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Does geographical proximity favour innovation?

Ron A. BOSCHMA¹³

1. Introduction

It is often stressed in the literature that geographical proximity matters for innovation. To be more specific, the claim is made that geographical proximity facilitates interaction between agents, and it is through interaction that agents get new ideas and learn from each other, resulting in innovations. While this position is well pronounced in the literature, it is also increasingly subject to criticism. In this paper, we take a critical stand toward two quite influential types of empirical studies that have made such claims (see also e.g. Crevoisier, 1999; Weterings, 2006).

The first one is the so-called knowledge spillover literature that provides empirical evidence for this general statement at the regional level. For example, it relates regional stocks of knowledge to all kinds of performance indicators (such as patents). If a positive relationship is found, two main conclusions are drawn: knowledge spillovers are not only geographically localised, but also result in more innovations. While more recent studies account for more sophisticated spatial econometric techniques, the message remains the same: regions with high knowledge intensity rank highest in terms of innovative performance, because knowledge does not spill over large distances. Although valuable in their own right, this paper argues that this literature is too much built on assumptions. For instance, it suggests but does not prove that knowledge externalities are geographically bounded: it may well be that non-local agents are a key source of knowledge. In doing so, it suggests that place matters, but it may well be that it is more a matter of being connected to the right network, rather than being located in the right place (Giuliani and Bell, 2005).

The second one concerns more qualitative case study approaches that are most prominent in economic geography. In contrast to the first approach, they describe in detail what forms of proximity, besides geographical proximity, affect the performance of firms in clusters or regional innovation systems (Cooke and Morgan, 1998). It is the interplay between the different forms of proximity in a territory that is believed to contribute to the competitive advantage of

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local production systems. Although this bunch of literature has provided important insights, it suffers from various shortcomings. Not only are all forms of proximity assumed to be local, they are also considered to have an impact on the performance of local firms (not distinguishing analytically between the different forms of proximity). In addition, all forms of proximity are assumed to have a positive impact on innovation almost by definition.

The structure of the paper is as follows. In Section 2, we discuss the first approach, and explain what may be its drawbacks. In Section 3, we set out the second approach, and explain what are its limitations. In Section 4, some suggestions will be brought forward with the purpose of establishing an approach that can isolate the effect of geographical proximity, next to other factors that can affect the innovative performance of firms. For instance, the paper argues that the impact of geographical proximity on innovation should be studied at the firm level, in which one accounts explicitly for other forms of proximity. In Section 5, some conclusions are drawn.

2. Knowledge spillover literature

The so-called knowledge spillover literature has emerged in the 1990s. Basically, it argues that geographical proximity favours knowledge diffusion, and that proximity to knowledge sources affects positively the performance of economic agents (Feldman, 1994). By and large, this literature makes use of secondary databases to provide empirical evidence for this at the regional level. For example, it relates regional stocks of knowledge (as embodied in universities or R&D intensity) to all kinds of performance indicators (such as patents, new products, productivity) (see e.g. Jaffe et al. 1993; Audretsch and Feldman, 1996; Anselin, Varga and Acs, 1997). If a positive relationship is found, two main conclusions are drawn: knowledge spillovers are not only geographically localised, they also result in more innovations.

This literature also covers the urban dimension, stating that major urban centres (agglomeration economies) are the key drivers for innovation. However, not every urban centre is believed to have potential in that respect. It matters what the sectoral composition of urban regions looks like: some say that specialised urban regions show the highest growth dynamics, while others argue that more diversified urban regions result in more innovations, due to Jacobs' externalities (Glaeser et al. 1992; Henderson et al. 1995). Once again, these empirical studies assume that knowledge spillovers do not cross boundaries of regions, and that knowledge almost automatically results in innovation and economic growth.

