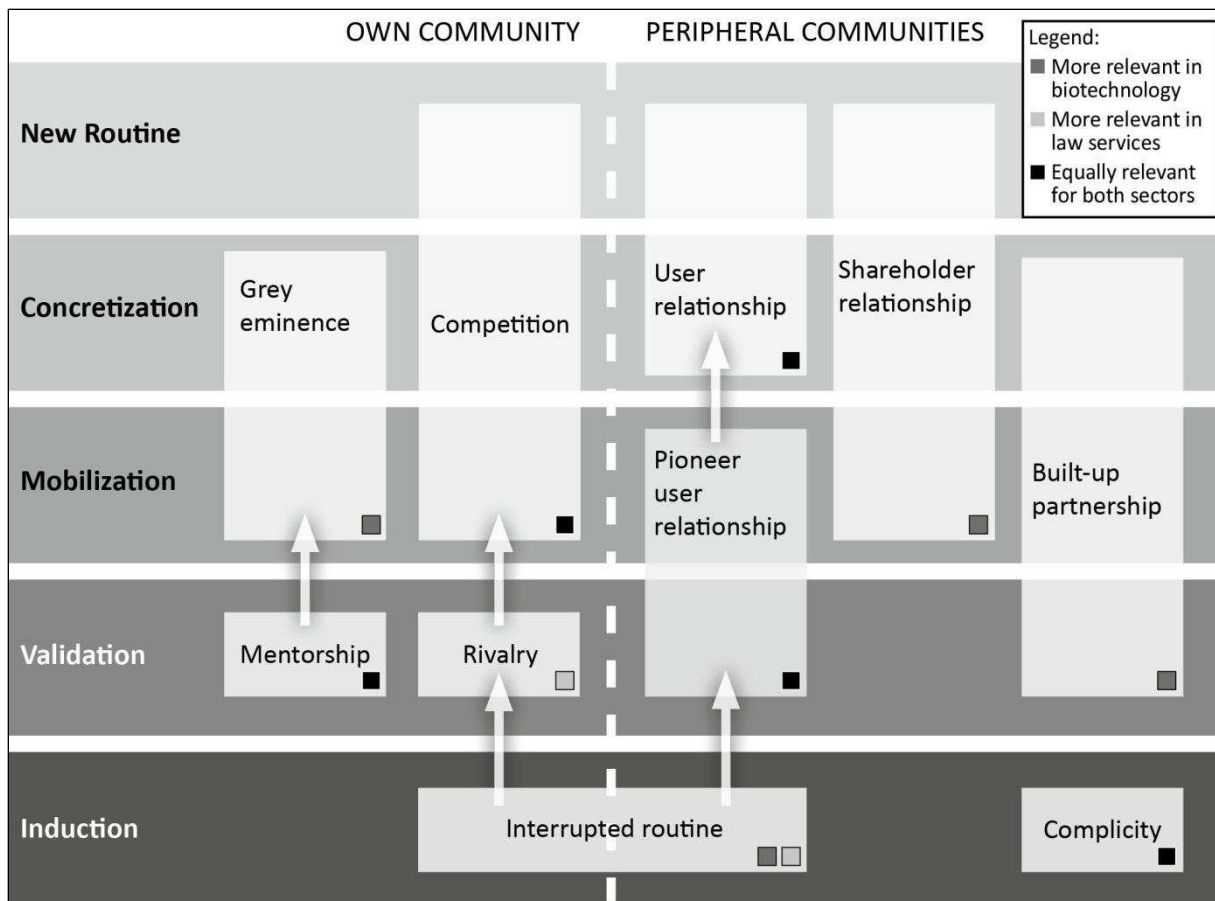
However, despite the predominance of distance in the physical space geography does still matter, however it does so in a more subtle way. For instance, in order to employ the positive effects of competition it is necessary to avoid overt competition on the same

markets. Competitors do so by segmenting the growing market into territorial submarkets each of which subsequently can be monopolized by one of the competing parties. User-producer interaction is strongly driven by the necessity to emancipate the core idea from particular socio-material conditions in a locally situated context. This endeavor is most promising when the manifold users are dispersed in the physical space and thus represent rather divergent local context conditions. However, if one customer raises more fundamental problems, that turn out to become vital for the idea as a whole, it makes sense to engage more deeply with the "project universe" (L11) of the customer to scrutinize in greater detail the particularities of his or her local conditions. For instance, in case study L1, the law service firm frequently opened new branch offices to be co-located with customers who promise to give access to new market segments. Equally, shareholding employs some forms of temporary co-presence in order to enact a network of relations the majority of which cross greater physical distances. In case study B1 one partner co-located in the region represents the consortium of investors and frequently used the improved access to the biotech firm to discuss strategically important decision personally with the funders (B15).

