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Not too close, not too far. Towards an Empirical Test of the Goldilocks Principle of Non-Geographical Distance in Collaboration Networks for Innovation

Rune Dahl Fitjar
University of Stavanger
Centre for Innovation Research, Business School
rune.d.fitjar@uis.no

Franz Huber
University Seeburg Castle
Business Administration
fra.huber@gmail.com

Andrés Rodríguez-pose
London School of Economics and Political Science
Department of Geography and Environment
a.rodriguez-pose@lse.ac.uk

Abstract

It has been argued that not only geographical proximity but also cognitive, organisational, social and institutional proximity may be important for innovation networks. However, excessive proximity can also be harmful as it reduces the scope for learning. Hence, one possible solution is that collaboration with partners for innovation should follow the Goldilocks principle of being not too close and not too far, but occurring at just the right distance. In contrast to previous studies, we measure proximities more directly by asking firm managers about their perception of the distance across each of the dimensions to their most important partner. The data set covers 533 firms with more than ten employees across all industries and all regions of Norway. A first contribution is that the results tend to confirm the basic proposition of the Goldilocks principle that for product innovation, a medium level of distance to partners outperforms collaboration at both lower and higher levels of distance. Subsequently, we examine the relationship between geographical and non-geographical proximity dimensions. There is a significant degree of interaction, whereby firms with a low level of geographical proximity and higher levels of cognitive and institutional proximity are significantly more likely to innovate.

This supports the theoretical perspective of a substitution mechanism, whereby geographical distance can be compensated by proximity in another dimension. There is no empirical support for an overlap mechanism, as the combination of high geographical proximity and high non-geographical proximity does not show a positive association with innovation.

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Abstract

Over the past ten years, a growing literature in economic geography has acknowledged that distance does not only have a geographical dimension, but also comes in cognitive, organisational, social and institutional forms. A main idea in this literature is that collaboration for innovation requires a certain level of proximity in all non-geographical dimensions for successful knowledge transfer to occur. However, excessive proximity can also be harmful as it reduces the scope for learning. Hence, one possible solution is that collaboration with partners for innovation should follow the Goldilocks principle of being not too close and not too far, but occurring at just the right distance. An increasing number of contributions have sought to test this principle using empirical data, but the indicators used are often quite crude and based on register data using strong assumptions about the relationships between sectors, places and organisations. In this paper, we attempt to measure proximities more directly by asking firm managers about their perception of the distance across each of the dimensions to their most important partner. The data is based on matched data from two surveys of Norwegian firms, conducted in 2013, in which firms were asked about their innovation activities and about their most important partners in innovation processes. The data set covers 533 firms with more than ten employees across all industries and all regions of Norway. We examine the level of innovation in terms of new-to-firm and new-to-market product innovation for firms that collaborate with partners at different levels of distance in each dimension, compared to firms which do not collaborate with any partners. The results tend to confirm the basic proposition of the Goldilocks principle that a medium level of distance to partners outperforms collaboration at both lower and higher levels of distance. Firms with medium cognitive, social and institutional proximity to partners are significantly more likely to introduce new products, while a low level of geographical proximity is associated with the highest levels of innovation. Subsequently, we examine the relationship between geographical and non-geographical proximity dimensions, finding that the geographical proximity to partners is not significantly correlated with any of the non-geographical dimensions. However, there is a significant degree of interaction between geographical and non-geographical proximity, whereby firms with a low level of geographical proximity and higher levels of cognitive and institutional proximity are significantly more likely to innovate. This supports another important proposition in the literature of a substitution mechanism, whereby distance in one dimension can be compensated by proximity in at least one other dimension. There is no empirical support for the overlap mechanism, as the combination of high geographical proximity and high non-geographical proximity does not show a positive association with innovation.

1. Introduction

It has been widely acknowledged that 'open' strategies, which allow the outflow and inflow of knowledge and resources across organisational boundaries, are promising for innovation (Chesbrough, 2003; Enkel et al., 2009). In this context, external networks with partners, for instance knowledge-intensive strategic alliances, can facilitate the innovation process (Narula and Hagedoorn, 1999). Yet, more research is needed to understand to what extent characteristics of the participating actors (on individual or organisational level) are related to innovation performance (Capaldo and Petruzzelli, 2014). Within this context, it has been argued that geographical distance between actors in inter-organisational networks matters for innovation. This discourse has been enriched by recent literature, which stresses that alternative forms of proximity such as social or cognitive proximity between actors need to be considered too (Boschma, 2005; Lagendijk and Lorentzen, 2007; Lagendijk and Oinas, 2005; Torre and Rallet, 2005).

Whilst proximity can be critical for facilitating efficient and effective interaction between actors, too much proximity can hamper innovation as it reduces the scope for novelty and learning. This tension has been called 'proximity paradox' by Boschma and Frenken (2010). However, it is not really a paradox, as there is no inherent contradiction in saying that there is an optimal level of proximity that lies somewhere in between the extremes of very high and very low proximity. Hence, we refer to this instead as the "Goldilocks principle", arguing that collaboration with partners for innovation should be not too close and not too far, but rather at a distance which is just right.

Empirical investigations of this principle have often used indirect indicators that are quite crude. In this paper, we attempt to measure proximities more directly by asking firm managers about their perception of the distance across each of the dimensions to their most important partner. We aim to investigate the role of various types of proximity by examining possible interrelationships between them and by considering the distributions of proximity levels instead of merely looking at average values. The results confirm the relevance of the Goldilocks principle and make important qualifications. Furthermore, the paper finds confirmation for the substitution mechanism as geographical distance can be compensated by proximity in other dimensions. There is no evidence of an overlap mechanism as the combination of high geographical and high non-geographical proximities is not positively associated with innovation.