Recent studies account for more sophisticated spatial econometric techniques, assessing the spatial range of knowledge diffusion. In doing so, no particular spatial scale is selected beforehand (Parr, 2002): the empirical data will ultimately decide at what spatial scale knowledge spillovers occur, that is, they will determine over what distance growth spillovers take place and to what degree neighbouring regions will be affected by high-growth regions. However, the message remains the same: regions with high knowledge intensity rank highest in terms of innovative performance, because knowledge does not travel over large distances. Although differences between sectors are noticeable, those studies tend to agree that only neighbouring regions, utmost, may benefit from these knowledge spillovers (Van Oort, 2002).

This knowledge spillover literature has provided many valuable insights between knowledge spillovers and economic growth at the regional level. They have made clear that the higher the number of (potential) knowledge sources in a territory, the larger the (potential) benefit for each local agent. Having said that, it could be stated that only indirect empirical evidence is provided for this relationship. It may even be argued that the empirical studies are too much built on assumptions.

First of all, this literature suggests but does not prove that knowledge spillovers are geographically localised. In fact, it overlooks that knowledge is often transmitted through networks, which may be quite extended in space. For instance, non-local agents may well be a key source of knowledge, but the use of data measured at the regional level do not allow for their identification. In doing so, it suggests that place matters, but it may well be that it is more a matter of being connected to the right network, rather than being located in the right place (Breschi and Lissoni, 2002). In other words, is it pure co-location of similar activities in transparent clusters without explicit interaction that makes local firms more successful, or is it being part of a network that is decisive?

Secondly, the knowledge spillover literature does not control for other dimensions of proximity besides geographical proximity that may influence knowledge exchange and innovative behaviour. Basically, they are not interested in explaining how local knowledge spillovers occur, but if they occur. In doing so, they do not describe the different mechanisms behind knowledge spillovers. Although such a stance is valid in its own right, the point is that ignoring this may lead to wrong conclusions. In Section 4, we explain that the different forms of proximity may be complementary to each other, but they may also act as substitutes. In the former case of complementarity, geographical proximity is likely to be involved, but only in combination with other forms of proximity will interactive learning between local firms take place. For instance, geographical

proximity will not favour interactive learning between local firms when they do not share similar competences (that is, cognitive proximity is required). In the latter case of substitution, geographical proximity may be substituted by another form of proximity in order to enable effective knowledge transfer. For instance, trust-based linkages (based on social proximity) may facilitate interactive learning between agents that are not located in the same place (that is, no geographical proximity is needed).

Thirdly, the knowledge spillover literature also tends to overestimate the importance of external sources of knowledge. In doing so, they ignore the fact that firms may rely much more on internal sources of knowledge (Sternberg and Arndt, 2001). In addition, they treat firms as one and the same, overlooking the fact that the absorptive capacity of firms may differ, even in the same region, which influences their learning capability. We will come back to this issue in the following sections.

3. Descriptive approaches: clusters, districts and regional innovation systems

The second type of literature that investigates the regional dimension of knowledge spillovers concerns qualitative case study approaches. It emerged mainly in the 1980s and 1990s. This literature can be associated with the territorialised view on economic development (see e.g. Lagendijk, 2003; Boschma and Kloosterman, 2005), encompassing the literature on industrial districts (Becattini, 1987), clusters (Porter, 1990), innovative milieus (Camagni, 1991) and regional innovation systems (Cooke, 1991; Iammarino, 2005). In contrast to the first type of literature, these approaches make thorough analyses of highly successful regions, and describe in detail through which mechanisms knowledge spills over from one local organisation to the other. In doing so, they acknowledge that other forms of proximity, besides geographical proximity, may affect the performance of firms in dynamic territories.

