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Proximity, Innovation and Networks: A Concise Review and Some Next Steps

Pierre-Alexandre Balland, Ron Boschma and Koen Frenken

Utrecht University

Human Geography and Planning

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Pierre-Alexandre Balland*, Ron Boschma*, Koen Frenken**

* Department of Human Geography and Spatial Planning, Utrecht University

** Copernicus Institute of Sustainable Development, Utrecht University

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Abstract: We review proximity research on collaborative innovation among organizations. We discuss the basic theorical tenets of collaborative innivation and summarize empirical findings on the roles of various forms of proximity. At the aggregative level, we look at studies of inter-organizational relations at the aggregate level of innovation systems. We end with a discussion of next steps in proximity research on collaborative innovation.

Keywords: proximity, innovation, networks, inter-organizational relations, innovation systems, knowledge base

1. INTRODUCTION

Proximity as a concept in economic geography goes back to early 1990s (Bellet et al. 1992). At the time, the main object of study was the effect of firm location and co-location on the production activities in the tradition of Perroux (1950). The renewed interest in local development is to be understood against the background of globalization of the economy and decentralization of economic policy within the European Union (Zimmermann et al., this volume).

Only later, scholars started to apply the proximity concept in the context of innovative activities (Rallet and Torre 1999). Since, proximity thinking has enjoyed wide popularity in the field of geography of innovation, both as a conceptual framework (Boschma 2005; Torre and Rallet 2005) and in empirical research designs (Ponds et al. 2007; Balland 2012). This interest can be understood both as a logical sequence from production activities to innovation activities in proximity theorising as well as the growing conviction among policy makers and academics that innovation is the key driver of economic growth and employment creation.

In particular, scholars recognised that knowledge production and innovation takes places within inter-organizational networks rather than only within single organizations (Powell et al. 1996; Hagedoorn 2002). This motivated research on the role of proximity in establishing innovation networks and in supporting their success. In doing so, proximity research has benefitted from advances in network science (Schweitzer et al. 2009), which can be applied both at the level of actors (inventors, teams, organizations) and spatial units (cities, regions, countries). At the same time, the proximity concept has proven useful in enriching some other key concepts in

innovation studies, including the notions of knowledge base (Davids and Frenken 2018) and innovation system (Hardeman et al. 2015).

This chapter summarizes the theoretical and empirical advances in proximity research collaborative innovation focusing on the bilateral relationships rather than full networks. We will do so by first discussing the basic premises and findings of proximity research in the area of knowledge production, innovation and networks (section 2). We then turn to the aggregate level of analysis of inter-organizational relations within innovation systems (section 3). We end with a discussion of some of the next steps that can be taken in proximity research as applied to innovation, highlighting the need to understand proximity dynamics in addition to statics and the need to move beyond bilateral relations by looking at organizations' portfolio of relations (section 4).

2. PROXIMITY AND INNOVATION

While the proximity concept has been used in several sub-fields in economics and geography, the field of application which has probably contributed most to its popularity in that of geography of innovation and in particular the studies on of inter-organizational learning. The key thesis in the early contributions has been that the thesis that geographical proximity between organizations is neither a sufficient nor a necessary condition for inter-organizational collaboration and learning to take place (Boschma 2005). This thesis motivated detailed empirical studies on knowledge exchange in clusters, where scholars found that firms within the same cluster (thus all equal in terms of geographical proximity), displayed very different interaction patterns when it comes to knowledge sharing (Giuliani and Bell 2005; Morrison 2008). While some firms occupy central positions in the knowledge network, other firms had

hardly any ties to other firms. And, while some firms interacted with a number of firms outside the cluster, others did not have such connections. Hence, knowledge networks within clusters are "uneven and selective, not pervasive and collective" (Giuliani 2007), illustrating that geographical co-location is neither sufficient nor necessary for knowledge to be transmitted between actors.