The paper proceeds as follows. First, section 2 provides an overview of relevant theoretical debates. Section 3 outlines the research methods including the novel dataset. The empirical results are presented in the analysis section 4 and the paper concludes with a discussion of the results in section 5.

2. Theoretical framework

Proximity for innovation

It has been widely argued that geographical proximity can be beneficial for inter-organisational collaboration and innovation (Moulaert and Sekia, 2003). Within this context, it has been argued that the possibilities of face-to-face interactions reduce coordination costs and facilitate the transfer of

tacit knowledge (Howells, 2002; Lawson and Lorenz, 1999; Storper, 1997). In general, proximity has been argued to be an important factor for innovation (Knoben and Oerlemans, 2006). This is usually based on the argument that a certain form of proximity is required for successful knowledge interactions. It has been argued that proximity between organisations facilitates knowledge interactions via facilitating coordination and reducing uncertainty (Boschma, 2005). Proximity refers to the degree of closeness of actors and is often characterised by the degree of similarity of actor characteristics. Importantly, the recent discourse on proximity has emphasised that we need to consider various types of proximity in addition to geographical proximity, including organisational, social, cognitive or institutional proximity (Boschma, 2005; Gertler, 2004; Lagendijk and Lorentzen, 2007; Lagendijk and Oinas, 2005; Mattes, 2012; Torre and Rallet, 2005; Zeller, 2004). Whilst these concepts have been defined and operationalised in various ways (see section 3 below), in this paper we aim to follow the influential contributions by Boschma (2005) and Boschma and Frenken (2010).

Social proximity refers to the strength of interpersonal links in the sense of interacting socially.[1] This notion has been influenced by the embeddedness literature (Granovetter, 1985; Uzzi, 1996), which has stressed the importance of social context for economic action. In this tradition, it has been widely argued that trust-based ties, based on friendship or repeated interaction, can facilitate knowledge interaction for innovation (Gertler, 2004, p. 156).

Whilst *organisational proximity* has been defined and operationalised in various ways (see section 3 below), in this paper it refers to the extent to which the external partnerships are organised through formal arrangements. This is based on the idea the degree of control of organisational relations, which can range from 'on the spot' market to formal arrangements of different degree. Organisational proximity is often seen to reduce uncertainty and opportunism, which is beneficial for developing innovation networks (Boschma and Frenken, 2010).

Furthermore, *institutional proximity* refers to the extent to which the partner's norms and values are similar. The level of similarity of formal or informal institutions (North, 1990) can influence inter-organisational relationships. For instance Gertler (2004) has illustrated that the macro-level institutional differences of German versus Canadian machinery producers can affect learning and innovation. Also the different institutional settings of university versus industry versus government actors can be a hurdle for interactions (Etzkowitz and Leydesdorff, 2000).

Finally, *cognitive proximity* refers to extent to which actors are sharing a common knowledge base and expertise. The capacity to identify, understand and exploit external knowledge requires cognitive proximity (Cohen and Levinthal, 1990). Cognitive proximity is vital for understanding each other in R&D alliances (Nooteboom et al., 2007) and for inventions as indicated by patent citations (Breschi and Lissoni, 2009). The notion of cognitive proximity can include sub-dimensions and similarity in terms of technical language appears to be the most critical one (Huber, 2012a). The latter study suggests that whereas high levels of similarity in terms of technical language are very important, certain levels of dissimilarity in terms of know-how, know-what and the way of thinking can be fruitful for important inter-organisational knowledge relationships of R&D workers.

[1] This has sometimes been referred to as relational proximity (Coenen et al., 2004) or personal proximity (Schamp et al., 2004).

As discussed in section 3 below, these types of proximities have been operationalised in various ways and often in a highly indirect fashion. One contribution of this paper is that it is based on a novel dataset, where proximities are measured using dedicated survey questions to capture the meaning of the non-geographical types of proximities more directly.

The Goldilocks principle

The theoretical arguments on the importance of proximity for innovation involve intricate dimensions (Mattes, 2012). As difference between actor characteristics can make understanding each other challenging (Nooteboom et al., 2007), proximity has been argued to facilitate interactions, as mentioned above. Yet, too much proximity between actors may make learning new knowledge difficult, and yet access to heterogeneous resources and diverse knowledge has been argued to be beneficial for innovation (Nooteboom, 2000). The *Goldilocks principle* of proximity being in the sweet spot between too close and too far away is therefore an important implication emerging from the literature. The underlying assumptions of the Goldilocks principle as understood in this paper are that first, collaborating with external partners is beneficial for innovation, and second, a medium level of proximity delivering the best innovative returns to collaboration. A generalised version of the Goldilocks principle would suggest that the optimum of the medium level concerns all non-geographical types of proximities. This has occasionally been referred to as a "proximity paradox" (Boschma and Frenken, 2010), although it does not actually constitute a paradox. Just as it is no paradox that Goldilocks can find one porridge which is too hot and another porridge which is too cold, there could also be an optimal distance between partners that lies somewhere in between close proximity and long distance. We therefore refer to this instead as the "Goldilocks principle".