To put it briefly, this literature claims it is the interplay between different forms of proximity in a territory that is believed to contribute to its competitiveness. It is the place where it all happens: all forms of proximity are believed to reinforce each other at the regional level. Geographical proximity is involved, because short distances facilitate knowledge sharing. Consequently, place-specific capabilities and competences are built, to which local agents have access ('in the air', as Marshall put it), but which are not understood by non-local firms, because they lack the capacity to absorb the local knowledge (Boschma, 2004). The territorial system is characterised by local agents that are well connected to other local agents economically, socially and culturally (Torre and Gilly, 2000). There is

an extreme division of labour between the local firms, based on personal, trust-based network relationships, which keep transaction costs low, and favour interactive learning. This network type of organisation is strongly rooted in a specific social and cultural context, in which shared norms and values facilitate the transfer of knowledge, showing the relevance of institutional proximity (Kirat and Lung, 1999).

By and large, this literature has provided many insights in how the different forms of proximity affect interactive learning and innovation at the regional level. As such, it has provided additional insights, as compared to the knowledge spillover literature. Despite these merits, this literature suffers from various shortcomings. By and large, it assumes: (1) all local firms are similar in the cluster or district; (2) all forms of proximity are local and have an impact on the performance of local firms; (3) all forms of proximity have a positive impact on innovation almost by definition. In that respect, it suffers from analytical rigour, being unable to assess the impact of each form of proximity (including the role of geographical proximity) on the performance of firms in clusters or districts.

Firstly, this literature has overlooked intra-firm processes of knowledge creation, emphasising the role of external linkages in the acquisition and creation of knowledge. Recent studies have shown that the ability of a firm to understand and absorb external knowledge is very much dependent on its own competence base (Weterings, 2006). In addition, this literature treats firms as a sort of black box, assuming all local firms to be similar in the cluster: (1) all local firms are supposed to have equal access to the local knowledge being in the air, as Marshall has once put it; (2) all local firms are conceived to be connected to the local network of input-output linkages; (3) all local firms have similar levels of absorptive capacity. In reality, firms differ from each other, and this is no less true for firms in districts than everywhere else: some firms are leading firms, having economic and cognitive power, and these leaders are extremely well connected to non-local firms with similar levels of absorptive capacity. Accordingly, it becomes extremely relevant to control for firm-specific features (such as their absorptive capacity and network position) when assessing the performance of firms in clusters.

Secondly, this literature assumes all forms of proximity being local and having an impact on the performance of local firms. In doing so, they overstress, and even assume the role of geographical proximity in the transfer of knowledge between local firms in a place. Such a stance does not take into account that knowledge is likely to be unevenly distributed in a cluster, and that knowledge networks may cross the boundaries of the cluster. Knowledge circulates and flows through networks that consist of agents sharing cognitive

capabilities and trust, but not necessarily in the same location (Giuliani and Bell, 2005). Thus, the performance of firms may have more to do with their network position (being in the right network), than their location per se (being in the right location). This can only be assessed when the different forms of proximity (including geographical proximity) are distinguished analytically in empirical studies. Till so far, this literature has largely failed to make this analytical distinction.

Thirdly, it would be wrong to assume that proximity has a positive impact on performance almost by rule. The fact that proximity can have negative impacts on innovation has largely been overlooked by this literature, although Camagni (1991) is an exception to this rule. In doing so, it has been ignored that geographical proximity may contribute to the problem of lock-in. Here again, we argue that empirical studies should account for the impact of other forms of proximity, because they can also cause, besides geographical proximity, this problem of lock-in, with adverse impacts on the performance of firms (Boschma, 2005). In Section 4.2, we will go into this issue more into detail.

4. Need for a more systematic approach

In Section 4, some suggestions are presented with the purpose of establishing an approach that can isolate the effect of geographical proximity, next to other factors that can affect the innovative performance of firms. The paper argues that the impact of geographical proximity on innovation should be studied at the firm-level, in which one accounts for firm-specific features and other forms of proximity. Firstly, we briefly present the different forms of proximity. In doing so, we explain why there is a need to distinguish each of them analytically, which is directly linked to the issue of substitution versus complementarity. Secondly, we stress the importance of empirical testing since proximity may also have adverse effects, but it is still uncertain in what circumstances.