Following from the theoretical premise that geographical proximity has no privileged role to play over other drivers of network formation in innovation processes, the next step in empirical research was to find what other forms of proximity may explain knowledge transfer, interactive learning, and, ultimately innovation. Particularly influential has been Boschma's (2005) four forms of proximity next to geographical proximity: cognitive, social, institutional and organizational. This framework critically assessed the French proximity literature at that time and explored other distinct literatures on proximities, beyond the French literature. In particular, the notion of cognitive proximity became popular at the time in the fields of economics of innovation and management of innovation. Here, the key idea was the notion of optimal cognitive proximity (Cohendet and Llerena 1997; Nooteboom 2000). The theoretical insight put forward holds that cognitive proximity both enables and constrains learning. While cognitive diversity increases the scope of learning, some degree of cognitive proximity is needed to economize on the cost of communication. In economic sociology, by contrast, most emphasis was put on social proximity to establish trust required to maintain reciprocity and lower transaction costs in contracting. This type of proximity, elaborated by Uzzi (1996) in economic sociology, stems from personal ties between members of different organizations, which enhance trust and effective communication. The study by Breschi and Lissoni (2009) has been particularly important in this respect, providing very systematic empirical evidence of the

role of social networks between employees in different firms supporting knowledge flows between organizations as proxied by patent citations.

The role of institutional proximity was emphasized by geographers at the time, mostly associated with firms operating under similar national institutions. A lack of institutional proximity could explain why firms may struggle to adopt technology that has been developed under different national institutions (Gertler 1995). Later, institutional proximity was also defined as organizations or individuals operating under the same 'institutional logic', for example, when operating within academia, or within industry, or within government (Ponds et al. 2007). The so-called triple helix notion referring to university-industry-government relations (Etzkowitz and Leydesdorff 2000), then, is an instance of organizations collaborating under institutional distance. The final strand of literature relevant to the proximity framework is transaction cost economics, which explains the boundaries between firms and markets. Inter-organizational networking, then, can be considered as a mixed governance mode in between markets and hierarchy (Williamson 1985) or even a separate third mode altogether (Powell 1991). Organizational proximity between two firms, for example, being part of the same holding, may help learning and collaboration as a membership to the same organizational entity allows the mobilization of hierarchical control and various modes of conflict resolution. The notions of institutional and organizational proximity are related to the early proximity theory by Rallet and Torre (1999) who subsumed both membership of the same organization and membership of the same professional community under organizational proximity. In both cases, individuals can rely on shared routines –explicit or implicit– which allow them to coordinate their informal interactions.

One of the advantages of distinguishing between different forms of proximity as analytical dimensions, holds that the various proximities can enter as explanatory variables in econometric research designs aiming to explain inter-organizational collaboration. Indeed, during the past decade or so, we have witnessed a surge of proximity studies looking at inter-organizational innovation networks at national levels (Ponds et al. 2007; Breschi and Lissoni 2009; Scherngell and Hu 2011; Broekel and Boschma 2012; Bouba-Olga et al. 2012; D'Este et al. 2013; Cassi and Plunket 2015; Balland et al. 2016), European level (Autant-Bernard et al. 2007; Maggioni et al. 2007; Hoekman et al. 2009; Scherngell and Barber 2009; Hoekman et al. 2010; Balland 2012; Marrocu et al. 2013; Fernandez et al. 2016) and even at a more global scale (Cassi et al. 2012; Balland et al. 2013; Hardeman et al. 2015). Though these studies often differ slightly in exact measurements or statistical methodology, we can nevertheless list some consistent findings.

First, many studies show that that the effect of geographical proximity on collaboration and learning within contexts of innovation is not so strong once controlling for the four non-geographical forms of proximity (Singh 2005; Breschi and Lissoni 2009; Balland 2012; Heringa et al. 2016; Bergé 2017). That is, geographical and non-geographical proximities tend to be positively correlated, which explains why the effect of geographical proximity is overestimated if other forms of proximity are not controlled for. The correlation between geographical proximity and other proximities, in turn, most likely reflects that geographical proximity facilitates the establishment of non-geographical forms of proximity.

Second, some studies investigated whether the lack of one form of proximity can be compensated by the presence of another form of proximity. An early study in this regard is the study by Ponds et al. (2007) who compared co-publications in science-based industries and

found that triple-helix collaborations (low institutional proximity) were more prevalent in regions (high geographical proximity). And, Singh (2005) found that geographical proximity is especially important in the establishment of interdisciplinary research collaborations, when cognitive proximity between organizations is low.

