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Changing the geographic scope of collaboration: Implications for product innovation novelty and commercialization

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Abstract

Prior research points out the benefits of external collaboration for innovation, yet little is known of: (a) the changes in the scope of external collaboration over time (i.e., firms increasing, seeking stability, or decreasing the geographic scope of their collaboration), and (b) how such changes in the geographic scope of collaboration affect product innovation novelty and commercialization. Here, we build on organizational learning theory, with the objective of exploring how changes in the geographic scope of collaboration over time affect the novelty of product innovation and its commercial success. Econometric analysis of a large panel of UK firms reveals three novel findings: First, while stability in the geographic scope of collaboration is common, there is a marked incidence of change, that is, firms are increasing or decreasing the geographic scope of collaboration. Second, while moving toward more geographically distant collaboration is beneficial mostly for radical innovation, maintaining stability in the geographic scope of collaboration is particularly beneficial for incremental innovation. Third, we demonstrate that becoming less international in the geographic scope might be beneficial for innovation commercialization. Finally, we identify six pathways to geographic collaboration that map to innovation outcomes.

KEYWORDS

collaboration, econometric analysis, product innovation

1 | INTRODUCTION

Collaboration is recognized as a way of accessing external knowledge for innovation—but should collaboration be local or distant? There has been a long-standing debate in the innovation literature about the *geographic scope of collaboration*, namely whether firms should collaborate locally or rather seek to engage with distant partners (Balland et al., 2015; Hansen, 2014, 2015; Mattes, 2012). Local collaboration allows knowledge to be exchanged relatively easily "because local firms are assumed to be more willing to share knowledge and exchange ideas with other local actors as a result of shared norms, values, and other formal and informal institutions" (He & Wong, 2012, p. 542). Some nations, regions, and local areas remain more "knowledge rich" than others (Roper & Love, 2018). One way for a firm to access such localized knowledge available elsewhere, is to expand

their collaboration with other organizations in selected geographic locations. For academics and managers, it is crucial to understand the geographic scope of collaboration, because it allows them to learn how successful firms increasingly innovate through networks that stretch across regional and national boundaries (Guile & Fosstenløkken, 2018; Hsieh et al., 2018).

However, while previous studies have assumed that collaborating with more distant partners can lead to greater innovative outputs than more local collaborations (Bertrand & Mol, 2013; Hsieh et al., 2018; Kafouros et al., 2020; van Beers & Zand, 2014), relatively little is known about the dynamics or *changes in the geographic scope of collaboration over time* at the firm level. An in-depth examination of these changes can alter and enrich our understanding of geographic collaboration. This is because *increasing* the *scope* from local/national collaboration to international linkages or vice versa could matter for *product innovation novelty* and its *commercialization*. For example, are there circumstances under which *reducing the geographic scope* of collaboration is beneficial for product innovation? When is it desirable to sustain *stability* with an existing geographic scope of collaboration?

We theorize that these decisions affect product innovation novelty and commercialization. Specifically, we argue that for a firm, moving toward more geographically distant collaborations, increases the likelihood of radical product innovation because such firms are seeking a variety of new knowledge. Furthermore, we contend that stability in the geographic scope of collaborations increases the likelihood of incremental product innovation as such firms are learning to refine knowledge from selected sources via stability in the geographic scope of collaboration. Our final hypothesis states that decreasing the geographic scope of collaborations leads to an increase in the commercial success of both radical and incremental product innovation because this strategy allows firms to learn to appropriate the returns from their innovation investment.

We draw on organizational learning theory and extend it in two ways. First, we focus on how the geographic scope of collaboration strategies of firms changes over time (i.e., firms increasing, seek stability, or decreasing the geographic scope of their collaboration). Second, we look at how these changes are linked to product innovation novelty and commercial success.

Regarding the first extension, research that combines *changes over time* in the geographic dimensions of *collaboration* matters because it has been shown to have implications for the innovation performance of firms. A recent study shows that UK firms change their external knowledge search over time and that such

Practitioner points

- Not all managers should move toward distant geographic collaboration. A strategy that maintains stability of the spatial scale of collaboration enhances modest continuous improvements in product innovations.
- Managers who bear the costs of increasing the geographic scope of collaboration, toward international collaborators, are more likely to produce radical market-disrupting product innovations.
- While total "reversion" to a closed strategy is detrimental to innovation, managers who periodically consolidate with less geographic distance in their collaboration, find it useful as this strategy enhances the commercialization of new product innovations.