4.1. The role of geographical proximity: substitution versus complementarity

Below, we distinguish between five forms of proximity, of which geographical proximity is just one (see for more details Boschma, 2005). In doing so, we explain that in theory, geographical proximity, combined with some level of cognitive proximity, may facilitate interactive learning and innovation. However, other forms of proximity may also act as substitutes for geographical proximity. In other words, geographical proximity is not a necessary, and not even a sufficient condition for learning and innovation to take place.

Utmost, geographical proximity may strengthen the other forms of proximity, meaning it may play a complementary role.

Basically, proximity in its various forms provides solutions for the problem of coordination. This problem is especially urgent in innovation processes. Innovation is not only ridden with uncertainty and opportunism, it is also often the outcome of recombining different pieces of knowledge that are distributed among different agents (Antonelli, 2000). In order to cope with uncertainty and opportunism, and to enable effective knowledge transfer between different agents, one needs mechanisms that can act as bridges between different agents.

Cognitive proximity is a key mechanism in this respect (Nooteboom, 2000). There is agreement that one can only learn from other agents when they possess similar absorptive capacities, that is, when their knowledge gap is not too large (Cohen and Levinthal, 1990). Their own cognitive base should be close enough in order to communicate, understand and process new knowledge successfully. With the notion of cognitive proximity, it is meant that people sharing the same knowledge base and expertise may learn from each other. Geographical proximity may facilitate this learning process, for the reasons mentioned previously. Besides geographical proximity, there are other forms of proximity that may bring together actors within and between organisations. To be more specific, each of these alternative mechanisms may act as substitutes for geographical proximity, because they may connect agents irrespective of where they are located.

Organisational proximity is a prime example. Organisational proximity is often treated in the literature as a broad category (Gilly and Torre, 2000). Here we concentrate on organisational arrangements that may act as vehicles for the transfer of knowledge, solving the problem of coordination. Our definition of organisational proximity focuses on the rate of autonomy agents have and the degree to which control can be exerted in organisational arrangements (relevant for the issue of appropriability) (Williamson, 1985). We assume some kind of continuum that goes from low organisational proximity (no ties between independent actors, e.g. 'on the spot' markets), loosely coupled networks (weak ties between autonomous entities, e.g. a joint-venture or a flexible firm or network) to high organisational proximity (as embodied in strong ties, e.g. a hierarchically organised firm or network).

There are several reasons why the capacity of agents to innovate requires organisational proximity. As mentioned above, new knowledge creation goes along with uncertainty and opportunism. In order to reduce these, strong control mechanisms are required in order to ensure ownership rights and sufficient rewards for own investments in new technology. Markets often cannot offer this

because it would involve too high transaction costs. In principle, a hierarchical organisation, or tight relationships between different organisational units can provide a solution to these problems. In addition, the transfer of complex knowledge requires strong ties because of the need of feedback.

As such, organisational proximity may act as a substitute for geographical proximity (Torre and Rallet, 2005). Rallet and Torre (1999) showed in a study on research projects in France that the need for geographical proximity is rather weak when there is a clear division of precise tasks that are co-ordinated by a strong central authority (organisational 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. This need for physical co-presence could be organised by bringing people together through travel now and then. In other words, it did not need geographical proximity in the meaning of permanent co-location.

Another alternative coordination mechanism is social proximity. Following the embeddedness literature (Granovetter, 1985), social proximity is defined in terms of socially embedded relations between agents at the micro-level. Relations between actors are socially embedded when they involve trust that is based on friendship, kinship and experience. The embeddedness literature suggests that the more socially embedded the relationships of a firm are, the more interactive learning, and the better its (innovative) performance. Lundvall (1993) claimed that social proximity encourages an open attitude of 'communicative rationality', rather than a calculative market orientation towards minimising costs. In addition, effective interactive learning requires committed, durable relationships, as opposed to pure market relationships that dissolve as soon as problems between the exchange partners arise.

