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Dynamic Proximities – Changing Relations by Creating and Bridging Distances

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ABSTRACT: The analysis of qualitative regional change requires an approach that is able to cope with these changes from a relational perspective. While the proximity concept explains the spatiality of relations at a particular point in time and describes them in terms of proximity and distance, a dynamic proximity concept must explain how these distances are both bridged and created. Three different dynamics are elaborated: a cognitive dynamic that changes through learning, a network dynamic that changes when connections are made and a spatial dynamic that changes whenever actors move in space. Proximity dimensions are constructed using these three dynamics. It is argued that bridging distances is the crucial process in changing relations and that bridging distance in one dimension requires proximities in other dimensions. Implications for regional development are derived.

KEYWORDS: proximity, network, cognitive distance, regional change

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Introduction

Since Marshall's few, but fundamental pages on industrial districts, scientists from different disciplines have investigated the possible advantages of colocalisation. A particular strand in this discussion is the literature on proximity (Torre and Gilly 2000; Morgan 1997). This approach presents an analytical grid to compare network externalities between geographically proximate and distant actors (Torre and Rallet 2005; Rallet and Torre 1999).

The intention of the approach is to give further insight into why and when geographical proximity is necessary, and how it shapes innovative activity as well as the underlying relations (Torre and Rallet 2005; Boschma 2005). In doing so, it disentangles geographical proximity from other forms of proximity to elucidate when colocation is necessary to co-ordinate actions and when the benefits of colocation can be substituted by other forms of proximity, like temporary geographical proximity in project teams or organised proximity that exists within firms and networks. For this aim, the approach integrates insights from several concepts such as social network theory, learning and tacit knowledge and merges them under a common code of proximity and distance. Through the differentiation between colocation and proximity, the proximity concept deviates from territorial innovation models (Moulaert and Sekia 2003) such as the industrial district or the innovative milieu in that it does not conflate geographical proximity with non-geographical forms of organisation.

The proximity approach has inspired many studies that deal with the spatiality of networks and relations (Morgan 1997; Boschma 2005; Zeller 2004) and has contributed significantly to the understanding of economic coordination for different geographical scales at a particular point in time. However, relations are inherently dynamic and subject to continuous change. Actors establish new contacts and intensify existing relations while cancelling others.

Changing relations and networks become a crucial factor during the adjustment of regional systems to qualitative and structural economic change and in the emergence of regional paths. Grabher and Stark (1997), for example, argue that the various organisational forms in the Third Italy are the source of continuously renewed relations, which enable the district to adjust to a changing economic environment. Bathelt and Boggs (2003) show for the emerging Media Cluster in Leipzig (Germany), that actors had to develop new network structures to "rebundle" the existing regional competencies to form a new regional trajectory. Owen-Smith and Powell (2006) point out that the different origins of the biotech clusters in the Bay Area and Boston - VC in the Bay Area and public research organisations in Boston – led to different network structures. These differences between the networks diminished during their evolution.

Coping with these regional dynamics requires a dynamic view on the spatiality of relations. While the proximity concept explains the spatiality of relations at a particular point in time and describes them in terms of proximity and distance, a dynamic proximity concept would explain how these distances are both bridged and created, and how this bridging process is related to regional development. Several approaches already apply proximity to changing relations and illustrate the differences between network configurations at different points in time using the proximity concept (e.g. Rallet and Torre 1999, Zeller 2004, and Gilly and Wallet 2001). Boschma (2005) additionally describes the extremes of too much and too less proximity for several proximity dimensions and gives some insights on how to avoid negative lock-in. This paper is based on this strand of work. However, it deviates from the existing approaches in that it does not start with the proximity dimensions and subsequently dynamise them, but begins with the fundamental dynamics that change relations with the goal of indigenise change dynamics. In doing so, insights from different schools, such as network theory (Watts 2004; Barabasi 2003) or cognitive science (Johnson-Laird 1983; Denzau and North 1994) are analysed in regard to their explanations of bridging and creating distances. Using these change logics, proximity dimensions are derived. It is argued that bridging distances is the core process in changing relations and the adaptability of firms and regions, and that bridging distances in one dimension requires proximities in other dimensions. The region is the entity in which this bridging takes place.

The paper proceeds as follows: the next section gives an overview of the results on changing relations found in proximity literature. The third section elaborates on the different change logics and their respective proximity dimensions. The interdependencies between the different dimensions and how proximity in one dimension contributes to bridging distances in other dimensions are the topic of the fourth section. The fifth section concludes and gives some indications for spatial evolution.

Approaching Proximities

There are several attempts to dynamise the concept. Rallet and Torre (1999) describe changing network configurations in French regions. Zeller (2004) illustrates how Novartis and Roche established different research facilities to establish proximities to regional knowledge and to their competitors in an oligopolistic market. Gilly and Wallet (2001) describe the conversion of the aerospace defence industry in Bordeaux that was accompanied by a change in the institutional, organisational and geographical extension of proximities between actors. The examples given attempt to comprehend temporal dynamics by comparing relations at time *t* with those at time *t'*. The causality of change between *t* and *t'* is either part of another theory, as in Gilly and Wallet (2001), the result of factors exogenous to the proximity dimensions (i.e. governmental action), as in Rallet and Torre (1999) or corporate strategy as in Zeller (2004). However, both empirical studies (Gulati and Gargiulo 1999; Grabher 1993) and theoretical explanations (Glückler 2007; Barabasi 2003) show that relations follow path dependencies, i.e. proximities between actors at time *t* have an influence on the proximities at time *t'*. An integration of these dynamics and change patterns into the proximity concept would enhance its explanatory power.

The difficulties in dynamising proximities lie in the very foundations of the concept. The original proximity concept elaborated by the French proximity school is based on two different types of proximity: geographical and organisational proximity:

> While organizational proximity deals with economic separation and relations in terms of the organization of production, *geographical proximity* deals with the separation in space and relation in terms of distance (Torre and Gilly 2000, p. 176).

Other contributions have altered the proximity concept and elaborated several new types of proximity. Kirat and Lung (1999), for example, introduced institutional proximity to indicate that learning is a collective process that requires an institutional setting. Further enhancements are cognitive proximity, which describes the ability of actors to communicate meaningfully and generate new knowledge, or cultural proximity, which describes commonalities originating from a shared socialisation (for an overview of proximity types, see Knoben and Oerlemans 2006 as well as Boschma 2005). These enhancements and the application of the term “proximity” to different aspects beyond the mere interplay between geography and organisation indicate the complexity of relations and the variety of factors of commonality and distinction that affect interaction.

