

Proximity and Innovation: A Critical Assessment

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BOSCHMA R. A. (2005) Proximity and innovation: a critical assessment, *Regional Studies* **39**, 61–74. A key issue in economic geography is to determine the impact of geographical proximity on interactive learning and innovation. We argue that the importance of geographical proximity cannot be assessed in isolation, but should always be examined in relation to other dimensions of proximity that may provide alternative solutions to the problem of coordination. We claim that geographical proximity per se is neither a necessary nor a sufficient condition for learning to take place. Nevertheless, it facilitates interactive learning, most likely by strengthening the other dimensions of proximity. However, proximity may also have negative impacts on innovation due to the problem of lock-in. Accordingly, not only too little, but also too much proximity may be detrimental to interactive learning and innovation. This may be the case for all five dimensions of proximity discussed in the paper, i.e. cognitive, organizational, social, institutional and geographical proximity. Finally, the paper presents a number of mechanisms that offer, by their own, or in combination, solutions to the problems of coordination and lock-in. That is, they enhance effective coordination and control (solving the problem of too little proximity), while they prevent actors to become locked-in through ensuring openness and flexibility (solving the problem of too much proximity).

Proximity Innovation Geography Networks Learning

BOSCHMA R. A. (2005) La proximité et l'innovation: une évaluation, *Regional Studies* **39**, 61–74. Dans la géographie économique, la détermination de l'impact de la proximité géographique sur l'apprentissage interactif et l'innovation est capitale. Cet article affirme que l'on ne peut évaluer l'importance de la proximité géographique isolément. Plutôt, on devrait l'examiner toujours par rapport à d'autres dimensions de la proximité qui pourraient fournir des réponses alternatives à la question de la coordination. On affirme que la proximité géographique en soi ne constitue une condition ni préalable, ni suffisante, pour que l'apprentissage ait lieu. Néanmoins, elle facilite l'apprentissage interactif en renforçant, très vraisemblablement, les autres dimensions de la proximité. Cependant, il se peut que la proximité ait des retombées négatives sur l'innovation, à cause du problème de l'enfermement. Par la suite, non seulement trop peu de proximité, mais aussi trop de proximité pourraient s'avérer nuisibles à l'apprentissage interactif et à l'innovation. Cela vaudrait pour toutes les cinq dimensions de la proximité présentées dans cet article, à savoir la proximité cognitive, organisationnelle, sociale, institutionnelle et géographique. Pour finir, on présente quelques mécanismes qui fournissent, indépendamment ou conjointement, des réponses aux problèmes de la coordination et de l'enfermement. C'est-à-dire, ils font valoir la coordination et le contrôle effectifs (ce qui répond à la possibilité qu'il y ait trop peu de proximité), tout en empêchant l'enfermement des agents en assurant l'ouverture et la flexibilité (ce qui répond à la possibilité qu'il y ait trop de proximité).

Proximité Innovation Géographie Réseaux Apprentissage

BOSCHMA R. A. (2005) Nähe und Innovation: eine kritische Beurteilung, *Regional Studies* **39**, 61–74. Vom Standpunkt der Wirtschaftsgeographie gesehen, spielt die Bestimmung der Auswirkung geographischer Nähe auf interaktives Lernen und Innovation eine Schlüsselrolle. Der Autor vertritt die Auffassung, daß die Bedeutung der geographischen Nähe nicht isoliert werden kann, sondern immer in Bezug auf andere Dimensionen der Nähe untersucht werden sollte, die alternative Lösungen für das Problem der Koordination liefern könnten. Der Autor behauptet, daß geographische Nähe an sich weder eine notwendige noch eine ausreichende Bedingung dafür ist, daß Erwerb von Kenntnissen stattfindet. Nichtsdestoweniger erleichtert es interaktives Lernen, höchstwahrscheinlich dank Festigung der anderen Dimensionen der Nähe. Das Problem des Sichgebunden-fühlens kann sich jedoch auch negativ auf Innovation auswirken. Dementsprechend kann sich nicht nur zu wenig Nähe, sondern auch zu viel Nähe nachteilig auf interaktives Lernen und Innovation auswirken. Dies könnte auf alle fünf in diesem Aufsatz besprochenen Dimensionen der Nähe zutreffen, d.h. auf kognitive, organisatorische, gesellschaftliche, institutionelle und geographische Nähe. Abschließend werden verschiedene Mechanismen vorgestellt, die selbst oder in Verbindung mit anderen, Lösungen für die Probleme der Koordination und Bindungen anbieten. Das heißt, sie bestärken effektive Koordination und Steuerung (und lösen damit das Problem zu geringer Nähe), und verhindern zugleich, daß Spieler in Bindungen geraten, indem sie Offenheit und Flexibilität garantieren (das Problem übermäßiger Nähe lösen).

Nähe Innovation Geographie Netzwerke Lernen

BOSCHMA R. A. (2005) Proximidad e innovación: un examen crítico, *Regional Studies* 39, 61–74. Uno de los asuntos clave dentro de lo que es la geografía económica es determinar el impacto que la proximidad geográfica tiene en el aprendizaje interactivo y en la innovación. Argumentamos que la importancia de la proximidad geográfica es un hecho que no se puede examinar de forma aislada, si no que siempre debería ser analizado en relación a otras dimensiones de proximidad que pueden ofrecer soluciones alternativas al problema de co-operación. Sostenemos que la proximidad geográfica *per se* no es una condición ni necesaria ni suficiente para que el aprendizaje tenga lugar. No obstante, facilita el aprendizaje interactivo, con mayor probabilidad mediante el reforzamiento de las otras dimensiones de proximidad. Sin embargo, la proximidad también puede tener impactos negativos en la innovación, debido al problema de *lock-in*. Así pues, no sólo una escasa proximidad, sino también una proximidad excesiva puede perjudicar el aprendizaje interactivo y la innovación. Esto puede ser el caso en lo que respecta a las cinco dimensiones de proximidad que se discuten en este artículo, esto es, proximidad cognitiva, organizacional, social, institucional y geográfica. Por último, exponemos una serie de mecanismos que ofrecen, o bien por sí solos o en combinación, soluciones a los problemas de coordinación y de *lock-in*. Esto es, mejoran la coordinación efectiva y el control (solucionando así el problema de escasa proximidad), mientras que previenen que los actores se vuelvan *locked-in* mediante la garantía de claridad y flexibilidad (solucionando así el problema de proximidad excesiva).