Like organisational proximity, social proximity may act as a substitute for geographical proximity. It may bring people together, despite the fact that these are not at the same location. Breschi and Lissoni (2002) argue that social networks provide key channels for knowledge diffusion, through which much knowledge is produced. So, it is more about being in the right network, rather than being in the right place. This is not to deny that social networks may still be geographically localized. The point is that networks are social constructs that exclude outsiders, whether they are local agents or not. As such, geographical proximity cannot be considered a sufficient condition for the exchange of knowledge. For example, multinational corporations regularly fail to get access to local knowledge, because it proves hard to become a member of personal networks through which local knowledge circulates (Blanc and Sierra, 1999).

An alternative mechanism to bring people together is institutional proximity. Institutions function as a sort of 'glue' for collective action because they reduce uncertainty and transaction costs (North, 1990). Formal institutions (such as laws) and informal institutions (like cultural norms) influence the extent and the way actors or organizations co-ordinate their actions. As such, institutional proximity is an enabling mechanism that provides stable conditions for coordination and thus, influences the level of knowledge transfer and interactive learning between agents. A common language, shared habits, a law system securing intellectual property rights, etc., they all provide a basis for economic co-ordination and interactive learning.

Like the other forms of proximity, institutional proximity may act as a substitute for geographical proximity. For instance, many formal institutions at the level of the nation-state, or even beyond (such as language and laws) stimulate the interaction between agents, solving the problem of coordination between non-local agents.

In the foregoing, it has become clear that geographical proximity is neither a necessary, nor a sufficient condition for inter-organisational learning to take place. There are other forms of proximity that may solve the fundamental problem of coordination. However, geographical proximity is often complementary to the other forms of proximity in the process of interactive learning. Geographical proximity may play a complementary role in building and strengthening cognitive, organisational, social and institutional proximity. For instance, spatial proximity facilitates the establishment of informal relationships: co-located firms will have more face-to-face contacts and can more easily build up trust, resulting in more personal and embedded relationships between firms (Harrison, 1992). In that respect, geographical proximity may facilitate interactive learning, but it needs other forms of proximity to enable effective knowledge transfer.

4.2. Negative effects of proximity on innovation

Above, it has been explained that empirical analysis should account for the various dimensions of proximity when assessing the impact of geographical proximity on learning and innovation. Another reason for the need of such empirical analysis is that geographical proximity may also have an adverse impact on interactive learning and innovation. This issue concerning the downside of proximity has often been overlooked in the literature. We explain below that geographical proximity may contribute to the problem of lock-in. Here again, we argue that one should account for the other forms of proximity, because they can also cause (and even

worsen) the problem of lock-in (Boschma, 2005). Finally, we discuss how this problem of lock-in may be overcome. In doing so, we argue that geographical openness (as a purely spatial solution) is not a necessary, and not a sufficient condition for achieving this goal. It may be solved by either alternative mechanisms in situ (which thus act as substitutes for geographical openness), or by complementary mechanisms (which thus act as necessary complements to geographical openness).

The problem of lock-in is increasingly recognised in the literature, but not in a very systematic way. To put it briefly, it basically deals with the fact that agents may become too much inward looking. Due to too much proximity, they cannot value or implement new knowledge they have not acquired experience in. Too much geographical proximity may worsen this problem of lock-in and, thus, may become harmful for interactive learning and innovation. Regions may become locked into rigid trajectories, which may weaken their learning capability. This may be especially true for highly specialized regions in later stages of their development. However, the point is that too much geographical proximity cannot be considered the sole reason for the problem of lock-in. Utmost, it can negatively affect the downside effect of the other forms of proximity on innovation. Let us discuss these one by one.