However, the intention of describing the complexity of relations results in proximity dimensions which are not necessarily the appropriate dimensions for describing change dynamics. One difficulty lies in the overlapping boundaries between the different proximities (Knoben and Oerlemans 2006). When actors get closer in one dimension, they are also getting closer in other dimensions and are ultimately close in all dimensions. The other point that hinders the dynamisation of the concept is the combination of different logics of change in one proximity dimension. For example, organisational proximity changes through similarity and affiliation of actors (Torre and Rallet 2005). However, networks and properties of actors change in a different way (McPherson et al. 2001). A distinction between the two elements of organisational proximity has already made by Boschma (2005); he extracts similarities of actors from organisational proximity and establishes a cognitive proximity dimension. This separation is a precondition for describing the effects of different degrees of proximity and distance and supports his argument that both "too much and too little proximity may be harmful for effective interactive learning and innovation" (ibid., p. 62).

Step by step, these approaches have integrated logics of change into the proximity concept. Yet another move towards internalising change logics may be achieved with insights from other disciplines. In addition to this, this broader view would enable the exploitation of one of strengths of the proximity concept, namely the merging of different strands and concepts under the nomenclature of proximity and distance. To avoid the pitfalls of mingling different dynamics within the same proximity dimension or the description of different dimensions that actually follow the same dynamics, the following elaboration starts with those dynamics that change relations.

Constructing Proximities

The intention of this paper is to connect the change of relations to regional qualitative change, i.e. the change of knowledge bases of organisations and actors. Actors build relations and exchange knowledge with the goal of coordinating their actions and generating new knowledge. Absorption of external knowledge influences their knowledge base. Understanding the transferred knowledge and the ability to use it to generate new knowledge depend on the cognitive capabilities of particular individual actors (Arthur 2007; Nonaka and Takeuchi 1995). In addition to this, the efficiency and quality of knowledge transfer between two actors depends on the mode of interaction. It is the essential argument of existing proximity concepts that knowledge is best exchanged through face-to-face interaction, which requires geographical proximity (Torre and Rallet 2005). Finally, knowledge exchange is also influenced by the structure of the network and the interactions of other actors (Barabasi 2003; Watts 2004). Cowan and Jonard (2004), for example, simulate how the structure of a network influences knowledge diffusion. Burt (1992) shows that an actor's position in the network affects their access to knowledge.

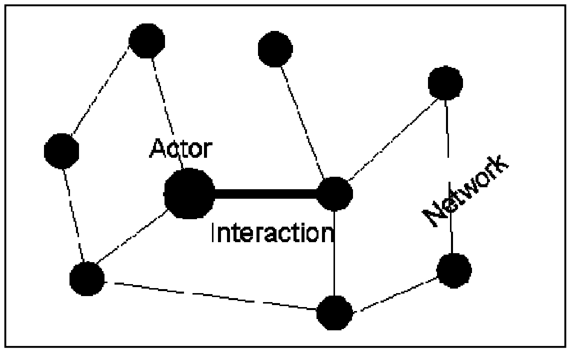

Figure 1: Building Blocks of Dynamic Proximities

To cover changing relations and qualitative regional change, the dynamic proximity concept must refer to the individual person or organisation as basis for qualitative regional change and how they process and combine external knowledge; the mode of interaction on the dyadic level, especially when and why geographical proximity for face-to-face interaction is necessary; and the structure of the network and the position of actors in this structure. Figure 1 describes actor, mode of interaction and network as the three building blocks of a dynamic proximity concept. All of them change, but each in a different way.

Cognition and Learning

When actors communicate, their mutual understanding depends on the compatibility of their interpretation of their environment, i.e. on their mutually shared mental models (Nonaka and Takeuchi 1995; Denzau and North 1994). Shared mental models describe a similarity of certain areas of knowledge that enable actors to understand others. In doing so, shared mental models form a "common language" or a “platform” as a basis for communication. Denzau and North (1994) developed a sender/receiver model to describe communication as dependent on shared mental models. The sender of a piece of information, or an “idea” as they put it, articulates and encodes the information into a language on the basis of their mental models. The receiver decodes the information and integrates their comprehension of the information into their own mental models. The more the idea matches the mental models of the receiver, the easier it is to decode the idea. By integrating the idea into their own mental models, the receiver learns from the sender.

Denzau and North (1994) describe how actors efficiently communicate with and learn from each other. Nooteboom's (1999a) “cognitive distance” additionally focuses on the generation of new knowledge as a function of communicability between actors:

> For learning, partners should have on the one hand sufficient ‚cognitive distance', i.e. possess different cognitive categories, to be able to capture knowledge that one could not have captured oneself, but on the other hand must be sufficiently close, in cognition and language, to enable meaningful communication (Nooteboom 1999b, p. 14).

While the central argument of Nooteboom (1999b) is that there is an optimal cognitive distance for innovative activities, his concept points out that the degree of novelty and learning depends on the equivalency of the actors' knowledge. In cognitive proximity, actors are able to communicate efficiently, yet only novelty of low degree results. The larger the differences in cognitive categories, the more radical the generated knowledge may be, but the more difficult communication becomes.

Apart from the generation of novelty, knowledge exchange also affects the cognitive categories of actors. During knowledge exchange, the shared mental models adjust and actors become more proximate (Denzau and North 1994). The larger the distance between the actors, the larger the potential to decrease the distance and, accordingly, the larger the possible learning effects, assuming that the distance is not too large to prevent meaningful communication. If actors are already close, there are few possibilities for further approximation and interaction more likely contributes to sustaining the already achieved degree of proximity than to enhancing it. Without interaction, however, mental models would diverge. These processes of learning and knowledge generation also take place on the firm level (Mowery et al. 1998; Cowan et al. 2006).

Learning and interacting comprise different types of knowledge. Of special relevance is knowledge is which leads to the generation of improvements, novelty, and inventions. According to Arthur (2007), invention may start as a reaction to a need or purpose for which existing solutions are not satisfactory. To emphasise the purposefulness of knowledge generation, Arthur (2007, p. 276) refers to a technology simply as a "means to fulfil a human purpose".[1] Accordingly, technological knowledge is the knowledge of these means.

The communicability of technological knowledge depends both on the shared technological knowledge and on the complexity of the transferred knowledge. For less complex technologies, less shared knowledge is necessary, while highly complex technologies require a larger common basis (Sorenson et al. 2006). From this point of view, actors are technologically distant if understanding each other is not possible or would require additional learning processes. Technological distance decreases with the increase of shared technological knowledge.

[1] Arthur (2007, p. 285) distinguishes between purposeful knowledge generation and "non-deliberate innovations such as trading arrangements or legal systems [which] 'emerge' via a social process of variation and selection".