Proximidad Innovación Geografía Redes Aprendizaje

JEL classifications: O18, R00, R11, Z13

INTRODUCTION

There is a strong awareness that knowledge creation and learning (or the capability to learn) is critical to the competitive advantage of firms and regions. Much has been written on the impact of proximity on learning, knowledge creation and innovation (e.g. AMIN and WILKINSON, 1999). Economic geographers have contributed to the literature by putting emphasis on the many (economic) advantages of being co-located. In doing so, they have pointed out that other dimensions of proximity (such as cognitive and organizational dimensions) besides geographical proximity are key in understanding interactive learning and innovation. BUNNELL and COE (2001) have referred to this as the 'de-territorialisation of closeness' (GERTLER, 2003). What unites the different dimensions of proximity is that they reduce uncertainty and solve the problem of coordination, and, thus, facilitate interactive learning and innovation. This raises at least two key questions that will be addressed in the paper.

The first objective is to discuss whether geographical proximity may still play a role in interactive learning and innovation, given the fact that other dimensions of proximity can also fulfil this role. It is claimed that geographical proximity *per se* is neither a necessary nor a sufficient condition for learning to take place: at most, it facilitates interactive learning, most likely by strengthening the other dimensions of proximity. This raises questions such as the following. In what ways are the various proximities related to each other? Are they substitutes or complements? Which dimensions of proximity are most likely to co-exist, and which ones matter more? There is yet little understanding of possible combinations of the various forms of proximity. In finding out, it is essential for analytical reasons to clarify and define the different dimensions of proximity in such a way that overlap is avoided as much as possible, and research can assess the effects of each

dimension (including the geographical dimension) on interactive learning and innovation. In other words, there is a strong need to isolate analytically the effect of geographical proximity from the other forms of proximity to determine whether geographical proximity really matters in processes of innovation (HOWELLS, 2002).

The second objective is to account for negative effects of proximity. In the literature, more often than not it is argued that the more proximity there is between actors, the more they interact, the more they learn and innovate. In this paper, a rather critical stand is taken towards this emphasis on the economics virtues of proximity. Proximity in its different dimensions may also have negative impacts on innovation, due to the problem of lock-in, meaning a lack of openness and flexibility. This issue of positive versus negative aspects of proximity is a challenging. When does proximity lead to good performance? For five dimensions of proximity, the paper briefly discusses how too much proximity may be harmful for learning and innovation. Again, this serves analytical purposes. Doing research, it would enable us to isolate analytically the effect of geographical lock-in from other dimensions of lock-in. In addition, it is claimed that geographical openness *per se* is neither necessary nor sufficient for breaking a situation of lock-in. It is not a necessary condition because the other dimensions may, in principle, provide alternative solutions to the problem of lock-in in the region itself. And it is not sufficient either, because the transfer of knowledge across large distances requires other forms of proximity to be effective.

Five dimensions of proximity (i.e. cognitive, organizational, social, institutional and geographical proximity) are presented below and it is explained for each dimension why too much and too little proximity may be harmful for effective interactive learning and innovation. In addition, the paper briefly presents a

number of mechanisms (such as loosely coupled systems) that may overcome problems of lock-in and coordination, because they provide openness (triggering new ideas) and a combination of control and flexibility (enabling the implementation of new ideas) simultaneously. The final section has some conclusive remarks.

DIFFERENT FORMS OF PROXIMITY

In the 1990s, the French School of Proximity Dynamics made a key contribution to the literature on innovation when it proposed that proximity covers a number of dimensions (e.g. TORRE and GILLY, 2000). In the school's view, proximity meant a lot more than just geography. Often, a distinction is made between organizational and geographical proximity. While geographical proximity is defined as spatial distance between actors, both in an absolute and relative meaning, organizational proximity is associated with the closeness of actors in organizational terms. On the one hand, organizational proximity covers the extent to which actors share the same space of relations (i.e. the way interaction and coordination between actors is organized). On the other hand, it incorporates the extent to which actors share the same reference and knowledge space, taking on board the cognitive dimension of organizational forms. Sometimes, they add a third form of proximity, institutional proximity, to account for the fact that interactions between players are influenced, shaped and constrained by the institutional environment (KIRAT and LUNG, 1999).

Five dimensions of proximity are presented below, i.e. cognitive, organizational, social, institutional and geographical proximity, respectively. In doing so, the paper builds on the work of this French group of researchers, yet, the approach differs in some respects. For example, for analytical reasons, five, instead of three, dimensions of proximity are distinguished, isolating, for instance, the cognitive dimension. In addition, some dimensions of proximity (e.g. organizational proximity) are defined differently for reasons that will be explained below.

Cognitive proximity

Knowledge is not a public good produced outside the economic system, as many neoclassical economists would like us to believe. Economic actors are subject to bounded rationality, which means that cognitive constraints of actors make it impossible for them to act optimally (SIMON, 1955). To reduce uncertainty, firms conduct routinized behaviour. This is especially true when they search for new knowledge: outcomes of search processes are uncertain and often unexpected (NELSON and WINTER, 1982). As a rule, firms search in close proximity to their existing knowledge base, which provides opportunities and sets constraints for

further improvement. This implies that knowledge creation and innovations are often cumulative and localized outcomes of search processes within firms, with a high degree of tacit knowledge (BOSCHMA, 2004). As a result, the cognitive base of actors and organizations, and, thus, their absorptive capacity and potential for learning, is likely to differ substantially. Due to the cumulative, localized and tacit nature of knowledge, cognitive differences often tend to persist (ANTONELLI, 1995), as long as the firm-specific competences are difficult to imitate by competitors (PRAHALAD and HAMEL, 1990).

This implies knowledge is dispersed among different organizations (ANTONELLI, 2000). Since knowledge creation and learning often depend on combining diverse, complementary capabilities of heterogeneous agents within and between organizations (NOOTEBOOM, 2000), there is strong need to bring these together. This is, however, not easy to do. The tacit and idiosyncratic nature of much knowledge implies that access to relevant knowledge is not a sufficient condition. The effective transfer of knowledge requires an absorptive capacity to identify, interpret and exploit the new knowledge (COHEN and LEVINTHAL, 1990). This has to do with the technical and market competencies organizations possess and have acquired while dealing with particular technologies and markets. If these are not sufficient, search and imitation costs will increase too much. In this vein, PEREZ and SOETE (1988) stress a negative relationship between the current knowledge base of a firm and the costs firms must make to get the required knowledge of a new technology. They claim that for each new technology, there exists a minimum level of knowledge, under which firms are incapable of bridging their knowledge gap. In other words, the cognitive distance should not be too great. For this reason, the capacity of actors or firms to absorb new knowledge requires cognitive proximity. That is, their own cognitive base should be close enough to the new knowledge in order to communicate, understand and process it successfully (BOSCHMA and LAMBOUY, 1999). With the notion of cognitive proximity, it is meant that people sharing the same knowledge base and expertise may learn from each other. This is not only a matter of speed and efficiency of the acquisition of information, but also, and even more so, of extending the scope of cognition (NOOTEBOOM, 2000).