"dynamic openness" strategies affect differently product versus process innovation (Kesidou et al., 2022). Likewise, Appleyard and Chesbrough (2017) suggest that technology firms may alternate knowledge sourcing strategies over time, for instance, going from open to closed innovation to appropriate the returns of innovation. Mavroudi et al. (2020) demonstrate how "temporal cycling" between exploratory and exploitative R&D has implications for business performance, suggesting that the dynamics of the organizational learning processes can change through time. Love et al. (2014) show that openness to external sources of collaboration reinforces the effects of future openness due to learning effects. These studies concentrate on the dynamics of different types of collaboration partners, while failing to pay attention to the geographic location of partners. Here, we extend the idea of dynamic openness to the *geographic* dimensions of collaboration for innovation.

In terms of the *geographic* dimension of collaboration, past studies have compared domestic with international collaboration in a static setting (Bertrand & Mol, 2013; van Beers & Zand, 2014) or the different sources of knowledge from local and international collaboration partners (Gittelman, 2007; Hsieh et al., 2018). By contrast, our concern is with the direction of geographic collaboration, rather than with partners as the knowledge source of that collaboration. We, therefore, concentrate on where the collaboration partners are located, rather than on the type of the partner. Collaboration in a new location helps access to local interactive knowledge (Roper et al., 2017), and collaborating with a new distant

partner provides access to not only its knowledge, but also local interactive knowledge offered by the new location. Given the changing nature of innovation needs, and the emergence of innovation clusters in different geographic locations, it is reasonable to expect some innovative firms to change the geographic extent of their collaboration from time to time.

With regards to the second extension, our underlying argument is that when firms can access knowledge from more distant geographic sources, they can enhance their innovation capacity by exposing themselves to more diverse and heterogenous knowledge that is not available locally or nationally. However, there are *costs* in doing so, which means that engaging in more international collaboration is not always optimal. Rather, moving toward more distant geographic collaboration is mostly associated with *radical product innovation*. By contrast, some dimensions of stability in geographic collaboration, or even a reduction in the geographic scope of collaboration, may be beneficial for *incremental product innovation*.

The empirical analysis is based on a panel of 16,021 firms made of the five waves of the UK Community Innovation Survey (UKIS) during 2009–2017. The results of our firm-level analysis show that while moving toward more geographically distant collaboration is beneficial for radical innovation, maintaining stability in the geographic scope of collaboration is beneficial for incremental innovation. Finally, we demonstrate that becoming less international in geographic scope might be beneficial for innovation commercialization.

The contribution of this article is threefold. First, we add to organizational learning theory by determining *ex ante* the conditions under which increasing, maintaining stability in, or decreasing the geographic scope of collaboration is beneficial to product innovation novelty and its commercialization. While orthodox theory concentrates on the benefits of accessing local or distant knowledge through partnerships (Balland et al., 2015; Bertrand & Mol, 2013), we conceptualize how strategic *change in the geographic scope of collaboration* is linked to different types of organizational learning for acquiring external knowledge for radical versus incremental product innovation, and for the commercialization of new product introductions. Second, we contribute to the openness of innovation literature by determining the boundary conditions of beneficial spatial change in collaboration for innovation. While a few prior studies (Appleyard & Chesbrough, 2017; Kesidou et al., 2022; Love et al., 2011) examined changes in the dynamics of collaboration (i.e., switching from open to more closed innovation strategies or the reverse), these studies did not consider the spatial dimension of collaboration. This article extends this literature by offering new insights into the dynamics of geographic collaboration and the effects of heterogeneous geographic collaboration strategies on innovation. We demonstrate that while more distant collaboration does indeed have innovation benefits, especially for *radical product innovation*, this is not always the case. Becoming less international in geographic scope can be beneficial for *the commercialization* of new products, and there is also evidence that maintaining stability rather than change in the spatial scale of collaboration is particularly beneficial for *incremental product innovation*. Finally, because we focus on intra-firm changes in the geographic scope of collaboration, we can determine the boundary conditions of beneficial spatial change. For example, while moving from UK regional to UK national collaboration is beneficial for incremental product innovation, a similar benefit in terms of radical product innovation requires a move from national to international collaboration. This offers new and nuanced insights into the dynamics of geographic collaboration and the effects of heterogeneous geographic collaboration strategies on innovation.

2 | THEORY

The theoretical basis for the benefits of external collaboration for innovation lies ultimately in organizational learning theory (Huber, 1991; Nooteboom, 1999). This suggests that firms have the capacity to learn from their activities which, through a process of performance feedback, leads to changes in organizational practices and routines (Argote & Miron-Spektor, 2011). These changes can in turn result in improved firm capabilities and ultimately improved performance (e.g., Jiménez-Jiménez & Sanz-Valle, 2011). Learning can be considered as a "reflexive, interactive and continuous process of recombining information and existing knowledge with new insights" (Glückler, 2013, p. 881). More specifically, organizational learning involves being able to access both internal and external knowledge and build appropriate competences and routines to make use of this knowledge (Powell et al., 1996; Roper & Love, 2018).