Interaction frequently depends on factors outside a technological dimension (Maskell and Malmberg 1999). Common experiences and knowledge of the behaviour and reactions of others generate trust and facilitate communication. While this socially shared knowledge refers to individuals and their dyadic relations, knowledge that is supra-individual can exist between individuals without a previous contact and thus is culturally shared. Saxenian and Hsu 2001) describe this effect for contact establishment between Taiwan-Chinese people in Silicon Valley. Members of this community immediately benefit from a large degree of mutual trust simply because of their compatriotism. The reciprocal relations in the industrial districts in the Third Italy (Piore and Sabel 1984) are a similar example. Mutual trust between the actors applies even if the collaborators did not previously know each other, merely because they are located in the same district. Similar corporate cultures may also facilitate collaborations between actors, whereas different cultures can prevent collaboration, even if it would be beneficial from an economic perspective (Lane and Lubatkin 1998).

Socially shared knowledge, cultural resemblance or shared values can create common ground between actors and influence the transfer of technological knowledge despite technological distance. Both types of shared knowledge belong to the cognitive dimension. Socially shared knowledge is a direct result of interaction on the dyadic level. Culturally shared knowledge is supra-individual and thus not an effect of direct interaction. Nevertheless, "culture is also manifest in people's heads" (DiMaggio 1997, p. 272) and results in particular actions, interactions and understandings. Therefore, on the individual level, culturally shared knowledge follows a cognitive logic and changes through learning, too.

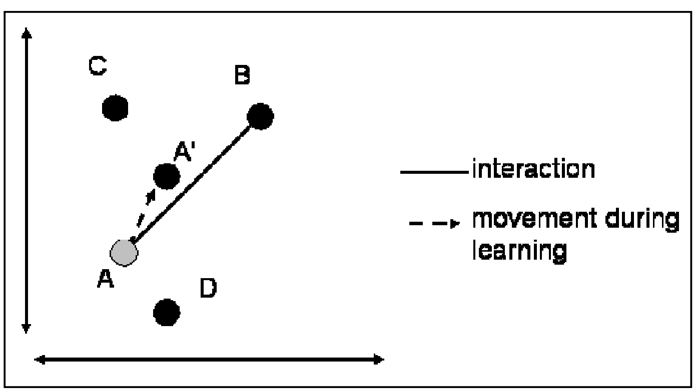

Figure 2: Indirect Changes of Proximities in Cognitive Space

The distinction between socially and culturally shared knowledge also shows that cognitive proximity changes in a direct and an indirect way. Direct and continuous contact between actors results in increased common understanding. But the changes to cognitive proximities between two actors also influence the cognitive distance to other actors that do not take part in the interaction. During interactive learning, the receiver acquires knowledge from the sender and the cognitive distance between them diminishes. During this approach in cognitive space, the receiver of the knowledge also moves towards other actors who are not part of the interaction, but also possess that particular knowledge. Figure 2 exemplifies this process. The interaction between A and B changes the knowledge base of A and thus their mutually shared knowledge. As a result, A moves through cognitive space towards A'. During this movement towards A', A not only approaches B but also C. In contrast, the distance to D may increase. This illustrates that the changes to their knowledge base not only affect the relation between A and B, but also the proximities to other actors such as C and D. In addition to this, the figure shows that creating proximities also always creates distances.

To summarise, actors can be distinguished by their cognitive proximity and distance, which are shaped by different types of knowledge such as technological knowledge, cultural norms or common experiences. The logic of how cognitive proximity changes is through learning.

Modes of Interaction, Space and Moving

Apart from the cognitive categories of actors, the efficiency of learning also depends on how the knowledge is exchanged between actors. Communication can take place in several ways, for example face-to-face, by mail or telephone. In recent years, the Internet has emerged as an important form of communication, making use of techniques such as e-mail, instant messaging and video conferences. It increasingly facilitates the disconnection of routine, standardised communications from spatial constraints by enabling reliable real-time interaction. However, face-to-face communication is still considered to be the most efficient mode of communication (Storper and Venables 2004). Maskell and Malmberg (1999), for example, argue that the more knowledge becomes globally available, the more knowledge whose generation and transfer depends on direct interaction (and is thus difficult to codify) will become valuable and scarce.

Communication does not rely on face-to-face interaction, but it facilitates communication, in particular when knowledge is complex or differs strongly between actors. Torre and Rallet (2005) mention some situations that depend on face-to-face interaction, namely

> in the phase of negotiation a transaction, the definition of guidelines and the organizational framework of cooperation, the realization of its initial phase in the case of a technological alliance, the necessity to share equipment in the experimental phase of a common research project or to exchange knowledge and, above all, to know personally the researchers (colloquium) belonging to a scientific community (ibid. p. 54).

It takes an effort to generate physical proximity between distant actors. The effort depends on the time and cost it needs to bridge the spatial distance and is affected by means of transportation (Glückler 2007). Being colocated to particular actors or connected by appropriate means of transport reduces this effort. Therefore, the opportunity for face-to-face interaction with particular actors becomes a rare commodity in and of itself, as this mode of communication is limited to those actors that are in physical proximity at a given moment.

Spatial proximity takes on a different meaning when the view is changed from the dyadic to the aggregate level, where a number of actors are in spatial proximity. It is not only the bridging of spatial distances with the intention of communicating with a particular actor, but also the possibility of both intentional and coincidental interactions with different types of actors in a spatially circumscribed area. In agglomerations, actors are close to many other actors, often without any direct intention of or necessity for being close. But being spatially close increases the possibility of contacting a wide variety of actors. Storper and Venables (2004) as well as Bathelt et al. (2004) use the word "buzz" to describe the informal, often diffuse but steady and pervasive stream of information within a region or a cluster. Grabher (2002) calls the same effect "noise". Glaeser (1999) argues that people learn through contact with other agents and that these contacts are more easily established in agglomerations than at the periphery. In addition to this, both the speed and the diversity of contacts are higher in urban areas than in the hinterland. Therefore, the distinctive characteristic of spatial proximity between many actors in the same location is not transaction cost or the efficiency of knowledge transfer. It is rather the possibility to intentionally and unintentionally exchange knowledge with a wide variety of actors.

Face-to-face interaction is not limited to actors that are permanently colocated, but can also be intentionally generated for a particular point in time (Torre and Rallet 2005; Torre 2008). For example, the launch of a project often requires intense face-to-face interaction and temporarily generated spatial proximity becomes necessary. As the project progresses, the importance of face-to-face interaction and spatial proximity decreases (Gallaud and Torre 2005). Examples of temporary geographical proximity (Torre 2008) on the aggregate level are "temporary clusters" (Maskell et al. 2006) such as conferences or industry fairs at which actors strive for spatial proximity to many different actors for a certain time.