Thus, cognitive proximity facilitates effective communication. However, too much cognitive proximity may be detrimental to learning and innovation. There are at least three reasons for why some cognitive distance should be maintained to enhance interactive learning. First, that knowledge building often requires dissimilar, complementary bodies of knowledge. That is, novelty of sources triggers new ideas and creativity (COHENDET and LLERENA, 1997). In this respect, cognitive distance tends to increase the potential for

learning, though, at the same time, as mentioned above, it limits the absorptive capacity of firms.

Second, that cognitive proximity may easily lead to cognitive lock-in, in the sense that routines within an organization (or in an inter-organizational framework) obscure the view on new technologies or new market possibilities. As a result, the cumulative nature of knowledge creation may turn against the well-being of the organization. LEVITT and MARCH (1996) have described this as the 'competency trap'. It may be difficult to unlearn habits or routines that have been successful in the past, but which have become redundant over time (LAMBOUY and BOSCHMA, 2001). In order to maintain some cognitive distance, organizations should secure access to heterogeneous sources of information and some openness to the outside world (SAVIOTTI, 1996). These potential solutions are related to the notions of organizational and geographical proximity respectively, which will be dealt with below.

Third, that cognitive proximity increases the risk of involuntary spillovers. As noticed above, cognitive differences between agents are likely to persist, due to many barriers of diffusion. However, knowledge cannot always be totally appropriated and, therefore, knowledge may spill over across organizations. This is especially true when the cognitive distance between agents is rather small. In such circumstances, competitors are very reluctant to share knowledge. CANTWELL and SANTANGELO (2002) state, for example, that competing firms do not co-locate their research activities when they operate in the same or strongly overlapping technological fields. As they compete in the same field, few complementary capabilities can be shared between them, while they run considerable risks linked to unintended spillovers.

Consequently, a not too great cognitive distance between firms (in terms of competencies and skills) enables effective communication and, thus, learning, while a not too small cognitive distance avoids lock-in, especially when access to dissimilar bodies of knowledge is required in product innovation. NOOTEBOOM (2000, p. 153) states that

a tradeoff needs to be made between cognitive distance, for the sake of novelty, and cognitive proximity, for the sake of efficient absorption. Information is useless if it is not new, but it is also useless if it is so new that it cannot be understood.

In sum, effective learning by interaction may be accomplished by maintaining some cognitive distance (limiting cognitive overlap) while securing cognitive proximity (i.e. for the sake of communication, there must be sufficient cognitive overlap).

A geographical cluster, as defined by MASKELL (2001), may fulfil these requirements. Maskell claims that knowledge creation in clusters takes place through variation and a deepened division of labour. At the

horizontal dimension, variation between local competitors with similar capabilities stimulates new experiments, which are readily taken up (against low costs) in a transparent cluster. This implies that the process of learning is conducive to a fruitful combination of cognitive distance (variation) and proximity (similar activities and capabilities). At the vertical dimension, inter-firm learning (between buyers-suppliers) is stimulated because low coordination costs in clusters encourage increasing specialization. Because of growing specialization, the knowledge bases of firms diverge to such an extent that interactive learning is stimulated. However, there will come a moment that the cognitive distance will become too great to bridge for firms. Since too much variation makes communication and interactive learning impossible, at least some cognitive proximity is required.

In sum, actors need cognitive proximity in terms of a shared knowledge base in order to communicate, understand, absorb and process new information successfully. However, too much cognitive proximity may be detrimental to interactive learning. It not only decreases the potential for learning, but also it increases the risk of lock-in and the problem of undesirable spillovers to competitors. Following NOOTEBOOM (2000), it can be stated that too little cognitive distance means a lack of sources of novelty, while too much cognitive distance implies problems of communication. Both kinds of problems may be dissolved by a geographical cluster endowed with a common knowledge base made up of diverse, but complementary, knowledge resources. In other words, an absorptive capacity that is open to new ideas is essential for interactive learning.

An interesting implication is that neither organizational proximity nor social proximity (i.e. embedded, trust-based interaction between actors) is required for inter-organizational learning. In principle, effective knowledge transfer does not presuppose close trust-based or arm's-length interactions between firms: collocation (or geographical proximity) may be just enough, because it enables local agents to 'monitor each other constantly, closely, and almost without effort or cost' (MALMBERG and MASKELL, 2002, p. 439). This is not to deny that organizational proximity may be helpful in stimulating interactive learning and innovation. This is the topic of the next section.

Organizational proximity

Organizational practices are very relevant to the issue of interactive learning. Although a common knowledge and competence base is a prerequisite for bringing firms together and enabling interactive learning, knowledge creation also depends on a capacity to coordinate the exchange of complementary pieces of knowledge owned by a variety of actors within and between organizations. Organizational arrangements (such as

networks) are not only mechanisms that coordinate transactions, but also they are vehicles that enable the transfer and exchange of information and knowledge in a world full of uncertainty (COOKE and MORGAN, 1998). Transaction cost economics has put attention to various forms of governance (market, firm, network) that differ, among other things, with respect to the degree of autonomy of exchange partners, and the extent to which control over knowledge flows can be exerted (e.g. relevant for the issue of appropriability).

As noted in the Introduction, organizational proximity is often treated in the literature as a broad category, including a cognitive dimension. GILLY and TORRE (2000) refer to 'the same space of relations', based on effective 'interactions of various nature' on the one hand. On the other hand, it includes similarity in which actors are connected by sharing the same reference space and knowledge. Often a distinction is made between a (inter-organizational) relation of similarity and a (intra-organizational) relation of membership. For KIRAT and LUNG (1999, p. 30), organizational proximity refers to the set of interdependencies within as well as between organizations 'connected by a relationship of either economic or financial dependence/interdependence (between member companies of an industrial or financial group, or within a network)'.