Yet, the Goldilocks principle might only apply to certain types of proximity. Broekel and Boschma's (2012) empirical study shows that cognitive proximity reduces innovative performance but social proximity doesn't, which suggests that cognitive proximity might be most critical for the Goldilocks principle. Broekel and Boschma (2012) and Nooteboom et al. (2007) maintain that there may be an optimal level of cognitive proximity for innovation in the sweet spot between too high and too low. Overall, more empirical research is needed to shed light on the question of for which types of proximity the Goldilocks principle may apply. Furthermore, an alternative 'solution' to the proximity paradox could be that high proximity in certain dimensions are compensated by distance in other dimensions (Boschma and Frenken, 2010; Huber, 2012a). That is, the optimal level of proximity of one dimension may be dependent on the levels of proximity in other dimensions.

Interrelationships: overlap mechanism or substitution mechanism

This raises the issue of how the types of proximity are related to one another, which has been empirically underresearched. The traditional view in economic geography would be that geographical proximity facilitates proximity in the other dimensions (Malmberg and Maskell, 2006; Saxenian, 1994), which subsequently is beneficial for innovation. Yet, this territorial focus has been criticised. First, it has been argued and shown that geographical proximity does not automatically lead to useful territorial relationships, for instance regarding knowledge networks (Giuliani, 2007, p. e.g.) or social proximity (Huber, 2012b; e.g. Letaifa and Rabeau, 2013). Second, a growing number of studies illustrates that geographically distant relationships can be vital for knowledge exchange and innovation (Bathelt et al., 2004; Bathelt and Cohendet, 2014; Fitjar and Huber, 2014; Knoben and Oerlemans, 2012; Moodysson, 2008; Trippl et al., 2009). This line of argument is often based on an alternative view is that non-geographical proximities may be a substitute for geographical proximity.

For instance, the study by Capaldo and Petruzzelli (2014) shows that the association of geographical distance between partners on alliance-level innovation is contingent on organisational proximity. A generalised version would be that a compensation mechanism is in place, whereas distance in one type of proximity can be bridged by proximity in other types (Menzel, 2013), which has been confirmed empirically by Huber (2012a). That is, overall, two positions on the relationship between geographical and non-geographical proximities can be differentiated (Hansen, 2014a): the *overlap mechanism*, where geographical proximity facilitates non-geographical types of proximity, and the *substitution mechanism*, where non-geographical types of proximity are able to substitute for geographical proximity. Whilst recent research has started to explore this issue (Hansen, 2014a; Huber, 2012a), we need more empirical research to clarify the prevalence of the overlap and the substitution mechanism.

3. Methods

The paper is based on survey data from a survey of Norwegian firms with more than ten employees across the private sector of the economy. The survey was conducted in 2013 in two stages: First, a total of 2002 firms were telephone interviewed by the professional survey firm Ipsos MMI. The interviews were conducted with the CEO or general manager of each firm. As part of the interview, the firms were invited to participate in a follow-up web-based survey distributed by e-mail. In total, 1628 firms agreed to participate in the web-based survey, and 533 firms eventually filled in the questionnaire. The web-based questionnaire was also mainly filled in by the CEO (in 82.0 percent of the cases) or other management (17.3 percent of the cases), while non-management personnel filled in only 4 of the questionnaires. The data for both parts of the survey were then matched to generate a complete data set for the firms that participated in both surveys. In the paper, the questions pertaining to proximities are drawn from the web-based survey, while the questions on innovation are from the telephone interviews.

The measure of innovation relies on a battery of questions related to the firms' product development, building on the wording of the cross-European Community Innovation Survey. We first asked whether the firms had introduced any goods or services into the market in the preceding three years that were new to the firm or significantly improved compared to their existing products. Second, we asked firms that answered affirmatively whether any of these product innovations were new to the market or whether they were only new to the firm and very similar to a product that already existed in the market. From these two questions, we derive an ordinal measure of innovation with three categories: Firms without product innovations (no to the first question), firms with new-to-the-firm product innovations only (yes to the first and no to the second question), and firms with new-to-the-market product innovation (yes to both questions).

In the full data set, 47.9 percent of firms reported no product innovation, while 23.9 percent reported new-to-the firm innovation and 28.2 percent new-to-the-market innovation. Innovative firms participated to a somewhat higher extent in the web-based follow-up survey, where 40.2 percent reported no product innovation, 27.6 percent new-to-firm innovation and 32.3 percent new-to-market innovation.

Measuring proximity

The measures of proximity in collaboration with partners are based on an ego-network analysis with a battery of questions focusing on the firm's most important partner. The set of questions are introduced by inviting the firm representative to "think of the external partner which has been the most important for the firm's development of new products or processes during the past three years and answer in relation to the cooperation with this partner". At this stage, 15.5 percent of the firms indicated that they had not collaborated with any partners in the development of new products or processes. These were classified as having "no partners" and will be treated as the baseline in the analyses to follow. One of the questions pertains to the geographical localisation of the partner. This question is used to measure geographical proximity, which is classified as low if the partner is located within the same municipality or in the same region; as medium if the partner is located elsewhere in Norway; and as high if the partner is located outside Norway.

Another set of questions covers the non-geographical dimensions of proximity identified in the highly influential contribution by Boschma (2005). Following this contribution, the five dimensions of proximities have been analysed in numerous empirical studies. For the most part, these have been based on register data, using either patents (e.g. Rigby 2013; Feldman et al. 2014) or matched employer-employee data, or regional level data (Marrocu et al. 2013). These data sources typically provide information on only a limited number of attributes for each firm or region, and consequently, the proximity dimensions are often captured in a fairly indirect way. Other papers use indirect indicators of proximities at an aggregated regional level (Marrocu et al., 2013). By contrast, very few papers (Broekel and Boschma, 2011) have so far used survey data to capture how the firms interpret their proximity to the partner in a more direct way. Few studies (in particular Hansen, 2014b) have measure proximities in a more detailed fashion on the basis of interviews. This paper returns to Boschma's (2005) original definition of each of the dimensions and suggests an alternative operationalization in which managers of the firms involved are invited to reflect on their proximity to (or distance from) their partner on each of the dimensions, building on the definitions proposed by Boschma (2005).