To summarise, actors can interact using several forms of communication in which different forms of codified, articulated and tacit knowledge are transferred. Face-to-face interaction is the most valuable form of communication. Spatial proximity describes the effort it takes for actors to enter into face-to-face communication. Therefore, spatial proximity becomes an important factor only when economic activities require face-to-face interaction (Glückler 2007). It changes whenever actors move in space.

Network and Connecting

The previous section described the position and relation of actors in physical and technological space. This section deals with network space. The dyadic relation between actors depends strongly on their relational environment and the structure of the network (Cowan and Jonard 2004), i.e. actors who do not directly participate in an interaction can nevertheless have an influence on it.

One expression of this indirect influence is access to knowledge. This access does not only depend on direct access to particular actors, but also on the access these actors have to other actors in turn. When two networks are separate, both networks have to rely on their own knowledge. Burt (1992) emphasises the necessity of bridging structural holes between otherwise separate networks. Actors at structural gaps serve as gatekeepers for their respective networks. They can both enable and impede the flow of knowledge between networks.

While social network analysis describes the structure of networks, graph theory additionally describes the interrelation between network structure and connective behaviour (Watts 2004; Barabasi 2003).[2] In general, network structure is positioned between two extremes. The first is the regular network, in which every actor is connected to their nearest neighbours. This network is highly clustered as two nodes A and B that are connected to C are also connected to each other.[3] The average distance between each node is large, as distant nodes are only connected through the chain of their neighbours' neighbours, and so on. The second extreme is the random network. Accidental node connections result in a network in which every node is connected to all other nodes in the network with the smallest possible degree of distance (Watts 1999). An intermediate type of network is the "small world" network (Watts 1999; Baum et al. 2003). It consists of clustered nodes, but a few additional

[2] In its analytical reach, graph theory is intended to form a connection between social science and natural science, as their protagonists argue that such different systems as economies, cells, the internet, etc. all follow (at least to a certain extent) the same fundamental logics (Barabasi 2003; Watts 2004).
[3] For this, each node has to have at least three ties, for example A has ties to B and C and to the next nearest neighbor (see Watts 1999; and Cowan and Jonard 2004).

links between the clusters considerably reduce the number of ties necessary to connect the different networks, which leads to the "coexistence of high local clustering and a small global length scale" (Watts 1999, p. 524).

Graph theory highlights several mechanisms of tie formation that influence the type of network structure. One is the connection to already connected nodes. If node A is connected to B and C, it is highly probable that a new contact will emerge between B and C. This regularity is empirically proven for social networks in many case studies, for example for inter-firm alliances by Gulati and Gargiulo (1999) and for the establishment of embedded ties in the New York apparel industry by Uzzi (1997). Kossinets and Watts (2006) found out with longitudinal data on e-mail traffic between more than 40,000 students that the probability for individuals to form a new tie is thirty times higher when their distance is two degrees, i.e. the mechanism described above, compared to a distance of three degrees. Obstfeld (2005) argues that this mechanism exists because actors profit from introducing otherwise unconnected actors to each other in several ways. They can expect other actors to act in a similar way and introduce them to new actors in turn. In addition to this, introducing unconnected actors increases the overall opportunities for innovation. When all actors follow the same goals, i.e. they are part of the same organisation or close network, the introducing actor profits from the increased innovativeness of the whole network. The connection to previously connected nodes results in a clustered network. Burt (1992) takes the opposing position and argues that actors profit from keeping other actors apart to exploit opportunities for arbitrage. In addition to this, the introducing actor A can lose by introducing B and C, as they then become independent from A. Another connection mechanism is by coincidence. If node A is connected to B and B to C, a connection between A and C is as probable as a connection to any other node in the network. This mechanism results in random networks.

The network grows when new nodes connect to the preexisting network. There are several mechanisms for making connections, each of which affects the overall shape of the network. When each new node randomly connects to existing nodes, the oldest nodes have the most ties, since they have taken part in the most tie selection rounds and thus have had more chances to acquire new links than younger nodes. Therefore, accidental tie connection results in a core-periphery pattern of a network, where the oldest nodes are in the centre and the youngest at the periphery.

The core-periphery pattern is amplified when new nodes have a preference for connecting to a particular kind of node. The "rich getting richer" rule assumes that new nodes try to connect to the most connected nodes, whose connectivity again grows stronger than that of the remaining network (Watts 2004; Albert and Barabasi 2002). The result is a network with a few highly connected hubs and many nodes with few or no connections. Due to first-mover advantages, the hubs that result from this attachment strategy are usually the oldest nodes. Preferential attachment to the largest hubs introduces a path-dependent element to graph theory, as the nodes that became hubs in an early stage of network evolution will also represent the hubs at later stages. However, the formation of social networks seems to be far more complex. Powell et al. (2005) could not prove the “rich getting richer” thesis for their analysis of alliance formation between biotechnology firms, as older nodes got considerably fewer new ties than younger nodes. They argue that this result stems from the strategy of older and larger firms to form ties to younger firms in order to diversify their network. Additionally, they observe that the rules of attachment changed over time.

Network governance approaches (Uzzi 1997; Granovetter 1985) emphasise that apart from the structure of the network, its character or “quality”, as Uzzi (1997) puts it, also affects contact and interaction. One example is the distinction between weak and strong ties. Loosely connected nodes are weak ties. As new connections emerge, they are often diffuse, but quite flexible. Strong ties, in contrast, are often long-term relations or connections with a high degree of formalisation. A special form of a network with strong ties is the firm, which is considered to be a “network within networks” (Dicken and Malmberg 2001) from a relational point of view. These networks are at their most dense between employees in the same working group or between departments of an organisation. The interrelation between network structure and quality of ties is empirically described by Owen-Smith and Powell (2004). They discovered that network position is not important for getting access to the knowledge that flows through weak ties, while it is essential for getting access to knowledge that flows through strong ties.

Weak ties are strengthened in different ways. One of these is embedding. The connection between two nodes A and B improves if their neighbouring nodes also form ties. This reinforcement prevents the actors from indulging in opportunistic behaviour, as it could be penalised by cutting the tie. In addition to this, knowledge can flow between A and B in different ways, either directly between them or indirectly via their adjacent nodes. Another possibility of strengthening a tie is to institutionalise the tie, for example through formal alliances or collaborations. But ties can also become weaker and ultimately disappear. The rate at which this happens depends on the nature of the ties. Burt (2000), for example, shows that embedded ties decay much more slowly than ties that are not embedded.