Purely for analytical purposes, the cognitive is separated from the organizational dimension of proximity. Accordingly, organizational proximity is defined as the extent to which relations are shared in an organizational arrangement, either within or between organizations. To be precise, this involves the rate of autonomy and the degree of control that can be exerted in organizational arrangements. In this respect, some kind of continuum is assumed that goes from one extreme (i.e. low organizational proximity, meaning no ties between independent actors, e.g. 'on-the-spot' market), from loosely coupled networks (weak ties between autonomous entities, e.g. a joint venture or a flexible firm or network) to the other extreme (i.e. high organizational proximity, embodied in strong ties, e.g. a hierarchically organized firm or network).

Organizational proximity is believed to be beneficial for learning and innovation. New knowledge creation goes along with uncertainty and opportunism. To reduce these, strong control mechanisms are required in order to ensure ownership rights (intellectual property rights) and sufficient rewards for own investments in new technology. Markets often cannot offer this because it would involve too high transaction costs. In addition,

with detailed formal contracting, it is more difficult (slow and costly) to modify terms when conditions change. It yields a straightjacket for action that can be very constraining especially when the goal of the relation is innovation: the development or implementation of novelty. Then virtually by definition one cannot foresee what duties are to be regulated and what returns are to be shared.

(NOOTEBOOM, 1999, p. 25)

In principle, a hierarchical organization or tight relationships between organizational units can provide a solution to these problems. Moreover, the transfer of complex knowledge requires strong ties because of the need of feedback. HANSEN (1999) showed that strong rather than weak ties between units in a multiunit organization stimulate the transfer of complex knowledge in product development projects.

However, too much organizational proximity can also be unfavourable to learning and innovation. First, there is the risk of being locked-in in specific exchange relations. Asymmetric relations due to different sizes and power of partners in a network may lead to hold-up problems: it brings about a high dependency on relation-specific investments in communication and understanding. In addition, intra- and inter-organizational networks may evolve in closed and inward-looking systems. Strong ties may limit access to various sources of novel information: search for novelty often requires going out of the established channels. Second, a hierarchical form of governance lacks feedback mechanisms common to more symmetrical relations. Consequently, new ideas are not rewarded in a bureaucratic system and interactive learning hardly takes place. Third, the implementation of innovation requires organizational flexibility (BLANC and SIERRA, 1999). Organizational proximity, as reflected in a hierarchical governance structure, is unlikely to provide such flexibility. The tighter and more dependent are the relations in an organizational arrangement, the less initiatives are undertaken and rewarded, with negative effects on flexibility and innovation (FRENKEN and VALENTE, 2002). This problem to break with lock-in may also have to do with vested interests in organizations opposing change that undermine their positions. Accordingly, too much hierarchy may result in a lack of intra- and inter-organizational learning (SAXENIAN, 1994).

In sum, while too much organizational proximity is accompanied by a lack of flexibility, too little organizational proximity goes along with a lack of control increasing the danger of opportunism. It is argued here that loosely, as opposed to tightly, coupled systems can satisfy both requirements. Loose coupling safeguards organizational autonomy within and between organizations and, thus, flexibility. For instance, it is less likely that 'red tape', bureaucracy and formal obligations are involved. In addition, it guarantees network connections within and between organizations and, thus, access to complementary sources of information. Within an organization, this requires a flat (network) organization of the firm, with relatively decentralized units, to enhance its capacity to explore new knowledge. It also requires centralized coordination in order to bring together the different units (stimulating interactive learning), and to integrate the new knowledge into its organizational routines (enabling the exploitation of new knowledge) (LAWSON and LORENZ, 1999).

Thus, on the one hand, a loosely coupled system secures a certain degree of organizational distance. It provides open access to various sources of information, meaning a broader learning interface. In addition, it offers some flexibility: independent autonomous partners may shift their goals and strategies more easily. According to GRABHER and STARK (1997, p. 538), 'in loosely coupled networks where the identity and separateness of elements is preserved, the network can potentially retain a great number of mutations and novel solutions than would be the case with a tightly coupled system'. On the other hand, a loosely coupled system includes some advantages of organizational proximity. It constitutes a more or less stable framework for interaction and communication, with coordination by a central authority. Power, or a strong coordination of a network (e.g. through large focal firms), enables the implementation of real change. This is especially true for networks that are large and consist of diverging interests and complex relationships between participants (MCNAUGHTON, 2000).

In sum, organizational proximity is needed to control uncertainty and opportunism in knowledge creation within and between organizations. However, too much organizational proximity may be detrimental to interactive learning due to lock-in and a lack of flexibility. Following Nooteboom and others, loosely coupled systems (both within and between organizations) may reflect a level of organizational proximity in which both control and flexibility are secured. Such a governance structure may also result in a satisfactory cognitive level, implying that the organizational and cognitive dimensions of proximity may be complements. Grouping together people with a certain degree of cognitive proximity (though securing some cognitive distance) may be achieved either through organizational arrangements with more or less autonomous divisions within an organization, or through trust-based networks between organizations. NOOTEBOOM (2000, p. 158) suggests that cognitive proximity and distance can be combined 'by having a group of people with cognitive proximity, typically within an organization, as well as communication with groups at a cognitive distance, typically between different organizational units'. There may, however, be other ways than organizational proximity to achieve this. For example, it was demonstrated above that geographical proximity (embodied in geographical clusters) may also satisfy the requirements for such an appropriate level of cognition.

Social proximity

The notion of social proximity originates from the embeddedness literature (POLANYI, 1944; GRANOVETTER, 1985). In essence, the literature indicates that economic relations are to some extent always embedded in a social context. In turn, social ties or relations affect economic outcomes. In contrast to

neo-classical economics, the embeddedness literature suggests that the more socially embedded are the relationships of a firm, the more interactive learning and the better its (innovative) performance. It is explained below that too much social proximity (socially embedded relations between actors) may weaken the learning capability of organizations, but too much social distance may also be harmful for interactive learning and innovation.

Social proximity is defined here in terms of socially embedded relations between agents at the micro-level. Relations between actors are socially embedded when they involve trust based on friendship, kinship and experience. Accordingly, the definition of social proximity does not include situations in which people share sets of values, such as ethnic and religious values. This aspect of cultural proximity at a more macro-level will be associated with the notion of institutional proximity below.

The capacity of organizations to learn and innovate may require social proximity. One of the main reasons is that trust-based social relationships facilitate the exchange of tacit knowledge which is, by nature, much more difficult to communicate and to trade through markets (MASKELL and MALMBERG, 1999). LUNDVALL (1993) has claimed that social proximity encourages a social and open attitude of 'communicative rationality' rather than a pure, calculative and narrow market orientation towards minimizing costs. This is often regarded as a prerequisite for interactive learning. Moreover, social proximity reduces, but does not eliminate, the risk of opportunistic behaviour. Effective interactive learning requires committed, durable relationships, as opposed to pure market relationships that dissolve as soon as problems between the exchange partners arise.