Cognitive proximity has in previous studies typically been measured with reference to similarity of either products or technologies across partners. Studies based on products often measure cognitive proximity through partners' belonging to the same or different sectors or sub-sectors in studies at the firm level (Balland, 2012; Balland et al., 2013) or by comparing the sectoral composition of the units in studies of macro-level units, such as regions (Marrocu et al. 2013). Other studies measure the relatedness of technologies, relying on co-classifications of patents (Feldman et al., 2014) or co-occurrences of patenting (Broekel and Boschma, 2012). In the original definition, Boschma (2005: 63) states that "with the notion of cognitive proximity, it is meant that people sharing the same knowledge base and expertise may learn from each other". This can only be captured to a partial extent by looking at sectors or technology classes. We try to address the concept in more directly by asking to what extent firms agree or disagree with the statement "we share a common knowledge base and expertise with this partner".

Organisational proximity has been measured in very different ways in previous literature. Some studies examine whether the partners share similar types of organisations. For instance, Broekel and Boschma (2012) base their study on a dichotomy between profit and non-profit organisations. Others examine whether the firms belong to the same organisation, e.g. to the same corporation or business

group (Balland, 2013; Balland et al. 2013; Marrocu et al. 2013). The latter seems to better represent the theoretical concept, where "organizational proximity is defined as the extent to which relations are shared in an organizational arrangement, either within or between operations" (Boschma, 2005: 65). However, belonging to the same corporation represents an extreme end of the spectrum of sharing organisational arrangements, where the relationship between units is not only organised, but actually part of the same organisation. As we are more interested in examining cooperation across different corporations in the current paper, we focus instead on the organisation of relationships between partners and whether or not this takes the form of a formal organisational arrangement. Consequently, we build our measure on the level of agreement with the statement "our relationship with this partner is organised through formal arrangements".

Social proximity has typically been measured in previous literature by the number of connections between places in the form of co-inventorships (Marrocu et al. 2013; Feldman et al. 2014), by previous collaboration between the organisations (Balland et al. 2013) or by whether they have any partners in common (Balland 2013). Neither of these operationalisations seems to address the crucial notion of social embeddedness that Boschma attaches to this concept: "Social proximity is defined here in terms of socially embedded relations between agents at the micro-level" (Boschma, 2005: 66). This implies that we should be interested in relations that are not purely economic, but extend to the social setting, while all previous operationalisations have been based on previous or current relations among partners precisely in the economic sphere. By contrast, our definition seeks to get at the social embeddedness of relations by asking for the level of agreement with the statement that "we interact socially with the people who work in the partner's organisation".

Finally, institutional proximity has also been measured in different ways in previous literature. Balland (2013) proposes a similar definition to Broekel and Boschma's (2012) operationalisation of organisational proximity above, looking at whether the organisations belong to the private sector or to a variety of non-profit sectors (government, universities, civil society). A similar approach is used by Ponds et al. (2007). Other studies simply measure institutional proximity by whether the partners belong to the same country (Balland et al., 2013; Hoekman et al., 2008; Marrocu et al., 2013). These are both very crude ways of getting at the original definition that "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" (Boschma, 2005: 68). While the earlier operationalisations might provide some indication of whether the partners are subject to the same formal rules or legal systems, they cannot say very much about the similarity of cultural habits and values. In this paper, we focus particularly on the latter aspect, gauging the level of agreement with the statement "the partner's norms and values are similar to ours".

For all the questions, based on a five-point Likert scale, we classify those that fully agree with the statement as having a high level of proximity to the partner, those that partly agree as medium proximity, and those that are either neutral or who disagree, or strongly disagree with the statement as having a low level of proximity to the partner.[2] It is useful to go beyond merely analysing average values of proximities but to consider the distribution of proximities (Broekel and Boschma, 2011).

[2] The three lower categories on the Likert scale are not very prevalent and we therefore combined them into one category. The overall rationale of our categorisation was that the low proximity category is the below median category, high proximity is above median, while medium proximity is the median category.

Table 1 shows the distribution across the sample of firms for each of the five dimensions of proximity.

Table 1: Frequency distribution for the proximity dimensions

Dimension	Measure	No partners	Low proximity	Medium proximity	High proximity	N
Cognitive proximity	We share a common knowledge base and expertise with this partner	19.0 %	16.0 %	30.0 %	35.0 %	443
Organisational proximity	Our relationship with this partner is organised through formal arrangements	19.1 %	16.0 %	19.1 %	45.8 %	439
Social proximity	We interact socially with the people who work in the partner's organisation	19.1 %	49.9 %	18.9 %	12.1 %	439
Institutional proximity	The partner's norms and values are similar to ours	19.1 %	19.1 %	30.1 %	31.7 %	439
Geographic proximity	Where is the partner located?	17.7 %	17.9 %	23.3 %	41.2 %	476

Overall, Norwegian firms express high levels of proximity to their partners. High proximity is the modal category in four of the five dimensions, and low proximity is the least common response in each of these dimensions. The exception is social proximity, where nearly half the firms (49.9%) state that they do not tend to interact socially with their partners. Conversely, almost half the firms – 45.8% – express a high level of organisational proximity, in the sense that the relationship is shared in a formal organisational arrangement. Almost as many – 41.2 percent – collaborate with partners that are close in a geographic sense. More than a third of firms also state a high level of cognitive proximity with their partners, and only 16 percent classify their cognitive proximity as low. Nearly a third of firms also collaborate with partners with very similar norms and values to themselves, signifying a high level of institutional proximity.