The examples given above describe the changes within one single network. Actors are often part of different types of networks with different purposes and characteristics, in which they occupy different positions. Actors can thus improve their position in one network by taking advantage of their position in another network (Ettlinger 2003). An example may illustrate this: a group of actors has strong connections through their social networks. Their economic networks, however, are quite different. They are all employed in different organisations in different branches, but can exploit their social network to get access to the economic networks of their friends, for example when one friend introduces another friend to a business partner or colleague.

To summarise, the probability of tie formation between two nodes is higher when their network distance is small. It decreases with increasing network distance. The network distance between different actors is therefore subsumed under the term “network proximity”. Network proximity changes when connecting to other nodes. Connecting takes place according to the rules of tie formation, network structure and the position of the respective nodes.

Learning, Connecting, and Moving

Table 1 summarises the characteristics of the three proximity dimensions. Cognitive proximity describes the similarities and differences between cognitive categories. It changes through learning. The technological share of cognitive distance is mostly measured using patent data, for example by Nooteboom et al. (2007) and Mowery et al. (1998). Other forms of cognitive proximity, for example its social dimension, are measured using common affiliation (Sorenson et al. 2006). Spatial proximity describes the positions in space and changes whenever actors move in space. It can be measured by the time and cost it takes to bridge spatial distances to enter into fact-to-face interaction, as proposed in Torre and Rallet (2005). Network proximity describes the distance between network positions and changes when actors connect to new nodes. Social network analysis and graph theory offer corresponding tools (Albert and Barabasi 2002).

The three proximity dimensions as described have very little overlap. Actors can be proximate in one dimension and distant in another. They can, for example, be cognitively proximate but spatially distant when actors in different places contribute to the same technological trajectory (Dosi 1988); they can be in spatial proximity but distant in the network when they belong to different regional networks (Owen-Smith and Powell 2004; Giuliani 2007); and they can be proximate in the network but at a cognitive distance when they are connected to the same gatekeeper, but have their main relations in different networks. The next section describes the interrelation between the different proximity dimensions and how proximity in one dimension contributes to bridging distances in another dimension.

Proximity Dimension	**Measuring Distances**	**Change Logics**
Cognitive	Differences in cognitive category	Learning
Spatial	Space-time constraints for face-to-face interaction	Movement in Space
Network	Distance between network positions	Connection

Table 1: Proximities, Distances and Logics of Change

Bridging Distances

Network, cognitive and spatial distances can be easily bridged when they are small. Network positions change slightly according to inherent positions, learning is easy when the knowledge resembles knowledge already acquired, and face-to-face interaction is facilitated when actors are at the same location. Larger distances are more difficult to bridge. While the previous section analysed the change within the three dimensions, the topic of this section is to put forward the argument that large distances in one dimension are bridged when proximities in other dimensions exist. As the three proximity dimensions differ in their change logic, so does their mutual influence. The questions that will be answered are: how do cognitive and spatial proximity contribute to bridging network distances; how do spatial and network proximity contribute to bridging cognitive distances; and how do cognitive and network proximity contribute to bridging spatial distances?

Bridging Network Distance through Spatial and Cognitive Proximity

Contact establishment is the precondition for interaction. A contact is established when the network distance between two actors is one. While network theories explain the connection of nodes by incrementally decreasing their network distance through various mechanisms, the connection across larger distances is often assumed to take place randomly (Watts 1999). This explanation often neglects the fact that individuals, groups or companies, when they bridge large network distances, often have a particular intention in mind (Watts 2004). This means that they do not bridge large network distances accidentally, but simply follow a logic other than that of the network. McPherson et al. (2001, p.415) emphasize that "similarity breeds connection". They point to the importance of homophily in the establishment of interpersonal networks, where ties form due to similar characteristics of actors. Important sources of homophily are the perception of other actors as similar or being at the same location.

Cognitive proximity can contribute to bridging network distances in different ways. The goal of interactions is often not only that of acquiring new knowledge but also of improving network positions. Using the advertising industry in London as an example, Grabher (2002) illustrates that communication does not only take place with the goal of exchanging knowledge, but also to gain access to other actors, thereby building network proximity. Different studies, such as Lane and Lubatkin (1998) or Nooteboom et al. (2007) show that companies form ties when actors are proximate enough in cognitive terms to be able to meaningfully communicate with each other and distant enough to profit from the different knowledge.

Apart from cognitive proximity, spatial proximity between actors also contributes to bridging network distances, as being in the same place facilitates direct interaction. Owen-Smith and Powell (2004) show that a central network position is not important for participating in the knowledge flows of a network when the network partners are in spatial proximity. Powell et al. (2005, p. 1178) point out that spatially proximate companies are twice as likely to collaborate as distant companies. In addition to this, spatial proximity between actors provokes coincidental contacts (Storper and Venables 2004; Malmberg and Maskell 2006). When this happens, actors that have previously been at a network distance of several degrees are directly connected. Existing literature on industrial districts, regional clusters and the innovative milieu (Saxenian 1994; Moulaert and Sekia 2003) even assumes that spatial proximity in connection with a regional milieu and institutional thickness results directly in the bridging of network distances and, in doing so, enables network structures that provide easy access, as long as the actors are located in the same region. While it generally seems to be the case that spatial proximity between actors can compensate for network distance, contributions such as Giuliani's (2007) description of Chilean wine clusters show that regional networks are not pervasive but selective and that this selectivity persists over time. This indicates that network distances are not necessarily bridged when actors - even in the same technological field - are in spatial proximity, but that other factors are also important.

Cognitive and spatial proximity both contribute to bridging network distances, but the types of network that result are different. Bridging through cognitive proximity gathers actors with the same properties. These networks have homogeneous actors and are spatially disperse. Bridging network distances through spatial proximity results in networks that are diverse, but spatially concentrated.

Bridging of Cognitive Distances through Spatial and Network Proximity

Qualitative change, an important process in economic development (Martin and Sunley 2006), requires the combination of knowledge from sources at comparatively large technological distances. When companies, as essential units of economic development, undergo qualitative and structural change, they have to acquire knowledge from sources that are often at cognitive distances, i.e. not only technologically distant but also contained in companies with differing company cultures and from other socioeconomic contexts. Spatial and network proximity can facilitate learning processes across cognitive distances, but in different ways.