However, too much social proximity may have adverse impacts on learning and innovation. First, embedded relationships, in which much loyalty is involved, may lead to an underestimation of opportunism when relations are based on emotional bonds of friendship and kinship (UZZI, 1997). Accordingly, too much social behaviour may have negative consequences in a world with calculating actors, in markets where technologies and policies continually change in conditions of uncertainty, and where opportunism is a common attitude. Second, long-term relationships, or too much commitment, may lock members of social networks into established ways of doing things at the expense of their own innovative and learning capacity. For instance, closed network systems may incur opportunity costs because entrepreneurs and other outsiders with new ideas are denied entry.

Thus, on the one hand, too little social distance in economic relationships (both at the intra- and inter-organizational levels) may weaken the innovative capacity of firms due to an overload of trust. On the other hand, too little social proximity may be harmful for

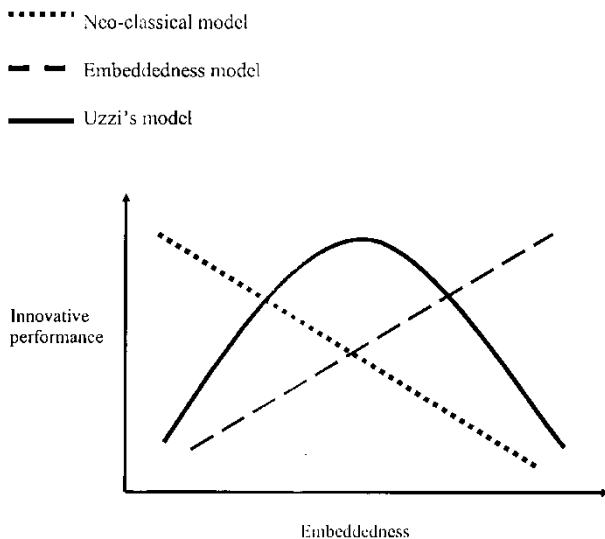


Fig. 1. Relationship between the degree of embeddedness and the innovative performance of a firm
Source: BOSCHMA *et al.* (2002, p. 31).

interactive learning and innovation due to a lack of trust and commitment. Thus, the more embedded economic relationships, the better the economic performance of a firm up to a certain threshold, after which adverse impacts arise because of lock-in. Following UZZI (1997), BOSCHMA *et al.* (2002) proposed an inverted-'U' relationship between embeddedness and innovative performance at the firm level (Fig. 1). In other words, the social dimension of economic relationships has a positive influence on the performance of a firm up to a certain threshold (contrary to neo-classical thinking), after which these positive effects can turn negative when the embedded relationships become too closely tied (contrary to the embeddedness model). In this respect, note that the embeddedness model shown in Fig. 1 reflects only to some extent the ideas of GRANOVETTER (1985). The positive relationship between embeddedness and innovation up to a certain level of embeddedness is more or less in line with Granovetter's ideas. However, Granovetter's concept of the 'weakness of strong ties' is opposite to the embeddedness model, and can be considered almost identical to UZZI's (1997) model.

UZZI (1997) suggested a mixture of both embedded and market relationships at the network level to secure social proximity and distance, respectively. In other words, the adaptive capacity of actors may increase considerably when the network consists of a mixture or balance of arm's length ties (keeping the firms alert, open-minded and flexible) and embedded relationships (lowering transactions costs and facilitating inter-organizational learning). Similarly, flagship firms in the information technology sector have a strategy to combine two types of network relationships (CECIL and GREEN, 2000). In so-called 'first-tier' networks, they form alliances laid down in official contracts,

while in the 'second-tier' networks, they benefit from informal, trust-based relationships with local partners.

In sum, social proximity may stimulate interactive learning due to trust and commitment. However, too much social proximity may also be detrimental to interactive learning due to lock-in and an underestimated risk of opportunism. Following Uzzi, it has been argued here that a network consisting of both market relationships (keeping social distance) and embedded relationships (involving social proximity) may circumvent these problems and increase its innovative performance.

In reality, this is not unrelated to the other dimensions of proximity. For example, social proximity (in terms of committed relationships) may decrease the cognitive distance between partners over time. As stated above, growing cognitive proximity may stimulate interactive learning but also reduces the potential for interactive learning. Organizational proximity (as embodied in tight, hierarchical forms of governance) may go along with a lack of social proximity, because relationships between people are not based on trust. However, both organizational and social proximity are characterized by strong ties between partners, although different mechanisms are involved (hierarchy and trust, respectively). Geographical proximity is most likely to stimulate social proximity, because short geographical distances favour social interaction and trust building. In addition, GORDON and MCCANN (2000) argued that agglomerations can compensate for the negative aspects of social proximity. That is, agglomerations may weaken strong ties in networks because they offer a wide range of potential partners and nodes that provide access to extra-regional networks. In this way, closed networks with too strong ties will dissolve because agents in agglomerations have more opportunities to pursue 'more pluralistic and open-ended network-building strategies'. As a result, they expect that strong social networks are more likely to develop in areas where agglomeration economies are more or less absent. The topic of geographical proximity will be discussed further below.

Institutional proximity

Whereas social proximity has been defined in terms of socially embedded relations between agents at the micro-level (based on friendship, kinship and past experience), institutional proximity will be associated with the institutional framework at the macro-level. We follow NORTH (1990), who made a broad distinction between the institutional environment at the macro-level (such as norms and values of conduct) and institutional arrangements at the micro-level, in which these norms and values are embodied in specific exchange relations. As mentioned above, this latter aspect has been covered by the notions of organizational and social proximity. As such, the social, organizational

and institutional forms of proximity may be strongly interconnected, because the ways intra- and inter-organizational relations are governed are deeply embedded in institutional settings.

EDQUIST and JOHNSON (1997, p. 46) define institutions as 'sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals and groups'. Institutions function as a sort of 'glue' for collective action because they reduce uncertainty and lower transaction costs. Formal institutions (such as laws and rules) and informal institutions (like cultural norms and habits) influence the extent and the way actors or organizations coordinate their actions. As such, institutions are enabling or constraining mechanisms that affect the level of knowledge transfer, interactive learning and (thus) innovation. Following the distinction between formal and informal institutions, the notion of institutional proximity includes both the idea of economic actors sharing the same institutional rules of the game, as well as a set of cultural habits and values (ZUKIN and DIMAGGIO, 1990). A common language, shared habits, a law system securing ownership and intellectual property rights, etc., all provide a basis for economic coordination and interactive learning. A culture of shared trust, for example, is often regarded as a capability that supports learning and innovation: information is transmitted more easily with cultural proximity and a common language (MASKELL and MALMBERG, 1999).