5   The idea-centered framework

Studying innovation processes in the presented manner affords a deeper understanding of the dynamism and the interdependencies of relationships relevant for innovation. The framework's specific strength lies in the combination of a horizontal and a vertical dimension of analysis, as well as the qualitative depth in which both are observed. None of the relations identified is new *per se*, however, within the framework of an idea-centered knowledge network analysis it becomes possible to be more exact in terms of their contribution to innovation and also of their possible limitations.

Figure 3: Framework of relational dynamics in innovation processes

	OWN COMMUNITY	PERIPHERAL COMMUNITIES		Legend: ■ More relevant in biotechnology □ More relevant in law services ■ Equally relevant for both sectors
New Routine				
Concretization	Grey eminence	Competition	User relationship ■	Shareholder relationship
Mobilization	■	■	Pioneer user relationship	Built-up partnership ■
Validation	Mentorship ■	Rivalry □	■	■
Induction		Interrupted routine ■□		Complicity ■

Source: own design

A *horizontal analysis* puts an emphasis on the interaction of several kinds of relations within a specific phase. For instance, our case studies suggest that complicity offers support for actors who are involved in perplexed, trying situations of interrupted routines. It is easier to maintain "cognitive friction" (Hautala 2011, p. 618) with the help of an accomplice who is not directly involved in the situation but offers confirmation for an interpretation that is negated by the majority of insiders. So the presence of one tie can *strengthen* the effects of the other tie. In contrast to that, the interaction between mentorship and rivalry exemplifies a constellation in which the presence of one tie *weakens* the effects of the other tie. By mobilizing resources for idea validation a strong mentor reduces the hindering effects of the hostility of rivals.

In the *vertical dimension* the framework highlights the dynamics of relations throughout the innovation process. For instance, user integration was important throughout the whole process, whereas other kinds of relations are more typical for singular phases of the innovation process (e.g. mentorship for validation, interrupted routines for induction, competition for concretization). Also the dynamic view on relations suggests that ties can change their nature during the innovation process. For instance, mentorship has to

transform into grey eminence, otherwise it becomes difficult to proceed from validation to mobilization.

Furthermore, using the *horizontal and vertical axis together*, the framework demonstrates how topics that so far have been discussed in isolation from each other can be better connected. For instance, the topics of venture capital and user-integration have only rarely been related to each other, even though in concrete innovation processes both challenges, of course, have to be addressed together. Here the presented analysis expands the discourse when suggesting that shareholders use their influence on the knowledge generation process to give user desires a higher priority. The framework can also be used to register differences between sectors. In all observed cases the incubation phase in law services took place with an intensive participation of users (see also Oliveiraa/von Hippel 2011), whereas in biotechnology this phase typically was allocated within the academic world. Demand also exerted an influence on innovation in biotechnology, however, our analysis suggests that the integration of users into knowledge networks takes place at a later stage (in the mobilization phase).

6. Conclusions

The presented innovation biographies tell stories of innovation as a process of a) balancing proximity and distance with regard to phase specific challenges and b) of managing the transition from one constellation to another in order to meet the next challenge. In this sense the approach serves to integrate existing accounts of relationships in innovation which are either vertical or horizontal. A number of aspects are however fundamentally new.

Firstly, the productive use of distance as well as deliberate distanciation, both essential tasks in innovation, are found to be active relational practices, too. Paradoxically, they also seem to require proximity. In the early phases of innovation, an emergent new idea needs to be specified, set explicitly apart from the existing body of knowledge, but also protected from orthodoxy's advocates. To this end, frequent encounters between rivaling factions take place, necessitating temporary co-presence at the topologic places of the respective community. Later in the process existing bonds of proximity need to be deliberately thinned out, often at high emotional and social costs. Our initial treatment of distance as an analytical dimension equal to proximity is now rewarded with empirical proof that the management of distance is as demanding as the creation of proximity.

Secondly, we find that not only directed, but also undirected, even unintended search prior to the explicit formulation of an idea, has a relational quality of its own. With this finding we extend the theorizing of search into yet uncharted territory. The relationships in the induction phase unfold in constellations of overlapping cultures of practice. They involve either boundary spanning individuals occupying structural folds or personal bonds across community boundaries. These relational settings display a pronounced geography, which

operates in topological spaces (places) and trans-local mobility patterns rather than territories. When an idea is defined and subsequently materialized as a first project (validation phase) the local context accounts for a large part of the socio-material framing conditions. The innovation receives a spatial imprint. Later in the process the idea is separated from its originating context and becomes more mobile in the physical space space. However the selective and associative decisions made in the validation phase and, maybe even more so, the undirected boundary crossings in the previous induction phase might remain influential throughout the entire innovation trajectory.