Cowan et al. (2006), for example, simulate network formation based on mutual learning processes. They show that being in the same network reduces cognitive distance. Mowery et al. (1998) show empirically for company alliances that the technological overlap between the companies, measured in patents, increases during the time of the alliance. Bridging of cognitive distances also occurs within companies. Kogut and Zander (1992) argue that the company provides a framework for interaction that facilitates the recombination of different kinds of knowledge. Entities like companies can bring strong pressure to bear on their individual parts and affect the interactions of individual actors and groups that would otherwise develop separately. Fleming (2002), for example, describes how the most important invention for Hewlett-Packard’s ink-jet technology was made by an “odd couple” (ibid., p. 1064). The network proximity between them which was generated by Hewlett-Packard led to the invention in spite of distances in other dimensions.

Spatial proximity influences the bridging of cognitive distances in other ways. Spatial proximity has been proven in many empirical studies to generally correlate with innovative activity (Cooke 2001; Jaffe et al. 1993). Fewer studies consider the type of innovation that is affected by spatial proximity, i.e. which degree of cognitive distance requires continuous interaction to be bridged. Sorenson et al. (2006) compare the transfer of less complex, complex and highly complex knowledge. The transfer of complex knowledge is facilitated when actors are able to meet regularly and thus depends on spatial proximity. In contrast, the transfer of both less complex and highly complex knowledge does not require spatial proximity: the less complex knowledge because it is easy to absorb, the highly complex knowledge due to its strong dependence on cognitive proximity, as only a few people may be able to understand that knowledge. Zeller (2004) gives another example of how spatial proximity serves to bridge cognitive distances. The big Swiss pharmaceutical companies established research facilities in knowledge centres worldwide in order to tap into the embedded regional knowledge. Additionally, Torre and Gilly (2000) mention that spatial proximity is necessary when knowledge differs strongly between actors, but that it loses its importance during the subsequent learning processes. All these studies illustrate that continuous interaction contributes not only to innovative activities in general, but also enables actors to understand and absorb diverse knowledge and, in doing so, creates cognitive proximity.

Often, both network and spatial proximity together contribute to bridging large cognitive distances, as this depends both on regular interaction, which is accounted for by strong network proximity, and face-to-face interaction. But their influence differs. Obstfeld (2005) emphasises that incremental innovation takes place in dense networks, while radical innovation takes place in loose networks in which cognitive distances are larger. As loose networks can be connected more easily when the nodes are located in spatial proximity (Owen-Smith and Powell 2004), it can be assumed that spatial proximity contributes to connecting different types of knowledge flows to a larger extent than network proximity.

Bridging Spatial Distance through Network and Cognitive Proximity

Spatial proximity facilitates contact establishment, but it is not necessary for the maintenance of contacts. Lissoni and Pagani (2003) show that employees build epistemic communities that are qualified by a strong cognitive proximity. This cognitive proximity persists even when members of the community move to different places and possibilities for face-to-face interaction are reduced (Amin and Cohendet 2004). Additionally, cognitive proximity enables companies to exploit knowledge that was developed at different places. Phene et al. (2006), for example, prove that innovations that recombine technologically proximate knowledge are more successful when this knowledge originates in different places in different countries.

Spatial proximity can also be replaced by network proximity. Multinational enterprises, for example, sustain coherency between their dispersed divisions through various means such as intra-organisational labour mobility (Nonaka and Takeuchi 1995), codification of knowledge (Cowan and Foray 1997) or regular meetings. Additionally, long range interactions between companies are often conducted through "pipelines" (Bathelt et al. 2004) such as formal alliances or research collaborations. The tight institutional setting of these distant interactions enables efficient knowledge exchange without spatial proximity.

The combination of cognitive and network proximity can even result in company concentrations without benefiting from the colocation. Torre (2008) argues that continuous colocation between firms is the result of regionally embedded social relations, i.e. networks of cognitively proximate actors. Klepper (2007) demonstrates how firm concentrations are the result of subsequent spin-off processes which take place in the same region. Actors that work in the same firm, and are thus in network proximity, create cognitive proximities due to learning and spin off with their own company in spatial proximity to their parent firm. These examples indicate that regional concentrations may exist without any positive effect from agglomeration economies or from being geographically close.

Therefore, the advantages of colocation can be made up for in various ways. Being independent from spatial constraints can be a source of flexibility and competitive advantage, as this independence enables companies to exploit and combine knowledge from different places without the necessity of actually being there (Gertler 2003).

Conclusion and Discussion

This paper began with the observation that changing settings such as the emergence and evolution of regional paths or regional industrial restructuring that go hand in hand with changing relations are difficult to grasp with existing proximity approaches. The main reasons for this are overlapping boundaries of different proximity dimensions, which means that changing one proximity leads to changes in other proximities and the embracing of different change logics in individual proximity dimensions. To avoid these pitfalls, a proximity concept has been presented, starting with the elaboration of change dynamics.

Three different logics of change have been elaborated and connected to three proximity dimensions: the cognitive dimension comprises commonly shared knowledge as a basis for interaction and changes through learning processes; the network dimension describes network distance and the properties of ties; it changes by connecting and disconnecting. The spatial dimension, finally, describes the effort it takes to enter into face-to-face interaction and changes whenever actors move in space. The interrelations between the different proximities have been important aspects in many studies: cognitive proximity in the form of shared technological knowledge shapes places like Silicon Valley and leads to network formation in the technological trajectory (Dosi 1988). Spatial proximity fosters learning processes, as described in the literature on knowledge spill-over (Jaffe et al. 1993), and the formation of diverse networks (Owen-Smith and Powell 2004; Glückler 2007). Network proximity serves to bridge spatial distances, as described in the literature on global production networks (Coe et al. 2008) and constitutes learning processes (Mowery et al. 1998; Nooteboom 1999a). The added value of the proximity approach at hand is the insight that these dynamics are not unidirectional, but instead mutually influence each other. The intensity and direction of this influence depends on the respective distances and proximities: it is the central argument of this paper that bridging distance in one dimension requires proximity in other dimensions. Additionally, with their movement through geographical, cognitive and network space and the bridging of distances in one direction, distances in other directions are created.

The interrelations between the proximities also indicate that different kinds of innovative activity require different patterns of proximity and distance. Interaction that is dominated by cognitive proximity enables the transfer of highly complex knowledge. This knowledge often flows in academia or in industries of new technologies. The places where this knowledge diffuses have the potential to be the seedbed for a new cluster. Interaction that is dominated by spatial proximity is highly fuzzy and unstable, as it often depends on loose and coincidental contacts. Still, it provides the actors with access to diverse knowledge sources and may generate networks of the "small world" type. Interaction that is dominated by network proximity is highly regulated and implies a routine exchange of knowledge, which is necessary for incremental innovation. The more knowledge is integrated in such processes, the less its generation depends on individual locations.