Third, some studies investigate the idea of optimal proximity (Boschma 2005). In particular, quite a number of studies took up Nooteboom's (2000) thesis regarding a fundamental trade-off in inter-organization learning, that is: *"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." (Nooteboom 2000, p. 72)*. It follows, then, that there is an optimal cognitive distance between two organizations that maximizes the benefits of learning by one firm from the other firm. The optimal cognitive proximity thesis has been confirmed in several empirical studies on knowledge transfer in R&D collaborations (Wuyts et al. 2005; Nooteboom et al. 2007) as well as the effects of mergers and acquisitions on innovative performance (Ahuja and Katila 2001; Cloodt et al. 2006).

The notion of optimal proximity has been further elaborated as the 'proximity paradox' (Boschma and Frenken 2010). The paradox lies in that close proximity often leads organizations to collaborate and to learn, but by being so biased towards proximate organizations, learning is not optimized. Thus while high levels of proximity render collaboration and knowledge transfer more likely, the extent to which organizations truly profit may be limited. Empirically, Broekel and Boschma (2012) indeed found that cognitive and organizational proximity were important drivers of tie formation, these did not yield superior innovative performance for the firms concerned. Similarly, Cassi and Plunket (2015) found for European co-inventor networks in

genomics that geographical and organizational proximity increased collaboration and knowledge sharing, but not innovative performance.

A final example where the proximity concept has proven useful in the analysis of collaborative innovation between organizations is the framework proposed by Davids and Frenken (2018), who linked the roles and importance of various proximity dimensions to different knowledge bases and stages in the innovation processes. Innovation projects typically draw on and combine multiple knowledge types (Mattes 2012; Strambach and Klement 2012), with relative importance of a knowledge base generally shifting during different stages of an innovation process (Ibert and Müller 2015). One could characterize the research stage of an innovation process as drawing mainly on analytical knowledge and the development stage as drawing more on synthetic knowledge (Moodysson et al. 2008). One can add a third stage where the final product needs to be marketed to gain acceptance by clients and, in some cases, by government and the wider public as well. This stage mainly draws on symbolic knowledge, often, of a territorial kind (Davids and Frenken 2018). Distinguishing between three knowledge bases and three stages of new product development (as in a 3x3 matrix in Table 1), Davids and Frenken (2018) started theorizing about the type of proximity that matters most. In the *research* stage, the main knowledge being produced comes from the R&D department. Here, researchers are generally familiar with the relevant scientific knowledge and the academic norms governing its production, validation and exchange, thus operating under high cognitive and institutional proximity. In the *development* stage, knowledge production concerns mainly solving of practical problems on site, within the boundaries of a company (as to protect IPR) and under the institutional logic of the market. Thus, geographical, institutional and organizational proximity is rather high in this stage. Finally, at the marketing stage of new product development, the relevant geographical context becomes the cultural context of a territory

where cultural codes are shared and territorial institutions are governed. Hence, geographical and cultural proximity are expected to matter most.

Table 1. Knowledge base and proximity per innovation stage (Davids and Frenken 2018, p. 31)

	Research	**Development**	**Marketing**
Knowledge base			
Analytic	high	variable	low
Synthetic	variable	high	variable
Symbolic	low	variable	high
Proximity			
Geographical	low	high	high
Cognitive	high	low	low
Social	variable	variable	variable
Institutional	high	high	high
Organizational	low	high	low

3. INNOVATION SYSTEMS

As an analytical concept, the proximity concept can also be used to characterize innovation systems in terms of the main proximities that are mobilized to organize inter-organizational collaboration among actors within an innovation system (Freeman 1987; Lundvall 1998). Hardeman et al. (2015) provide such a framework, starting from the distinction between the traditional Mode 1 scientific knowledge production within universities and the new more distributed Mode 2 knowledge production. According to Gibbons et al. (1994, p. 34), this new mode of knowledge production got established in the late 20th century, which they describe as follows:

"not only is the average number of authors per paper increasing, but much more significantly, so are the diversity of specialisms and disciplines involved in the writing of a single paper and the range of institutions and organizations from which the authors originate. In addition, the geographical distribution of these institutions continue to broaden. In mode 2, not only are more actors involved in the genesis of knowledge, but they remain socially distributed."