As such, institutional proximity is an enabling factor, providing stable conditions for interactive learning to take place effectively. However, it may also become a constraining factor, hampering collective learning and innovation. This is because an institutional environment consists of an interdependent set of institutions. HALL and SOSKICE (2001) talk about 'institutional complementarities', which means that the effectiveness of one institution increases the returns from complementary institutions. This mutual interdependence of the various parts of an institutional system may cause local inertia. When each element in such a complex system has a structural position, change brings in instability because positions between elements are disturbed (HANNAN and FREEMAN, 1977). As a result, either no change is taking place or only localized change, i.e. minor changes that do not upset the functioning of the whole system. GRABHER (1993) has drawn attention to inward-looking networks consisting of powerful institutional players that react to change in a very routinized and conservative way, especially when their vested interests are threatened, or when they have obligations towards other actors in the network (HERRIGEL, 1993). In sum, on the one hand, an institutional system may evolve into a situation of lock-in, providing no opportunities whatsoever for newcomers. On the other hand, it may lead to institutional inertia, hindering the development of new

innovations that require the build-up of new, or the restructuring of old, institutional structures (FREEMAN and PEREZ, 1988). As a result, institutional rigidity leaves no room for experiments with new institutions that are required for the successful implementation of new ideas and innovations.

In other words, too much institutional proximity is unfavourable for new ideas and innovations due to institutional lock-in (obstructing awareness of new possibilities) and inertia (impeding the required institutional readjustments). On the other hand, too little institutional proximity is detrimental to collective action and innovation due to weak formal institutions and a lack of social cohesion and common values. Having said this, it is not easy to describe how an effective institutional structure may overcome these problems. In one way or another, an effective institutional structure needs to reflect a kind of balance between institutional stability (reducing uncertainty and opportunism), openness (providing opportunities for newcomers) and flexibility (experimenting with new institutions). In order to achieve this, the institutional system should fulfil several requirements that guarantee checks and balances. For instance, it should enable change in the political arena on a regular basis (e.g. through democratic elections), which, in turn, may set in motion required changes in formal (laws) and informal institutions (cultural norms). Moreover, it needs to ensure a power of balance that prevents organizations and big institutional players to take control of the system and use it only for their own reproduction (HERRIGEL, 1993).

Institutional proximity is strongly linked with the other forms of proximity. GERTLER (2003) suggests that organizational and social proximity may not be enough for organizations to engage in effective interactive learning when these organizations are located in different institutional contexts. Moreover, institutional structures may provide a basis on which some forms of organizational arrangements better develop than other forms. When there is a lack of strong institutions that effectively handle with transactions and uncertainty (such as a legal system that enforce contracts), economic actors tend to rely more on informal (trust-based) relationships (KNACK and KEEFER, 1997). As a result, social proximity may compensate for distrust in societies where a supportive institutional environment is largely missing. Furthermore, one expects that institutional proximity (especially its cultural dimension) is associated with geographical proximity. However, this is very likely to depend on the type of institutions involved. Shared informal institutions are often much more geographically localized (e.g., at the level of the community), while the impact of shared formal institutions (such as laws) is more likely to operate at the level of the nation-state, or even beyond. The topic of geographical proximity is now discussed.

Geographical proximity

In the foregoing, it has become clear that it is wrong to associate proximity with its geographical meaning. So, what role can geographical proximity play, taking into consideration the roles that the other forms of proximity might play? Is geographical proximity, for example, essential to enhance interactive learning and innovation, or may other forms of proximity act as substitutes?

For the sake of analytical clarity, geographical proximity is defined in a very restricted manner. It refers to the spatial or physical distance between economic actors, both in its absolute and relative meaning. A large body of literature claims that agents that are spatially concentrated benefit from knowledge externalities. Short distances literally bring people together, favour information contacts and facilitate the exchange of tacit knowledge. The larger the distance between agents, the less the intensity of these positive externalities, and the more difficult it becomes to transfer tacit knowledge. This may even be true for the use and spread of codified knowledge (although often stated otherwise), because its interpretation and assimilation may still require tacit knowledge and, thus, spatial closeness (HOWELLS, 2002). Empirical studies tend to confirm that knowledge externalities are geographically bounded: firms near knowledge sources show a better innovative performance than firms located elsewhere (e.g. JAFFE *et al.*, 1993; AUDRETSCH and FELDMAN, 1996).

For analytical purposes, it is essential to define geographical proximity in such a restricted manner and to isolate it from the other dimensions of proximity. For instance, it allows one to identify a situation of pure knowledge externalities that are geographically bounded, but in which no other forms of proximity are necessarily involved. In this particular case, the transfer of knowledge takes place without explicit interaction or coordination between local agents. MASKELL (2001) stated that co-location of similar activities in transparent clusters may ensure that successful experiments by other local firms (especially rivals) do not remain unnoticed, but are readily taken up almost without costs. It is a typical example of spatial externalities: the higher the number of knowledge sources in the territory, the larger the potential benefit for each local agent. It comes close to what GORDON and MCCANN (2000) have called 'pure agglomeration', which presumes no form of formal and stable relations among local firms. Each firm located in an area in principle can benefit from external economies, as long as the agglomeration provides 'open membership' to each local firm. Therefore, instead of assuming beforehand that other dimensions of proximity next to geographical proximity play a role in knowledge transfer, one claims empirical analyses have to decide whether or not this is the case. There is one possible exception

though. It is quite hard to imagine that imitative learning through monitoring can take place without cognitive proximity (ANTONELLI, 2000). That is, local firms require a capacity (e.g. competences in a particular knowledge field) to absorb and process external knowledge.

Thus, in theory, geographical proximity, combined with some level of cognitive proximity, is sufficient for interactive learning to take place. However, other forms of proximity may also act as a substitute for geographical proximity. Although spatial proximity facilitates interaction and cooperation, it is not a prerequisite for interactive learning to take place (MALECKI and OINAS, 1999). Due to advanced information and communication technologies, networks through which learning takes place are not necessarily spatially delimited. RALLET and TORRE (1999) showed in a study on research projects that tacit knowledge may be transmitted across large distances through other forms of proximity. They demonstrated that the need for geographical proximity is rather weak when there is a clear division of precise tasks that are coordinated by a strong central authority (organizational proximity), and the partners share the same cognitive experience (cognitive proximity). In this respect, it is essential to stress that the exchange of tacit knowledge still required face-to-face contacts. However, this need for physical co-presence could be organized by bringing people together through travel now and then. In other words, it did not need spatial proximity in the meaning of permanent co-location.