Coming back to the opening question regarding the advantages of colocation, the approach presented in this paper adds an additional and complementary explanation to the many others. Firms benefit from colocation through two different, but connected processes. The first is the bridging of network distances, which is easier for colocated than for distant actors. The second is the bridging of cognitive distances. Once actors have established contact to actors previously at a distance in the network and still at a cognitive distance, colocation facilitates face-to-face interaction and thus the ability to understand and absorb the distant knowledge. These processes cannot wholly be substituted by "temporary clusters" (Maskell et al. 2006) or “temporary geographical proximity” (Torre 2008). Temporary clusters like industry fairs indeed bear the possibility to bridge network distances, but their temporality impedes the bridging of large cognitive distances. Additionally, the generation of temporary proximity between the participants in particular projects presupposes already certain network and cognitive proximity which precedes the start of a project.

Therefore, under the condition that diverse knowledge is available in the region, the two interconnected processes of bridging network and cognitive distances account for the long-term adaptability of colocated actors to a changing economic environment and for the whole regional system of production and innovation on the aggregate level as well as its emergence, change and evolution (Menzel and Fornahl 2007). In contrast, regional concentrations in the Klepper (2007) sense that form without these benefits of spatial proximity and do not generate them during their development would ultimately decline.

References

Albert, R. and Barabasi, A. L. (2002): Statistical Mechanics of Complex Networks. In: Reviews of Modern Physics 74(1), 47-97.

Amin, A. and Cohendet, P. (2004): Architecture of Knowledge: Firms, Capabilities and Communities. Oxford: Oxford University Press.

Arthur, W. B. (2007): The Structure of Invention. In: Research Policy 36(2), 274-287.

Barabasi, A.-L. (2003): Linked: B&T.

Bathelt, H. and Boggs, J. S. (2003): Towards a Reconceptualization of Regional Development Paths: Is Leipzig's Media Cluster a Continuation of or a Rupture with the Past? In: Economic Geography 79(3), 265-293.

Bathelt, H., Malmberg, A. and Maskell, P. (2004): Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation. In: Progress in Human Geography 28(1), 31-56.

Baum, J. A. C., Shipilov, A. V. and Rowley, T. J. (2003): Where Do Small Worlds Come From? In: Industrial and Corporate Change 12(4), 697-725.

Boschma, R. (2005): Proximity and Innovation: A Critical Assessment. In: Regional Studies 39(1), 61-74.

Burt, R. S. (1992): Structural Holes. Cambridge MA: Harvard University Press.

Burt, R. S. (2000): Decay Functions. In: Social Networks 22(1), 1-28.

Coe, N. M., Dicken, P. and Hess, M. (2008): Global Production Networks: Realizing the Potential. In: Journal of Economic Geography 8(3), 271-295.

Cooke, P. (2001): Regional Innovation Systems, Clusters, and the Knowledge Economy. In: Industrial and Corporate Change 10(4), 945-974.

Cowan, R. and Foray, D. (1997): The Economics of Codification and the Diffusion of Knowledge. In: Industrial and Corporate Change 6(3), 595-622.

Cowan, R. and Jonard, N. (2004): Network Structure and the Diffusion of Knowledge. In: Journal of Economic Dynamics & Control 28(8), 1557-1575.

Cowan, R., Jonard, N. and Zimmermann, J. B. (2006): Evolving Networks of Inventors. In: Journal of Evolutionary Economics 16(1-2), 155-174.

Denzau, A. T. and North, D. C. (1994): Shared Mental Models - Ideologies and Institutions. In: Kyklos 47(1), 3-31.

Dicken, P. and Malmberg, A. (2001): Firms in Territories: A Relational Perspective. In: Economic Geography 77(4), 345-363.

DiMaggio, P. (1997): Culture and Cognition. In: Annual Review of Sociology 23, 263-287.

Dosi, G. (1988): Sources, Procedures and Microeconomic Effects of Innovation. In: Journal of Economic Literature 26(September), 1120-1171.

Ettlinger, N. (2003): Cultural Economic Geography and a Relational and Microspace Approach to Trusts, Rationalities, Networks, and Change in Collaborative Workplaces. In: Journal of Economic Geography 3(2), 145-171.

Fleming, L. (2002): Finding the Organizational Sources of Technological Breakthroughs: The Story of Hewlett-Packard's Thermal Ink-Jet. In: Industrial and Corporate Change 11(5), 1059-1084.

Gallaud, D. and Torre, A. (2005): Geographical Proximity and the Diffusion of Knowledge. In: Rethinking Regional Innovation and Change: Path Dependency or Regional Breakthrough, ed. P. Shapira, 127-146.

Gertler, M. S. (2003): Tacit Knowledge and the Economic Geography of Context, or the Undefinable Tacitness of Being (There). In: Journal of Economic Geography 3(1), 75-99.

Gilly, J.-P. and Wallet, F. (2001): Forms of Proximity, Local Governance and the Dynamics of Local Economic Spaces: The Case of Industrial Conversion Processes. In: International Journal of Urban and Regional Research 25(3), 553-570.

Giuliani, E. (2007): The Selective Nature of Knowledge Networks in Clusters: Evidence from the Wine Industry. In: Journal of Economic Geography 7(2), 139-168.

Glaeser, E. L. (1999): Learning in Cities. In: Journal of Urban Economics 46254-277.

Glückler, J. (2007): Economic Geography and the Evolution of Networks. In: Journal of Economic Geography 7(5), 619-634.

Grabher, G. (1993): The Weakness of Strong Ties. The Lock-in of Regional Development in the Ruhr Area. In: The Embedded Firm, ed. G. Grabher. London: Routledge, 255-277.

Grabher, G. (2002): The Project Ecology of Advertising: Tasks, Talents and Teams. In: Regional Studies 36(3), 245-262.

Grabher, G. and Stark, D. (1997): Organizing Diversity: Evolutionary Theory, Network Analysis and Postsocialism. In: Regional Studies 31(5), 533-544.

Granovetter, M. S. (1985): Economic-Action and Social-Structure - the Problem of Embeddedness. In: American Journal of Sociology 91(3), 481-510.

Gulati, R. and Gargiulo, M. (1999): Where Do Interorganizational Networks Come From? In: American Journal of Sociology 104(5), 1439-1493.

Jaffe, A., Trajtenberg, M. and Henderson, R. (1993): Geographic Localisation of Knowledge Spill-Overs as Evidenced by Patent Citations. In: Quarterly Journal of Economics 108577-598.