According to Hardeman et al. (2015), then, Mode 1 stands for knowledge production in which actors are proximate, while Mode 2 knowledge production stands for distributed knowledge production processes, in which actors are distant. This proposed definition of Mode 1 coincides with the ivory tower image of scientific knowledge production: disciplinary (cognitive proximity), within university departments (organizational proximity), in stable networks (social proximity), under a strict set of academic norms (institutional proximity) and located within the walls of the laboratory (geographical proximity). Mode 2, by contrast, can be characterized as transdisciplinary (cognitive distance), cross-organizational (organizational distance), in temporary and open networks (social distance), with various, possibly conflicting, goals (institutional distance), and crossing national borders and physical space (geographical distance). Note that the role of geographical proximity is not limited *per se*. Rather, the need for face-to-face contact is organized through 'temporary proximity' as in meetings and short stays, as well as supported by ICTs (Torre 2008).

One can expect to observe very few instances of innovation systems that fully adhere to Mode 2 knowledge production, that is, a system where organizations collaborate in the absence of any form of proximity between them. After all, some degree of trust and understanding is needed in any form of knowledge collaboration. More often, one would expect to observe that actors are proximate in at least one dimension as a means to manage the difficulties and conflicts that arise from being distant in the other dimensions (Ponds et al. 2007). Hence, Mode 2 knowledge production is better understood as an extreme ideal type rather than a precise empirical description. Accordingly, one can think of a more refined typology of Mode 2 knowledge production by looking at the dominant form of proximity that is employed to manage distance in other dimensions. For example, Mode 2 knowledge production within regional innovation systems would make use of geographical proximity as an organizing principle, while Mode 2

knowledge production within a dedicated national public research organization would make use of organizational proximity as organizing principle.

Conceptualizing an innovation system in terms of proximate and distant actors renders the empirical description of an innovation system rather straightforward. In an empirical research design, one simply needs to operationalize the cognitive, organizational, institutional, social and geographical attributes of each organization such that the mutual distance between each pair of organizations can be established in five-dimensional space. This also allows one to 'test' the Mode 1 and Mode 2 theses. If proximity is an important driver of collaboration between organizations of an innovation system in all five dimensions, then this innovation system is characterized by Mode 1 knowledge production, while in the absence of such proximities, one can speak of Mode 2 knowledge production. More often, one will find that only some proximities matter in explaining collaboration; these proximities are then characterizing the organizational principles of the innovation system in question. For example, Hardeman et al. (2015) found that the global innovation system (here: in the field of type 2 diabetes research) is generally characterized by Mode 1 instead of Mode 2 knowledge production as evidenced by the statistical importance of all proximities in explaining inter-organizational collaboration.

What is missing is this framework, however, it the role of users. In this context, it is important to recall that one of the initial tenet of the innovation system concept was to the importance of user-producer interaction in innovation processes (Lundvall 1988). Here, users may refer to downstream clients within value chains or final users. In either case, studies using the proximity concept have largely ignored the interaction between firms and its users. Arguably, particularly with end users, proximity may be largely absent in user-producer relations rendering collaboration challenging.

4. NEXT STEPS

A limitation in the majority of studies on proximity and innovation has been the static perspective on proximity. The focus has been on understanding collaboration and learning from proximity relations among actors. To the extent that change is taken into account, it is mostly done in a comparative static approach by investigating whether the effect of proximity on collaboration is changing over time (Hoekman et al. 2010; Balland et al. 2013; Ter Wal 2014) and whether the network structure itself affect the formation of new ties in the next period (Balland et al. 2013). However, the proximity between organizations itself is also subject to change and such changes may be at least partly due to the learning process itself. Hence, as advocated by Balland et al. (2015), a dynamic and endogenous approach to proximity would be a possible next step in thinking about proximity and innovation. The proximity dynamics, then, follow from the interacting actors becoming more similar over time. This phenomenon s more generally known as 'social influence' between individuals in sociology (Friedkin 1998). Social influence expresses the idea that social networks tend to diffuse behavioural norms and shape individual's characteristics. Whether or not this also applies to organizations, however, remains an open question.