Next to simple co-location, it is common to stress the importance of networks as vehicles of knowledge creation and diffusion. Since networks are defined and demarcated in a non-territorial way, it would be wrong, and even misleading, to assume that knowledge spillovers are spatially bounded (BUNNELL and COE, 2001). In a study on patent citations, BRESCHI and LISSONI (2002) found that social connectedness between inventors, and not geographical proximity, played a significant role in knowledge spillovers. That is, social networks, based on personal acquaintances due to common working experiences not only provide the main channels for knowledge diffusion, but also produce most knowledge. It is reminiscent of the fact that tacit knowledge is a common property or club good that is shared between members of 'epistemic communities' or 'communities of practice', wherever they are located (BRESCHI and LISSONI, 2001; GERTLER, 2003).

In other words, social networks are not necessarily localized geographically because there is nothing inherently spatial about networks. This is not to deny that social networks can be location specific, sustained and reproduced by ongoing collective action of local actors. In that case, the resulting knowledge spillovers will be geographically localized as well, and geographical proximity becomes a necessity, i.e. a prerequisite for

being a member of the network. Nevertheless, even in this situation, one has to keep in mind that networks are social constructs that exclude outsiders, whether or not they are local players (HUDSON, 1999). As such, geographical proximity cannot be considered a sufficient condition for the exchange of tacit knowledge. This may be illustrated by the experience of multinational corporations when they try to get access to the knowledge base of a host region through the setting up of a local plant (BLANC and SIERRA, 1999). They regularly fail to do so, because it turns out to be hard to become a member of tight networks of personal relationships through which local knowledge circulates (BRESCHI and LISSONI, 2002). Another illustration is the role of gatekeepers that bring external information into their home region, but this new information diffuses only to those local agents that form part of their network (MORRISON, 2004).

Geographical proximity may also be complementary to the other forms of proximity in the process of interactive learning. HAUSMANN (1996) claims that for inter-organizational learning, social or organizational proximity may be more important than spatial proximity, but that spatial proximity may still facilitate interactive learning. Geographical proximity may play a complementary role in building and strengthening social, organizational, institutional and cognitive proximity. This comes close to what HOWELLS (2002) calls 'a more indirect and subtle impact' of geographical proximity. For instance, spatial proximity facilitates informal relationships (AUDRETSCH and STEPHAN, 1996). That is, firms located near to each other have more face-to-face contacts and can build up trust more easily, which, in turn, leads to more personal and embedded relationships between firms (HARRISON, 1992). Geographical proximity may also stimulate the formation and evolution of institutions such as norms and habits that may affect interactive learning and innovation. In addition, FREEL (2003) claimed that there exists an inverse relationship between geographical and cognitive proximity. Only when the requisite knowledge differs considerably from the internal knowledge base of firms can geographical proximity then play a role in bridging this gap.

Thus, interactive learning may indeed be enhanced by geographical proximity, but not necessarily so. Too much geographical proximity may also be harmful for interactive learning and innovation. When regions become too much inward looking, the learning ability of local actors may be weakened to such an extent that they lose their innovative capacity and cannot respond to new developments. Such a situation of spatial lock-in may especially emerge in highly specialized regions. Geographical closeness alone, however, is unlikely to harm interactive learning and innovation. Only when a lack of openness to the outside world enhances cognitive proximity between local actors will interactive learning be negatively affected. In fact, it has been

observed more than once that routines or competences between firms in a particular industry converge within regions rather than between regions due to local processes of imitation and selection (BOSCHMA, 2004). As a result, agglomeration economies based on knowledge externalities will eventually erode, transforming clusters into 'blind spots', while non-clustered firms potentially remain more adaptable to new developments because they are not trapped into such a situation of regional lock-in (POUDER and ST JOHN, 1996).

Spatial lock-in may be solved or avoided by establishing non-local linkages, providing access to the outside world. Some argue that knowledge creation requires a balance or mixture of local and non-local relations (CAMAGNI, 1991; OINAS, 1999; ASHEIM and ISAKSEN, 2002). Empirical studies tend to show that local as well non-local relationships are important sources for interactive learning (JAFJE *et al.*, 1993; FELDMAN, 1994; KAUFMANN and TÖDTLING, 2000). In addition, local relations are believed to be even more beneficial when they are supported by non-local relations that provide new impulses and ideas and bring new variety into the territory (BATHELT, 2003).

Thus, the problem of lock-in may be solved by geographical openness, meaning more access to the outside world. However, geographical openness is neither necessary nor sufficient to break with a situation of lock-in. It is not necessary because other dimensions of proximity may provide alternative solutions *in situ*. For instance, regions may avoid lock-in by diversifying the knowledge base of their local economy (i.e. building so-called Jacobs externalities) or by establishing loosely coupled networks. Geographical openness is also not a sufficient condition because the effective transfer of tacit knowledge across large distances requires other forms of proximity, such as cognitive proximity. That is, a prerequisite is that the local actors have the capabilities to absorb the external knowledge, i.e. they require cognitive proximity. Institutional proximity may also be helpful in this respect because sharing the same values and expectations with non-local organizations may be beneficial for interactive learning (GERTLER, 1997). Therefore, geographical openness is more likely to enhance interactive learning and innovation more indirectly, providing opportunities to break with cognitive and organizational lock-in.

This issue of geographical openness also depends, at least partly, on the question of which spatial scale is meant by local. This is not to say, however, that one should associate the role of space with some predefined entity. On the contrary, the various mechanisms behind learning and innovation are expected not to occur at one particular spatial level but instead operate across different spatial scales at the same time (MALMBERG and MASKELL, 2002). For example, inter-firm networks often tend to operate at higher, more aggregate spatial scales, while alternative mechanisms of knowledge transfer, such as spin-off dynamics and labour

Table 1. Five forms of proximity: some features

| | Key dimension | Too little proximity | Too much proximity | Possible solutions |
|-------------------|--------------------------------------|--------------------------|-------------------------------|---|
| 1. Cognitive | Knowledge gap | Misunderstanding | Lack of sources of novelty | Common knowledge base with diverse but complementary capabilities |
| 2. Organizational | Control | Opportunism | Bureaucracy | Loosely coupled system |
| 3. Social | Trust (based on social relations) | Opportunism | No economic rationale | Mixture of embedded and market relations |
| 4. Institutional | Trust (based on common institutions) | Opportunism | Lock-in and inertia | Institutional checks and balances |
| 5. Geographical | Distance | No spatial externalities | Lack of geographical openness | Mix of local 'buzz' and extra-local linkages |

mobility, are more likely to operate at the local level. Thus, instead of selecting a geographical scale a priori, empirical analyses have been claimed to decide at what spatial levels knowledge creation, knowledge transfer and interactive learning take place, and to what extent nation states and regions are relevant in this respect. Adding a dynamic perspective, such a multilevel analysis would also shed light on how the various dimensions of proximity that operate at and across different spatial scales produce places that are unique (MARTIN, 1999). This would increase the understanding of how places are constructed and modified, and how the different dimensions of proximity co-evolve at multiple spatial scales, shaping the evolution of places over time (BOSCHMA, 2004; MORGAN, 2004).