Too much cognitive proximity may be detrimental to learning, and thus innovation. Knowledge building often requires dissimilar, complementary bodies of knowledge (Cohendet and Llerena, 1997). In this respect, cognitive distance tends to increase the potential for learning. In addition, routines within an organisation (or in an inter-organisational framework) obscure the view on new technologies or new market possibilities. It often turns out to be difficult to unlearn habits or routines that have been successful in the past, but which have become redundant in the course of time (Levitt and March, 1996). Moreover, cognitive proximity increases the risk of involuntary and non-intended spillovers. In such circumstances, local competitors are very reluctant to share knowledge (Cantwell and Iammarino, 2003).

Too much organisational proximity may also be unfavourable to learning and innovation. This shows strong resemblance with the notion of 'weakness of strong ties', as Granovetter put it (1985). First of all, there is the risk of being locked-in in specific tight relationships. Intra- and inter-organisational networks may evolve in closed and inward-looking systems, which seriously limit access to sources of novelty. In addition, a hierarchical form of governance lacks feedback mechanisms that are common to more symmetrical relations. As a consequence, new ideas are not rewarded in a bureaucratic system and interactive learning hardly takes place. Apart from that, the successful implementation of innovation

requires organisational flexibility (Blanc and Sierra, 1999). Organisational proximity, as reflected in hierarchical governance structures, is unlikely to provide such flexibility. This problem of organisational lock-in may also have to do with vested interests in organisations opposing change that undermine their positions.

Too much social proximity may also have adverse impacts on learning and innovation. Firstly, embedded relationships may lead to an underestimation of opportunism when these relations of loyalty are based on emotional bonds of friendship and kinship (Uzzi, 1997). This is especially relevant in markets where technologies and policies continually change in conditions of uncertainty. Secondly, long-term committed relationships may lock buyers and suppliers into established ways of doing things, at the expense of their own innovative and learning capacity.

Institutional proximity may also become a constraining factor, hampering collective learning and innovation for two reasons. First of all, an institutional system may evolve into a situation of lock-in, providing no opportunities for newcomers. Institutional systems consist of mutually interdependent set of organisations. When each institution in such a complex system has a structural position, change brings in instability because positions are disturbed (Hannan and Freeman, 1977). Powerful players often react to change in a routinised and conservative way, especially when their vested interests are threatened, or when they have obligations towards other actors in the system (Herrigel, 1993). As a result, either no change is taking place, or only localised change, that is, minor changes which do not upset the functioning of the whole system. Secondly, too much institutional proximity may lead to institutional inertia, hindering the development of radical innovations that require new institutional structures. As a result, institutional rigidity leaves no room for experiments with new institutions that are required for the implementation of radical innovations.

Till now, we have argued that geographical proximity may contribute to the problem of lock-in, but only in combination with one or more other forms of proximity. In addition, other forms of proximity may cause lock-in, in which geographical proximity plays no role whatsoever. If the latter is the case, it means that geographical openness may not offer a solution to overcome this problem of lock-in. When geographical proximity, however, causes lock-in, geographical openness may offer a solution, but only in combination with other mechanisms. It implies that geographical openness is not a necessary, and not even a sufficient condition for breaking a situation of lock-in. In other words, lock-in may be solved by alternative mechanisms in situ (which thus act as substitutes for geographical openness) on the one hand, or by complementary mechanisms (which thus act as necessary complements to

geographical openness) on the other hand. This is explained in the remaining part of this section.

In the literature, it has been suggested that establishing non-local relationships may dissolve lock-in (Camagni, 1991). Bathelt (2005) claims that the impact of local relations is reinforced when they are supported by non-local relations that provide new ideas and bring new variety into the territory. In this respect, lock-in is avoided through the establishment of connections with other organisations outside the territory. This leaves unanswered the question what is meant by local, and what is not. For instance, it is a complicated issue to determine which geographical scale is the most relevant for collective learning, because its various underlying mechanisms are most likely to operate at different spatial scales simultaneously (Malmberg and Maskell, 2002).