The crucial first step in organizational learning is the acquisition of new knowledge,[1] either by generating it internally or by (consciously or unconsciously) gaining knowledge from external sources. Where knowledge is to be acquired externally, Roper and Love (2018) differentiate between interactive and non-interactive knowledge search and learning activities. Interactive learning is

[1]Tippins and Sohi (2003) identify the other stages of organizational learning as information dissemination, shared interpretation, declarative memory, and procedural memory.

characterized by firms strategically building links and relationships with other firms and economic actors (e.g., research institutes, universities, and government departments) to capitalize on the knowledge of the linked parties or to cooperate with the linked parties and explore and/or exploit the knowledge together (Borgatti & Halgin, 2011). By contrast, non-interactive learning is characterized by the absence of reciprocal knowledge and/or resource transfers between actors, such as imitation and replication or reverse engineering (Glückler, 2013). Our concern is with the former, specifically in the context of innovation. By undertaking collaborations outside their own country firms are able to access more diverse and specialized forms of knowledge embedded in national innovation systems different from their own (Arranz & Fernandez de Arroyabe, 2008; van Beers & Zand, 2014), which in turn can complement the firm's internal knowledge generation activities (Erkelens et al., 2015; Hsieh et al., 2018).

Where successful, learning from external sources can also change the cognitive frameworks that help to shape a firm's ability to interpret and combine different forms of knowledge (Fiol & Lyles, 1985; Hsieh et al., 2018; Huber, 1991). This in turn encourages the firm to engage in the kind of activities that may lead to innovation: indeed, there is some evidence that innovation positively mediates the relationship between organizational learning and firm performance (Baker & Sinkula, 1999; Jiménez-Jiménez & Sanz-Valle, 2011), quite separately from organizational learning encouraging product innovation directly (Hsieh et al., 2018; Nasirov et al., 2021; van Beers & Zand, 2014). However, Love et al. (2011) demonstrate that the optimal degree of openness to external collaborators tends to alter at different phases of the innovation cycle, with high degrees of openness being appropriate for exploratory phases, but decreasing levels of external involvement becoming evident in the later, commercialization phase of innovation. We argue that changes in external knowledge search over time, referred to as "dynamic openness" (Kesidou et al., 2022), are also relevant to the analysis of the geographic scope of collaboration.

2.1 | Geographic scope of collaboration and innovation

There is a long-lasting debate in the economic geography and geography of innovation literatures stressing the positive impact of geographic proximity[2] on collaboration processes (Hansen, 2015; Morgan, 2004), and both assert that knowledge bases of firms are often highly localized (Oerlemans et al., 2001) and point out that it is easier to establish trustworthy and reciprocal inter-firm relations required for transfer of complex and tacit knowledge locally (Hansen, 2014), stimulating firm's innovation (Freel, 2003; Hsieh et al., 2018; Kafouros et al., 2020). However, excessive spatial proximity can draw attention into only local innovation networks, which can limit learning, and result in a situation called spatial lock-in (Jean et al., 2014; Molina-Morales et al., 2014). This can cause redundant ideas circulating inside the local networks and limit interaction with external networks, which can cause their cognitive environment becoming less diverse and possibly hindering innovation performance (Callois, 2008).

As a general rule, knowledge sources are relatively homogeneous within countries and more heterogeneous across countries (Bertrand & Mol, 2013). Because knowledge often involves direct face-to-face contact, and because knowledge spillovers are often spatially constrained (Berchicci et al., 2016), collaborations with local partners can be both relatively cost effective and effective in terms of innovation. However, local knowledge has limitations. It is likely to be provincial in nature (Granovetter, 1983), and less likely to produce the truly new or complementary knowledge that helps produce innovative products and practices. As Berchicci et al. (2016) suggest, local knowledge "... is likely to be familiar, to provide reassurance, but to be largely redundant" (p. 431).