In sum, geographical proximity may facilitate inter-organizational learning, but it is neither a necessary nor a sufficient condition. It is not necessary, because other forms of proximity may function as substitutes to solve the problem of coordination. It is not sufficient, because learning processes require at least cognitive proximity besides geographical proximity. Nevertheless, geographical proximity may enhance interactive learning and innovation more indirectly, most likely by stimulating the other dimensions of proximity. To make matters more complicated, geographical proximity may also cause problems of lock-in. This latter problem may be solved by geographical openness, providing access to the outside world. However, geographical openness is neither necessary nor sufficient to break with a situation of lock-in. It is not necessary because other dimensions of proximity may provide alternative solutions *in situ*, while it is not sufficient because the effective transfer of tacit knowledge across large distances requires other forms of proximity. Nevertheless, geographical openness may enhance interactive learning more indirectly, most likely by realizing some distance with respect to the other dimensions, such as cognitive distance.

CONCLUSION

This paper has taken a rather critical stand towards the relationship between proximity and innovation. It

argued that too much and too little proximity are both detrimental to learning and innovation. That is, to function properly, proximity requires some, but a not too great, distance between actors or organizations. Table 1 summarized the main results of the previous discussion.

The foregoing has made clear that some, but not too much, cognitive proximity (i.e. an absorptive capacity open to new ideas) is a prerequisite for interactive learning processes to take place. The other four dimensions of proximity are considered mechanisms that may bring together actors within and between organizations. This is essential because the innovation process, ridden with uncertainty, requires effective mechanisms to transfer complementary pieces of knowledge between agents. Organizational, social, institutional and geographical proximity may, each in their own way, but most likely in combination, provide solutions to this fundamental problem of coordination. In theory, geographical proximity, combined with some level of cognitive proximity, is sufficient for interactive learning to take place. Other forms of proximity may, however, act as a substitute for geographical proximity. Although geographical proximity facilitates interaction and cooperation, it has been claimed here that it is neither a prerequisite nor a sufficient condition for interactive learning to take place.

However, too much proximity is unlikely to contribute to interactive learning and innovation. Therefore, some preliminary thoughts have been put forward about how this latter problem may be circumvented. As summarized in Table 1, this may be achieved through a knowledge base made up of diverse but complementary capabilities, through loosely coupled networks, through a mixture of embedded and market relations with other actors, through a common institutional system that guarantees checks and balances, and through a combination of local 'buzz' and extra-territorial linkages. All these solutions offer, by their own, or in combination, mechanisms to make connections between actors in order to combine complementary pieces of knowledge (solving the problem of too little

proximity), while they prevent actors becoming locked-in (solving the problem of too much proximity). Broadly speaking, this latter problem of lock-in is solved in two ways. On the one hand, these mechanisms offer openness to the outside, providing new ideas, while on the other hand, they ensure control and flexibility, enabling the implementation of new ideas and change. In sum, effective interactive learning and innovations require an absorptive capacity open to new ideas (the cognitive dimension), while they necessitate mechanisms of coordination and control that are nonetheless flexible and outward looking (the organizational, social, institutional and geographical dimensions).

It is fair to say there is a strong need for empirical work concerning these issues. This is not to deny the many problems that need to be solved before such an empirical analysis can be carried out. First, good analytical concepts are needed. An attempt was made to disentangle and define different dimensions of proximity in such a way that there is no overlap between them. Especially broad notions like institutional and organizational proximity deserve careful attention. Only under these circumstances can one expect that future research can isolate and identify individually the effects of each dimension of proximity on interactive learning and innovation.

Another challenge for research is to determine in more detail in what way the different dimensions of proximity are related to each other. The foregoing has made it clear that it would be wrong, and even misleading, to assume a priori the importance of the other dimensions of proximity next to geographical proximity. The impact of geographical proximity can only be assessed in empirical studies when controlling for the other dimensions of proximity, because they may act as powerful substitutes. Geographical proximity as such, for instance, is unlikely to enhance interactive learning and innovation. For this to happen, one needs other dimensions of proximity. It seems that cognitive proximity is a prerequisite for learning. It is doubtful, however, whether this is true for the other forms of proximity discussed in the paper. Only empirical research can ultimately throw light on this complex issue and decide which out of many possible combinations of proximity are necessary for interactive learning

and innovation. In addition, one needs to specify under what circumstances some dimensions (or combinations) of proximity are more important than others.

When assessing the role of proximity, it is essential to adopt a dynamic approach. For instance, it has been argued that geographical proximity may reinforce or strengthen the other dimensions of proximity over time. In addition, proximity (in whatever form) may have a positive impact (solving the problem of co-ordination) and also a negative impact on innovation (lock-in). There is as yet little understanding of how proximity affects innovation over time (BOSCHMA, 2004). In the beginning of a life cycle of a major innovation, proximity may have both positive and negative effects. On the one hand, one might expect that too much proximity (in the meaning of inertia and lock-in) is harmful when a radical innovation requires completely new knowledge and skills, new organizational arrangements, and new institutions. On the other hand, problems of coordination (e.g. due to a lack of standardization) must be solved by the various dimensions of proximity. After some time, however, one might expect that proximity (in whatever form) has been established but does not yet cause problems of lock-in: positive impacts of proximity will predominate. At the final stage of development, problems of lock-in (and, thus, negative impacts of proximity) are expected to become more urgent. It is up to empirical studies to take up these challenges for research, and to demonstrate how the relative importance of each dimension of proximity may change as a new trajectory evolves over time. This would really increase the understanding of how the different dimensions of proximity co-evolve, to what extent these forms of proximity are substitutes or complements in different stages of development, and what is the precise role of geographical proximity over time.

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