4. Analysis

The Goldilocks principle rests on two main assumptions: First, firms may benefit from collaborating with external partners in innovation processes. Second, the returns to collaboration depends on the proximity between the partners, with a medium level of proximity delivering the best results. These assumptions are tested in the following sections through bivariate analyses using contingency tables and multivariate analyses using ordinal logit regression. In both cases, the analyses compare firms that collaborate with external partners at different levels of proximity to firms that do not collaborate with external partners.

Is proximity to partners associated with levels of innovation?

The first set of analyses examine bivariate correlations between the levels of proximity and the three product innovation outcomes. Table 2 shows five sets of contingency tables, one for each dimension of proximity. The data is consistent with the first assumption of the Goldilocks principle: The category "no partners" consistently has the lowest share of firms producing new-to-market innovations and

the highest share of firms which failed to introduce any product innovation at all. For most dimensions of proximity, the data is also consistent with the second assumption. In all the non-geographical dimensions of proximity, the highest share of new-to-market innovators can be found among those which collaborate with partners at medium levels of proximity. For cognitive, organisational and social proximity, firms with partners at medium proximity also report the highest level of innovation overall. Geographical proximity displays a somewhat different pattern, with firms collaborating with partners at a longer distance being most likely to innovate and to introduce new-to-market innovation. All bivariate correlations show statistically significant associations between the variables, with chi-squared tests significant at the 99 percent level or more.

However, there are some differences between the different dimensions when it comes to the strength of the associations and in particular the differences between the three levels of proximity in terms of the innovation outcomes. By far the highest chi-squared value and the largest differences in the share of innovative firms can be found in the geographical proximity dimension. Firms that collaborate with partners at low geographical proximity introduce new-to-market products more than twice as frequently as those which collaborate with partners located at high proximity and 1.7 times as frequently as those which collaborate with partners at medium proximity.

For the non-geographical dimensions, the differences are more muted. Indeed, the share of new-to-market innovators is almost identical across all levels of social proximity, although the overall share of innovators is more than 10 percentage points higher at medium levels of proximity. For cognitive proximity, the overall share of innovators is very similar across the three levels, but firms with partners at medium and high proximity report a higher share of new-to-market innovations. For organisational proximity, the share of innovative firms is also similar for medium and high proximity, although firms with medium proximity introduce more new-to-market innovations by more than 10 percentage points. For institutional proximity, there are very small differences in the levels of innovation for firms with low and medium proximity to partners, whereas those with high proximity tend to introduce innovations at a lower rate of around 10 percentage points both overall and for new-to-market innovation specifically.

Table 2: Proximity to partner and product innovation, contingency tables

	Product innovation, row percentages			
Type of proximity	**No innovation**	**New to firm**	**New to market**	**N**
Cognitive proximity				
No partners	52.38	32.14	15.48	84
Low proximity	38.03	36.62	25.35	71
Medium proximity	36.09	24.06	39.85	133
High proximity	39.35	23.87	36.77	155
Total	40.63	27.54	31.83	443
$\chi^2 = 19.70$, df = 6, P = 0.003				
Organisational proximity				
No partners	52.38	32.14	15.48	84
Low proximity	42.86	25.71	31.43	70
Medium proximity	35.71	20.24	44.05	84
High proximity	36.32	30.35	33.33	201
Total	40.32	28.02	31.66	439
$\chi^2 = 18.43$, df = 6, P = 0.005				
Social proximity				
No partners	52.38	32.14	15.48	84
Low proximity	39.27	25.11	35.62	219
Medium proximity	28.92	33.73	37.35	83
High proximity	41.51	22.64	35.85	53
Total	40.09	27.79	32.12	439
$\chi^2 = 17.53$, df = 6, P = 0.008				
Institutional proximity				
No partners	52.38	32.14	15.48	84
Low proximity	32.14	28.57	39.29	84
Medium proximity	34.09	24.24	41.67	132
High proximity	43.17	28.06	28.78	139
Total	40.09	27.79	32.12	439
$\chi^2 = 20.01$, df = 6, P = 0.003				
Geographical proximity				
No partners	52.38	32.14	15.48	84
Low proximity	21.18	22.35	56.47	85
Medium proximity	37.84	28.83	33.33	111
High proximity	44.9	27.55	27.55	196
Total	40.34	27.73	31.93	476
$\chi^2 = 37.86$, df = 6, P < 0.001				

Is the association between proximity and innovation robust to controls?

The second set of analyses examine the association between each of the proximity dimensions and the levels of innovation through a set of multivariate ordinal logit regression analyses. The purpose is to control for potentially confounding variables, such as the size, sector and technological sophistication of the firm. In the analysis, product innovation is defined as the dependent variables with three levels: No innovation, new-to-firm innovation, and new-to-market innovation. The main independent variable of interest is collaboration with partners at different levels of proximity, which is introduced in the form of dummy variables for collaboration with partners at low, medium and high proximity, respectively. The coefficient for each dummy variable represents the difference in the log odds of having a higher level of product innovation for firms in this category compared to those which do not collaborate with any partners.