One can elaborate Boschma's (2005) five forms of proximity in a dynamic setting, as done by Balland et al. (2015). Regarding cognitive proximity, the co-evolutionary logic entails the process of interactive learning, which will in turn reduce the cognitive distance between partners. Also note that as this distance becomes smaller over time, the opportunities to learn decrease (and the extent of competition may increase), which may lead partners to end their collaboration as a result. Obviously, collaboration also increases social proximity over time as

people from different organizations get more acquitted with each other, which may equally harm effective collaboration (Grossetti 2008). In addition, collaboration may induce job mobility between organizations further strengthening their social ties. Repeated collaborations may also contribute to the creation of common values, goals, and ethical practices (Gilly and Torre 2000). In such processes, institutional proximity between partners increases over time as a result of collaboration. Finally, organizational proximity can increase as collaboration lead to together integration of two organizations, and possibly even to mergers (Hagedoorn and Sadowski 1999).

This leave one with the question whether the same co-evolutionary applies to geographical proximity. Indeed, the wish to intensify knowledge networking with partners at a distance may itself become a motive to relocate close to partners or set up a branch in regions where partners are located. Note that this logic reverses causality generally assumed in economic geography, where co-located partners are assumed to become prone to collaborate and learn. Instead, co-location may actually result from such collaborations in the past. This way of thinking further underlines the importance of taking an evolutionary approach to network analysis in proximity research.

As a second line of research to pursue in future proximity research on innovation and networking, one may wish to go beyond dyadic analysis. It is quite striking that in the large majority of empirical studies, the focus lies on explaining why some organizations collaborate and others do not (and whether such collaborations are successful). The analysis, then, focuses on whether proximity between two actors – that is, at the dyad-level – affects the probability and success of that particular collaboration. However, organizations generally maintain many relationships at the same time and thus learn from many different actors simultaneously. Hence,

a portfolio view on inter-organizational networking is important as to understand the decisions underlying the choice of partners as well as the effect of such partnership on innovation (Cui and O'Conner 2012; Van de Vrande 2013).

From a portfolio perspective, the notion of optimal proximity becomes a subtler one (Boschma and Frenken 2010). Rather than assuming that there is some optimal distance between the focal organization and any partner, the optimal distance between an organization and one particular partner may well depend on the distance between an organization and its other partners. In particular, for any proximity dimension, one may expect that the optimal mix of distances is one in which an organization maintains relations both with proximate and with distant partners (Uzzi 1996; Burt 2004). Proximate partners help organizations to exploit their existing knowledge by further deepen their understanding in specialized contexts. Distant partners, by contrast, help organizations to explore new knowledge and new application contexts, which may be key to organizational performance in the longer run.

The portfolio perspective also bears implications for the dynamic view on proximity. As explained, one may expect that especially the partners' cognitive proximity increases over time. From a dyadic perspective, then, a partnership may end as and increased cognitive proximity implies fewer learning opportunities. However, from a portfolio perspective, this may not hold true. The extent that cognitive proximity increases over time as a result of learning processes will also depend on the number of relations that an actor maintains with other partners. The more such relations, the less the knowledge base will be influenced by a single partner, the less likely an organization's knowledge base will converge with the knowledge base of one of its partners. The hypothesis then holds that, *ceteris paribus*, two organizations with more partners will engage in longer relationships compared to two organizations with fewer partners.

5. FINAL REMARKS

Our review has been concise and fully focused only on the way the proximity concept has been applied in research on inter-organizational collaboration and innovation. We did not touch upon related research areas on collaborative innovation in economic geography including the role of gatekeepers, informal knowledge sharing, intra-organization networking, etc. Such topics would deserve a review on their own and otherwise draw less on the proximity concept than inter-organizational collaboration.

And, within the broader field of innovation studies, the proximity concept has also been used to study other phenomena including knowledge spillovers (e.g. as indicated by patent citations) and innovation outcomes of Mergers and Acquisitions, just to mention two examples. What is more, studies in evolutionary economic geography (Boschma and Frenken 2018) that look at regional development, build strongly on the notion of technological relatedness, *viz.* cognitive proximity, to explain regional development as an evolutionary process where new activities build closely on capabilities built up in the past. It shows the wide appeal and applicability of the proximity concept in the field and suggests that the framework can be extended, and applied, in many new ways in the years to come.

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