However, lock-in may also be dissolved by other mechanisms alone, or in combination with geographical openness. Firstly, lock-in may be solved by diversifying a local knowledge base that is made up of complementary knowledge resources. In that respect, both the problem of coordination and the problem of lock-in are solved. A certain degree of cognitive distance increases the potential for learning and reduces the problem of undesirable spillovers, while a certain level of cognitive proximity may secure effective communication and knowledge transfer (Nooteboom, 2000).

Secondly, lock-in may be solved by loosely coupled networks, which secure a certain degree of organisational distance. It provides access to complementary sources of information, meaning a broader learning interface. Moreover, loose coupling safeguards organisational autonomy within and between organisations and, thus, offers some flexibility when organisational adaptation is required. In order to avoid lock-in, a certain amount of organisational openness is required, not only to new potential entrants but also to the outside world (e.g. access to other networks). Apart from flexibility, a loosely coupled system includes some advantages of organisational proximity. It constitutes a stable framework for interaction and communication, with co-ordination by a central authority. Centralised coordination is needed to control uncertainty, to bring together the different autonomous divisions or agents, and to integrate the new knowledge into the routines of the organisation. In other words, loosely coupled systems (both within and between organisations) may reflect a certain level of organisational proximity, in which both control and flexibility are secured.

Thirdly, lock-in caused by an overload of trust may be circumvented by a certain degree of openness of networks. Uzzi (1997) suggested a mixture of both embedded and market relationships at the network level. The adaptive capacity of agents may increase considerably when the network consists of a mixture of

arm's length ties (keeping the firms alert, open-minded and flexible) and embedded relationships (lowering transactions costs and facilitating inter-organisational learning).

Fourthly, lock-in may also be solved by a certain degree of institutional openness. This may be reflected by institutional structures that find 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 political system should fulfil several requirements that guarantee checks and balances. For instance, it needs to ensure a power of balance that prevents organizations and institutional players to take control of the system and use it only for their own reproduction (Herrigel, 1993).

5. Conclusions

This article has aimed to put the impact of geographical proximity on innovation more in perspective. We have made some critical comments concerning two different types of literature (the knowledge spillover literature and the case study literature) that basically make the same claim: geographical proximity favours innovation, because knowledge spillovers are geographically localised.

When assessing the impact of geographical proximity on innovation, we have made the point that it is essential to account for other dimensions of proximity. This is because the other forms of proximity may solve the problem of coordination alone (in that case they act as substitutes) or in combination with geographical proximity (in that case they act as complements). In other words, geographical proximity is not a necessary condition, nor a sufficient condition for interactive learning and innovation to occur. Utmost, geographical proximity may play a complementary role: it needs other forms of proximity to bring together actors and enable effective interactive learning.

The same line of reasoning applies to the role of geographical openness in dissolving the problem of lock-in. This is because other mechanisms (such as diversifying the local knowledge base) may alone provide alternative solutions *in situ* (in that case they form substitutes for geographical openness), or in combination with geographical openness (in that case they act as necessary complements to geographical openness). It implies that geographical openness is not a necessary, and not even a sufficient condition for breaking a situation of lock-in. Utmost, it may contribute to breaking down lock-in: it requires other mechanisms securing openness and flexibility to enable interactive learning and innovation.

The foregoing has made clear that one should distinguish analytically between different forms of proximity, in order to assess the impact of each of them on innovation. Only then, one can clearly specify the role of geographical proximity: whether it plays a role or not, and when it does, what other forms of proximity are involved. In addition, we have claimed that it is essential to control for firm-specific features (such as their absorptive capacity and network position) when assessing the performance of firms. Such an analysis would really take seriously the fact that firms differ from each other, and that intra-firm processes of knowledge creation may be as important, or even more so, as external linkages. In doing so, the role of geography in innovation is no longer assumed, but tested empirically. That would really increase our understanding of the impact of geographical proximity on interactive learning and innovation.

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