We run five different models, one for each dimension of proximity. This is done for two reasons: First, because no partners is the baseline for all the five proximity variables. Including several of these variables in the same model would require selecting a different baseline for all except one of them, and this category could then not be compared to the no partners category. Second, to avoid including too many variables compared to the number of units in the model, in particular given that all the non-geographical proximity dimensions are fairly strongly correlated (Pearson's R is in the range of 0.60 to 0.76 for the bivariate correlations between these four variables).

The analyses further control for a number of factors which may be expected to affect firm's innovation output and could confound the analyses: First, the number of employees in the firm. Second, the share of employees with a tertiary level of education. Third, the level of investments in R&D as a share of the firm's total revenue. As the distribution of all these three variables is highly skewed, they are expressed as natural logarithms in the analyses. Fourth, the share of firm ownership by foreign stockholders. Fifth, the industry of the firm, measured as a set of fixed effects controlling for the following industries: Mining and quarrying; manufacturing; utilities; construction; wholesale and retail trade; food and accommodation services; transportation and storage services; information and communication services; financial and insurance services; and other services.

The analyses thus take the following form:

$$\text{logit}[\Pr(\text{Innovation}_i > j)] = \alpha_j + \beta_1 \text{Proximity}_i + \beta_2 \text{Controls}_i + \varepsilon_i \quad (1)$$

$j = \{\text{No innovation, New-to-firm innovation, New-to-market innovation}\}$

In this model, the probability of firm *i* having a level of product innovation which is higher that the *j*th category depends on the two vectors of proximities and control variables, explained above. Furthermore, the model includes a cut-off point a_j for each of the two lowest values of the dependent variable and a random error term ε with logistic distribution. Table 3 shows the results of fitting model (1) for each of the five proximity dimensions.

Table 3: Proximity to partner and product innovation, ordinal regression analyses

	Proximity type				
	Cognitive	**Organisational**	**Social**	**Institutional**	**Geographical**
Baseline: No partners					
Low proximity	0.10	0.37	0.29	0.37	1.01***
	(0.33)	(0.34)	(0.27)	(0.32)	(0.36)
Medium proximity	0.51*	0.45	0.63**	0.55*	0.51*
	(0.30)	(0.33)	(0.32)	(0.30)	(0.30)
High proximity	0.40	0.38	0.41	0.27	0.18
	(0.29)	(0.28)	(0.37)	(0.29)	(0.27)
Log no. of employees	0.09	0.10	0.09	0.09	-0.03
	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)
Log % of tertiary education	0.27***	0.27***	0.26***	0.26***	0.27***
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
R&D expenditure	0.57***	0.56***	0.59***	0.59***	0.68***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Share of foreign ownership	0.65**	0.63**	0.67**	0.68**	0.28
	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)
Industry fixed effects	Included	Included	Included	Included	Included
Cut 1	1.90	1.97	1.95	1.95	1.57
	(0.52)	(0.52)	(0.52)	(0.52)	(0.52)
Cut 2	3.32	3.40	3.38	3.38	3.06
	(0.54)	(0.54)	(0.54)	(0.54)	(0.54)
N	416	413	414	414	445
Log likelihood	-397.37	-397.83	-395.92	-396.17	-418.18
Pseudo-R^2	0.12	0.11	0.12	0.12	0.14

Note: The numbers in brackets refer to standard errors of the coefficients.
*: P < 0.10, **: P < 0.05, ***: P < 0.01

The results of the regression analyses are consistent with those from the bivariate analyses insofar as collaborating with partners at medium proximity is associated with a significantly higher probability of innovating at a higher rate in four of the five dimensions: Cognitive, social, institutional, and geographical proximity. The coefficient is relatively similar in all cases, ranging from 0.51 to 0.63, which corresponds to between 67 and 88 percent higher log odds of belonging to a higher category than if the firm has no partners. Organisational proximity is the only dimension in which partners at medium proximity do not provide a statistically significant benefit, although the coefficient remains positive. Furthermore, there is a strong and significant positive effect of collaborating with geographical partners at low proximity, which is also consistent with the bivariate analyses. This relationship also has the highest coefficient at $\beta = 1.01$, which corresponds to 175 percent higher log odds of innovating a higher rate. Conversely, collaborating with partners at high proximity does not yield significantly better results than having no partners at all in any of the dimensions. The same is true for collaboration at low proximity in all dimensions other than geographical proximity. It is worth noting that the significance tests reported in the analyses are based on comparisons against the baseline of no partners, i.e. the hypothesis that the coefficient is equal to zero, and hence this

does not indicate that the coefficients are significantly different from each other. Nonetheless, the analyses do show that collaboration with partners at medium cognitive, social and institutional proximity and at medium or low geographical proximity are the only types which are associated with significantly higher levels of product innovation.

Is there an association between geographical and non-geographical proximity dimensions?

The next question to be addressed is whether geographical and non-geographical dimensions are related. A central motivation for the contribution by Boschma (2005) was to uncover why geographical proximity would be related to interactive learning, the main argument being that geographical proximity facilitates the development of proximity in other dimensions. On this basis, a positive association between geographical and non-geographical dimensions of proximity might be expected. However, other contributions have instead argued for a compensation mechanism, whereby firms develop closer relationships in other dimensions to compensate for increased geographical distance (Huber, 2012a; Menzel, 2013). This suggests an alternative hypothesis of a negative association between geographical and non-geographical proximity dimensions.