Johnson-Laird, P. N. (1983): Mental Models: Towards a Cognitive Science of Language, Inference and Consciousness. Cambridge: Cambridge University Press.

Kirat, T. and Lung, Y. (1999): Innovation and Proximity - Territories as Loci of Collective Learning Processes. In: European Urban and Regional Studies 6(1), 27-38.

Klepper, S. (2007): The Evolution of Geographic Structures in New Industries. In: Applied Evolutionary Economics and Economic Geography, ed. K. Frenken. Cheltenham: Edward Elgar.

Knoben, J. and Oerlemans, L. A. G. (2006): Proximity and Inter-Organizational Collaboration: A Literature Review. In: International Journal of Management Reviews 8(2), 71-89.

Kogut, B. and Zander, U. (1992): Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. In: Organization Science 3(3), 383-397.

Kossinets, G. and Watts, D. J. (2006): Empirical Analysis of an Evolving Social Network. In: Science 311(5757), 88-90.

Lane, P. J. and Lubatkin, M. (1998): Relative Absorptive Capacity and Interorganizational Learning. In: Strategic Management Journal 19(5), 461-477.

Lissoni, F. and Pagani, M. (2003): How Many Networks in a Local Cluster? Textile Machine Production and Innovation in Brescia. In: Cooperation, Networks and Institutions in

Regional Innovation Systems, ed. T. Brenner. Cheltenham/Northampton: Edward Elgar, 220-246.

Malmberg, A. and Maskell, P. (2006): Localized Learning Revisited. In: Growth and Change 37(1), 1-18.

Martin, R. and Sunley, P. (2006): Path Dependence and Regional Economic Evolution. In: Journal of Economic Geography 6(4), 395-437.

Maskell, P., Bathelt, H. and Malmberg, A. (2006): Building Global Knowledge Pipelines: The Role of Temporary Clusters. In: European Planning Studies 14(8), 997-1013.

Maskell, P. and Malmberg, A. (1999): Localised Learning and Industrial Competitiveness. In: Cambridge Journal of Economics 23(2), 167-185.

McPherson, M., Smith-Lovin, L. and Cook, J. M. (2001): Birds of a Feather: Homophily in Social Networks. In: Annual Review of Sociology 27, 415-444.

Menzel, M.-P. and Fornahl, D. (2007): Cluster Life Cycles - Dimensions and Rationales of Cluster Development. Jena Economic Research Papers. 2007-076, Jena,

Morgan, K. (1997): The Learning Region: Institutions, Innovation and Regional Renewal. In: Regional Studies 31491-503.

Moulaert, F. and Sekia, F. (2003): Territorial Innovation Models: A Critical Survey. In: Regional Studies 37(3), 289-302.

Mowery, D. C., Oxley, J. E. and Silverman, B. S. (1998): Technological Overlap and Interfirm Cooperation: Implications for the Resource-Based View of the Firm. In: Research Policy 27(5), 507-523.

Nonaka, I. and Takeuchi, H. (1995): The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation. New York: University Press.

Nooteboom, B. (1999a): Innovation, Learning and Industrial Organisation. In: Cambridge Journal of Economics 23(2), 127-150.

Nooteboom, B. (1999b): Inter-Firm Alliances. Analysis and Design. London/New York: Routledge.

Nooteboom, B., Van Haverbeke, W., Duysters, G., Gilsing, V. and Van Den Oord, A. (2007): Optimal Cognitive Distance and Absorptive Capacity. In: Research Policy 36(7), 1016-1034.

Obstfeld, D. (2005): Social Networks, the Tertius Lungens and Orientation Involvement in Innovation. In: Administrative Science Quarterly 50(1), 100-130.

Owen-Smith, J. and Powell, W. W. (2004): Knowledge Networks as Channels and Conduits: The Effects of Spillovers in the Boston Biotechnology Community. In: Organization Science 15(1), 5-21.

Owen-Smith, J. and Powell, W. W. (2006): Accounting for Emergence and Novelty in Boston and Bay Area Biotechnology. In: Cluster Genesis. Technology-Based Industrial Development, ed. M. P. Feldman. New York: Oxford University Press, 61-83.

Phene, A., Fladmoe-Lindquist, K. and Marsh, L. (2006): Breakthrough Innovations in the Us Biotechnology Industry: The Effects of Technological Space and Geographic Origin. In: Strategic Management Journal 27(4), 369-388.

Piore, M. J. and Sabel, C. F. (1984): The Second Industrial Divide: Possibilities for Prosperity. New York: Basic Books.

Powell, W. W., White, D. R., Koput, K. W. and Owen-Smith, J. (2005): Network Dynamics and Field Evolution: The Growth of Interorganizational Collaboration in the Life Sciences. In: American Journal of Sociology 110(4), 1132-1205.

Rallet, A. and Torre, A. (1999): Is Geographical Proximity Necessary in the Innovation Networks in the Era of Global Economy? In: GeoJournal 49(4), 373-380.

Saxenian, A. (1994): Regional Advantage: Culture and Competition in Silicon Valley and Route 128. Cambridge: Harvard University Press.

Saxenian, A. and Hsu, J.-Y. (2001): The Silicon Valley–Hsinchu Connection: Technical Communities and Industrial Upgrading. In: Industrial and Corporate Change 10(4), 893-920.

Sorenson, O., Rivkin, J. W. and Fleming, L. (2006): Complexity, Networks and Knowledge Flow. In: Research Policy 35(7), 994-1017.

Storper, M. and Venables, A. J. (2004): Buzz: Face-to-Face Contact and the Urban Economy. In: Journal of Economic Geography 4(4), 351-370.

Torre, A. (2008): On the Role Played by Temporary Geographical Proximity in Knowledge Transmission. In: Regional Studies 42(6), 869-889.

Torre, A. and Gilly, J. P. (2000): On the Analytical Dimension of Proximity Dynamics. In: Regional Studies 34(2), 169-180.

Torre, A. and Rallet, A. (2005): Proximity and Location. In: Regional Studies 39(1), 47-59.

Uzzi, B. (1997): Social Structure and Competition in Interfirm Networks: The Paradox of Embeddedness. In: Administrative Science Quarterly 42(1), 35-67.

Watts, D. J. (1999): Networks, Dynamics, and the Small-World Phenomenon. In: American Journal of Sociology 105(2), 493-527.

Watts, D. J. (2004): The "New" Science of Networks. In: Annual Review of Sociology 30243-270.

Zeller, C. (2004): North Atlantic Innovative Relations of Swiss Pharmaceuticals and the Proximities with Regional Biotech Arenas. In: Economic Geography 80(1), 83-111.