Thirdly, just as territories, other 'black boxes' such as organizations should be opened up in order to better understand innovation. While accounts of innovation networks tend to conceptualize relational ties as either inter-organizational or inter-individual, we find that intra-organizational relationships interact with relationships crossing organizational boundaries. Frequently new ideas need to be defended against a knowledge orthodoxy within an organization, an endeavor which is aided by ties outside the organizational context (e.g. complicity). While this aspect is discussed in the literature on communities and situated knowledge creation (Brown and Duguid 2001; Hautala 2011) it is underrepresented in discussions of innovation networks. Our idea centered knowledge networks are thus trans-organizational and trans-territorial, but by no means independent from these entities. Both provide formative environments, essential resources and challenging constraints. Innovating as a practice involves utilizing, but also evading, circumventing and recombining organizational and territorial logics.

References

Amin, A. and Roberts, J. (2008). Knowing in action. Beyond communities of practice. *Research Policy* 37(2), 353-369.

Balconi, M., Brusoni, S., Orsenigo, L. (2010). In defence of the linear model: An essay. *Research Policy* 39(1), 1-13.

Bathelt, H. and Glückler, J. (2011). *The relational economy: geographies of knowing and learning*. Oxford, UK: Oxford University Press.

Belk, R. (2010). Sharing. *Journal of Consumer Research* 36(5), 715-734.

Brown, J. S. and Duguid, P. (2001). Knowledge and Organization: A Social-Practice Perspective. *Organization Science* 12(2), 198-213.

Burt, R. S. (1992). *Structural holes: the social structure of competition*. Cambridge, MA: Harvard University Press.

Cook, I. (2004). Follow the thing: Papaya. *Antipode* 36(4), 642-664.

Dewey, J. (1933): *How We Think*. 2nd Edition. Boston, MA: Heath.

Djelic, M. L. and Quack, S. (2010). Transnational communities and governance, in: Djelic, M.-L., and Quack, S. (eds.) *Transnational communities: shaping global economic governance.* Cambridge, UK: Cambridge University Press, 3-36.

Gertler M. S. (1995). Being there: Proximity, organization, and culture in the development and adoption of advanced manufacturing technologies. *Economic Geography* 71(1), 1–26.

Glückler, J. (2007). Economic geography and the evolution of networks. *Journal of Economic Geography* 7(5), 619-634.

Glückler, J. (2012). Organisierte Unternehmensnetzwerke: Eine Einführung, in: Glückler, J., Dehning, W., Janneck, M., Armbrüster, T. (eds.) *Unternehmensnetzwerke. Architekturen, Strukturen und Strategien*. Heidelberg: Springer, 1-18.

Grabher, G. (1993): The weakness of strong ties: The lock-in of regional development in the Ruhr area, in: Grabher, G. (ed.) *The Embedded Firm. On the Socioeconomics of Industrial Networks*. London: Routledge, 255-277.

Grabher, G. and Ibert, O. (2006). Bad company? The ambiguity of personal knowledge networks. *Journal of Economic Geography* 6(3), 251-271.

Grabher, G. and Ibert, O. (2012). *Distance as asset? Knowledge collaboration in hybrid virtual communities*. Paper to be presented at the "Knowledge Networking" International Workshop, 7-8th December 2012, RWTH Aachen.

Grabher, G., Ibert, O., Flohr, S. (2008). The neglected king: The customer in the new knowledge ecology of innovation. *Economic Geography* 84(3), 253-280.

Hautala, J. (2011). Cognitive proximity in international research groups. *Journal of Knowledge Management* 15(4), 601-624.

Howells, J. (2012). The geography of knowledge: never so close but never so far apart. *Journal of Economic Geography* 12(5), 1003-1020.

Ibert O. (2007). Towards a geography of knowledge creation. The ambivalences of 'knowledge as an object' and 'knowing in practice'. *Regional Studies* 41(1), 103-114.

Ibert, O. (2010). Relational distance: sociocultural and time-spatial tensions in innovation practices. *Environment and Planning A* 42(1), 187-204.

Ibert, O. and Stein, A. (2012). Spatialities of governance: Spatial imaginations associated with market, hierarchy, networks and communities. *Geography Compass* 6(10), 602-616.

Kenis, P., and Oerlemans, L. (2008). The social network perspective: understanding the structure of cooperation, in: Cropper, S., Ebers, M., Huxhum, C., Smith-Ring, P. (eds.) *Handbook of inter-organizational relationships.* Oxford, UK: Oxford University Press, 289-312.