In order to examine this relationship, Table 4 shows four sets of contingency tables between each of the non-geographical proximity dimensions and geographical proximity. The tables show the share of firms for each level of geographical proximity that have low, medium and high proximity to their partner on the non-geographical dimension. Overall, the tables show neither a statistically significant positive nor a negative association between geographical and non-geographical proximity. The chi squared tests for all associations show non-significant results. However, the patterns tend to support the presence of a negative rather than a positive association, as the share of partnerships with high cognitive, organisational and social proximity is highest among those with low geographical proximity.

Table 4: Geographical and non-geographical proximity, contingency tables

	Geographical proximity, column percentages			
Type of proximity	**Low proximity**	**Medium proximity**	**High proximity**	**N**
Cognitive proximity				
Low proximity	11.69	24.21	22.84	69
Medium proximity	40.26	30.53	38.27	122
High proximity	48.05	45.26	38.89	143
Total	100.00	100.00	100.00	334
$\chi^2 = 6.53$, df = 4, P = 0.163				
Organisational proximity				
Low proximity	13.16	18.75	25.79	69
Medium proximity	23.68	22.92	22.64	76
High proximity	63.16	58.33	51.57	186
Total	100.00	100.00	100.00	331
$\chi^2 = 5.58$, df = 4, P = 0.233				
Social proximity				
Low proximity	51.32	66.67	63.52	204
Medium proximity	30.26	22.92	21.38	79
High proximity	18.42	10.42	15.09	48
Total	100.00	100.00	100.00	331
$\chi^2 = 5.50$, df = 4, P = 0.240				
Institutional proximity				
Low proximity	33.77	21.05	20.13	78
Medium proximity	29.87	37.89	40.88	124
High proximity	36.36	41.05	38.99	129
Total	100.00	100.00	100.00	331
$\chi^2 = 6.38$, df = 4, P = 0.173				

The analyses in Table 4 examine whether there is an association between having partners at low or high levels of geographical proximity and the non-geographical proximity to partners. While there is no evidence of such an association, there might still be a relationship between the dimensions in the sense that firms that combine geographical and non-geographical proximities in certain ways are more likely to innovate. In order to examine this relationship, we respecify model (1) to include an interaction between geographical and non-geographical proximity dimensions. The model thus takes the following form:

$$\text{logit}[\Pr(\text{Innovation}_i > j)] = \alpha_j + \beta_1 \text{ Geographical proximity}_i + \beta_2 \text{ Non-geographical proximity}_i + \beta_3 \text{ Geographical proximity}_i * \text{Non-geographical proximity}_i + \beta_4 \text{ Controls}_i + \varepsilon_i \quad (2)$$

$j = \{\text{No innovation, New-to-firm innovation, New-to-market innovation}\}$

Table 5 shows the results of fitting this model to the data. We run four models, one for each of the non-geographical proximity dimensions.

Table 5: Interaction between geographical and non-geographical proximities and product innovation, ordinal regression analyses

	Cognitive	**Organisational**	**Social**	**Institutional**
Baseline: No partners				
*Low proximity * Low*	-0.24	1.70**	0.83*	0.72
geographical proximity	(0.72)	(0.80)	(0.44)	(0.48)
*Medium proximity * Low*	1.09**	0.02	1.19**	1.14**
geographical proximity	(0.46)	(0.56)	(0.50)	(0.52)
*High proximity * Low*	1.06**	1.18***	0.83	1.07**
geographical proximity	(0.46)	(0.42)	(0.63)	(0.51)
*Low proximity * Medium*	0.53	0.32	0.31	-0.13
geographical proximity	(0.46)	(0.54)	(0.35)	(0.52)
*Medium proximity * Medium*	0.30	0.80	0.54	0.91**
geographical proximity	(0.46)	(0.50)	(0.47)	(0.41)
*High proximity * Medium*	0.56	0.48	1.68**	0.51
geographical proximity	(0.39)	(0.36)	(0.69)	(0.40)
*Low proximity * High*	-0.02	0.09	0.11	0.58
geographical proximity	(0.40)	(0.40)	(0.31)	(0.42)
*Medium proximity * High*	0.31	0.29	0.39	0.16
geographical proximity	(0.36)	(0.42)	(0.41)	(0.36)
*High proximity * High*	-0.01	0.03	-0.40	-0.13
geographical proximity	(0.35)	(0.33)	(0.52)	(0.35)
Log no. of employees	-0.01	-0.01	-0.02	-0.06
	(0.12)	(0.12)	(0.12)	(0.13)
Log % of tertiary education	0.25***	0.28***	0.25***	0.26***
	(0.09)	(0.09)	(0.09)	(0.09)
R&D expenditure	0.60***	0.59***	0.64***	0.60***
	(0.12)	(0.12)	(0.12)	(0.12)
Share of foreign ownership	0.65**	0.56*	0.64**	0.66**
	(0.32)	(0.32)	(0.32)	(0.32)
Industry fixed effects	Included	Included	Included	Included
Cut 1	1.64	1.68	1.68	1.55
	(0.54)	(0.54)	(0.54)	(0.54)
Cut 2	3.10	3.17	3.15	3.03
	(0.56)	(0.56)	(0.56)	(0.56)
N	393	390	391	391
Log likelihood	-366.45	-364.89	-364.04	-363.89
Pseudo-R^2	0.14	0.14	0.14	0.14

Note: The numbers in brackets refer to standard errors of the coefficients.

*: P < 0.10, **: P < 0.05, ***: P < 0.01

The analyses provide some support for the hypothesis of a compensation mechanism. In particular, the combination of high non-geographical proximity and low geographical proximity has a positive

coefficient in all models and is significant for cognitive, organisational and institutional proximity. The combination of medium non-geographical proximity and low geographical proximity is also positive and significant in three of the four dimensions: Cognitive, social and institutional proximity. In these cases, firms seem to be able to bridge low geographical proximity to their partners with higher proximity in one or more of the non-geographical dimensions. However, the combination of low geographical and non-geographical proximity is also significant for both organisational and social proximity, suggesting that firms that maintain distance to their partners across several dimensions can still benefit from these partnerships in their innovation processes. Yet, as Table 6 illustrates, the presence of at least one type of non-geographical proximity appears to be critical. Of the 77 instances of low geographical proximity, there is only one case (=1.3%) where non-geographical distance is present in all dimensions. And 27 out of 77 firms (=35.1%) with low geographical proximity to partners have medium or high proximity in all non-geographical dimensions. Looking at the whole sample of firms, there is only one out of 368 cases (=0.27%) where low geographical proximity is combined with low proximity in all non-geographical dimensions.

Table 6: Frequency of non-geographical proximity dimensions for low geographical proximity to partners

Number of non-geographical proximity dimensions	Low	Medium	High
4	1	1	8
3	6	5	9
2	19	27	25
1	24	22	18
0	27	22	17

For medium geographical proximity, only two of the coefficients are statistically significant, specifically the combinations with high social proximity and with medium institutional proximity. For high geographical proximity, none of the coefficients are significant. However, it is worth noting that the combination of high geographical and high non-geographical proximity has a negative coefficient in three of the four dimensions, indicating that too much proximity may indeed be harmful for innovation.

5. Discussion and conclusions

This study has examined the role of proximity for innovation by examining multiple types of proximity in a holistic fashion. A dedicated survey on proximities of nominated most important external partners for innovation offers more direct indicators of the levels of proximity than previous quantitative studies, which have tended to use indirect and rather crude measures. Also, this paper scrutinises the distribution of proximity variables rather than merely analysing mean values, and it considers that the types of proximity may not be independent of one another but interrelated.

The first contribution of the paper is to find support for and to substantiate the Goldilocks principle. This principle can potentially address the tension of the 'proximity paradox' (Boschma and Frenken, 2010) as collaboration with partners for innovation could work best when being not too close and not too far but just the right mid-level distance. Bivariate correlations largely support the generalised Goldilocks principle. The data is consistent with the first assumption of the Goldilocks principle. First, having external partners is positively associated with innovativeness. Second, the highest share of new-to-market innovators can be found among those which collaborate with partners at medium levels of proximity for all non-geographical types of proximity. For geographical proximity, it is those firms that are collaborating with partners at a longer distance that are most likely to innovate and to introduce new-to-market innovation, which supports previous findings (Fitjar and Huber, 2014; Fitjar and Rodríguez-Pose, 2013, 2011). Multivariate ordinal logit regression analyses also support the Goldilocks principle: collaborating with partners at a medium level of proximity is associated with innovating at a higher rate, which is statistically significant for all types except of organisational proximity. Collaborating with partners at high proximity is not associated with significantly better innovative results compared to having no partners at all.

A second contribution of the paper is to provide a novel empirical assessment of the role of the substitution mechanism and the overlap mechanism for innovation. Here it goes beyond the contribution of Hansen (2014a) and Huber (2012a) by linking the substitution versus overlap question to innovation outcomes. There is some evidence that geographical distance can be compensated by proximity in other dimensions, which illustrates the importance of the substitution mechanism for innovation. Geographically distant partnerships combined with high levels of cognitive, organisational and institutional proximity are positively associated with product innovation. Also medium levels of cognitive, social and institutional proximity combined with geographical distance are positively related with innovation. Granted, also low organisational and social proximity combined with low geographical proximity shows a positive relationship with innovation. Whilst the latter suggests that distance to partners across several dimensions can still be effective for innovation, the results show that at least one type of non-geographical proximity needs to be present. Low geographical proximity combined with low proximity in all non-geographical dimensions is only present in 0.27% of the cases. This provides support for the theoretical perspective of a substitution mechanism where geographical distance can be bridged by proximity in at least one dimension (Huber, 2012a). The results do not support the traditional argument of the overlap mechanism (Malmberg and Maskell, 2006; Saxenian, 1994) that geographical proximity facilitates the development of proximity in non-geographical dimensions, which subsequently facilitates innovation. On the contrary, although not statistically significant, the combination of high geographical and high non-geographical proximities tends to be negatively associated with innovation.

Several *limitations* of this study need to be considered.

First, as this study is centred on the ego-network analysis of the most important external partner, it is not able to shed light on the question of what the optimal overall configuration of the portfolio of external partnerships for innovation could be. As Boschma and Frenken (2010) have argued, having a

balanced mixture of different relationships, combining some proximate and some distant partners, may lead to optimal outcomes, which needs to be addressed by further studies.

Second, more research is needed to clarify why certain types of proximity can be beneficial for innovation, and how the compensation mechanism operates, which require more detailed research on the qualitative processes. Desired proximity characteristics may be dependent on intended motivations of partnerships (Hansen, 2014b) or may vary for different innovation activities, which requires further attention by future research.

Third, this paper has not included an analysis of the role of temporary geographical proximity (Bathelt and Schuldt, 2008; Torre, 2008).

Finally, of course, this research provides an empirical snapshot and cannot shed light on evolutionary dimensions of the role of proximities over time (Boschma and Frenken, 2010; Broekel, 2012).

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