Knoben, J. and Oerlemans, L. A. G. (2006). Proximity and inter-organizational collaboration: A literature review. *International Journal of Management Reviews* 8(2), 71-89.

Knorr-Cetina, Karin (1999). Epistemic cultures.

Latour B. (1987). *Science in action: How to follow scientists and engineers through society*. Cambridge, MA: Harvard University Press.

Lave, J. C. and Wenger, E. (1991). *Situated learning: legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Law, J. and Mol, A. (2001). Situating technoscience: an inquiry into spatialities. *Environment and Planning D: Society and Space* 19(5), 609 – 621.

Lerner, J. and Tirole, J. (2002). Some simple economies of open source. *Journal of Industrial Economics* 52(2), 633-649.

Lundin, R. A. and Söderholm, A. (1995). A theory of the temporary organization. *Scandinavian Journal of Management* 11(4), 437-455.

March, J. (1991). Exploration and exploitation in organizational learning. *Organization Science* 2(1), 71-87.

Marcus, G. E. (1995). Ethnography in/of the world system: The emergence of multi-sited ethnography. *Annual Review of Anthropology* 24, 95-117.

Mattes, J. (2012). Dimensions of proximity and knowledge bases. Innovation between spatial and non-spatial factors. *Regional Studies* 46(8), 1085-1099.

Mayntz, R. (2010). Global structures: markets, organizations, networks – and communities?, in Djelic, M.-L., and Quack, S. (eds.) *Transnational communities: shaping global economic governance.* Cambridge, UK: Cambridge University Press, 37–54.

Nooteboom, B. (2000). Learning by Interaction: Absorptive Capacity, Cognitive Distance and Governance. *Journal of Management and Governance* 4(1-2), 69-92.

Oliveira, P. and von Hippel, E. A. (2011). Users as Service Innovators: The Case of Banking Services. *Research Policy* 40(6), 806–818.

Pachucki, M. A. and Breiger, R. L. (2010). Cultural holes: Beyond relationality in social networks and culture. *Annual Review of Sociology* 36, 205-224.

Rajagopal, K., Brinke, J., van Bruggen, J., Sloep, P. B. (2012). Understanding personal learning networks: Their structure, content and the networking skills needed to optimally use them. *First Monday* 17(1-2), 1-12.

Rittel, H. W. J. and Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences* 4(2), 155-169.

Schoenberger E. (1997). *The cultural crisis of the firm.* Cambridge, MA and Oxford, UK: Blackwell.

Stark, D. (2009). *The sense of dissonance. Accounts of worth in economic life*. Princeton, NJ: Princeton University Press.

Strambach, S. (2012). Knowledge dynamics and knowledge commodification of KIBS in Time and Space, in Di Maria, E., Grandinetti, R., Di Bernardo, B. (eds.) *Exploring Knowledge Intensive Business Services. Knowledge Management Strategies*, Basingstoke, UK: Palgrave McMillan, 56-78.

Ter Wal, A. L. J. and Boschma, R. A. (2009). Applying social network analysis in economic geography: framing some key analytic issues. *The Annals of Regional Science* 43 (3), 739-756.

Torre, A. and Gilly, J. P. (2000). On the analytical dimension of proximity dynamics. *Regional Studies* 34(2), 169–180.

Uzzi, B. (1997). Social Structure and competition in interfirm networks: the paradox of embeddedness. *Administrative Science Quarterly* 42(1), 35-67.

Vedres, B. and Stark, D. (2010). Structural folds: Generative Disruptions in Overlapping Groups. *American Journal of Sociology* 115(4), 1150-1190.

Von Hippel, E. A. (1988). *The sources of innovation*. Oxford, UK: Oxford University Press.

Von Hippel, E. A. (1994). 'Sticky Information' and the Locus of Problem Solving: Implications for Innovation. *Management Science* 40(4), 429–439.

Von Hippel, E. A. (2005). *Democratizing innovation*. Cambridge, MA: MIT Press.

Von Hippel, E. A. and Tyre, M. J. (1995). How Learning by Doing Is Done: Problem Identification in Novel Process Equipment. *Research Policy* 24(1), 1–12.

Wenger, E. (1998). *Communities of practice: learning, meaning, and identity*. Cambridge, UK: Cambridge University Press.

Wenger, E., McDermott, R., Snyder, W. M. (2002). *Cultivating communities of practice*. Boston, MA: Harvard Business School Press.

Wittel, A. (2001). Toward a network sociality. *Theory, Culture & Society* 18(6), 51–76.