By contrast, more distant knowledge pools have the advantage of being more likely to be dissimilar and complementary to the firm's existing knowledge sets, and therefore provide the opportunity for access to useful knowledge for innovation. Exposure to a range of heterogeneous knowledge helps promote technological learning, increasing the probability of creating valuable combinations of knowledge, and ultimately of producing innovative products (Hsieh et al., 2018). The trick is to access pools of distant knowledge, while maintaining the

[2]Proximity helps create other non-spatial factors, such as cognitive, organizational, social, and institutional proximities (Hansen, 2015). Cognitive proximity provides mutual understanding required to facilitate learning in close interaction (Mattes, 2012). Organizational proximity facilitates the exchange of stored information or codified knowledge, while social proximity promotes a willingness to share (especially tacit) knowledge with others. Institutional proximity refers to coherence regarding laws and values that create learning opportunities. While these non-spatial factors are also important for innovation, geographic proximity turns out to be less important empirically once non-geographic proximities are included in empirical analysis. The evidence nevertheless suggests that both geographic and non-geographic proximities tend to be positively correlated, and that geographic proximity facilitates the establishment of other forms of proximity (Balland et al., 2015). Thus, while in some cases non-spatial proximity can substitute for geographic proximity, geographic proximity can facilitate non-spatial proximity (Hansen, 2015).

direct contact required to absorb tacit knowledge and minimizing spillover outflows of knowledge which may result from spatial proximity. Many firms do this through research collaboration of some kind (Bertrand & Mol, 2013). The alliance portfolio literature argues an increase in portfolio internationalization[3] can put an initial barrier to knowledge exchange (Vanhaverbeke et al., 2015), but once effective collaboration routines are established the alliance may start to realize benefits from a greater flexibility, responsiveness, adaptability to global market conditions, reduction of risk and uncertainty, expansion of market reach to new product market, and sources of attractive technologies and resources that are in short supply (Lavie & Miller, 2008).

Collaborating with distant partners provides access to heterogeneous knowledge and so engaging in such collaborations provides access to knowledge that is more diverse than that from domestic collaborations of a similar kind (Hsieh et al., 2018; Kafouros et al., 2012; Ramadani et al., 2019; van Beers & Zand, 2014). For instance, Scalera et al. (2018) distinguish between domestic and international knowledge connections and show that accessing knowledge in foreign locations leads to innovation with wider technological scope. They argue that this happens because firms that develop international knowledge connections access a greater variety of knowledge inputs, which in turn are more valuable as they generate greater recombination opportunities (Scalera et al., 2018). Crucially, such collaborations provide access not just to the knowledge of the direct partners but permit access to localized knowledge that is spatially bounded and accessible by local members only (He & Wong, 2012), and so, to sets of geographically distant knowledge that would otherwise remain inaccessible. Empirical evidence—largely cross-sectional—suggests that more distant collaboration is generally more important for innovation (Bertrand & Mol, 2013; Freel, 2003; Hsieh et al., 2018; Kafouros et al., 2020; van Beers & Zand, 2014).

Changes in the geographic scope of collaboration can be understood by conceptualizing the different directional moves (e.g., toward more international or domestic colorations) a firm can choose. At any given point in time a firm is faced with the choice of remaining with its existing level of internationalization, becoming more international, or becoming less international. Notwithstanding the general benefits of geographically distant collaboration, in some circumstances opening up internationally may *not* be the optimal way forward. For example, Laursen and Salter (2014) address the "paradox of openness," in which managers have to balance the benefits of being open to new external sources of knowledge with the need to protect their own knowledge from being copied by competitors. Using extensive data on external innovation alliances among UK firms, Laursen and Salter (2014) find that while appropriability and openness initially move together, "high levels of appropriability are associated with decreasing levels of openness" (p. 868), suggesting that lower levels of external alliances may be appropriate where issues of appropriability are of greatest concern.

The same principle applies with respect to international collaboration. Through time the optimal level of international collaboration for a specific firm may change, and there is no guarantee that increased or continued levels of "internationalism" will remain optimal. The key issue is to determine under what circumstances increasing, decreasing, or having stability in the geographic scope of collaboration is beneficial at the firm level. We hypothesize below that these decisions affect the novelty of the innovation being undertaken and the commercialization of innovation. Specifically, we argue that organizational learning that expands access to knowledge sources from distant geographical regions enables radical innovation. On the other hand, organizational learning that refines knowledge from selected and trusted sources, by having stability in the geographic scope of collaboration, enables incremental innovation. Finally, we contend that organizational learning that controls and minimizes knowledge leakage, by decreasing the geographic scope of collaboration, enables the commercialization of innovations.

2.2 | Hypotheses

2.2.1 | Changing the geographic scope of collaboration and product innovation novelty

Conceptually and empirically, there are reasons to believe that moving to more geographically distant collaborations is beneficial for innovation at the firm level, that is, that there are positive dynamics of spatially distant collaboration. This is because there is likely to be a learning process involved as firms move toward increasingly international collaborations. Developing collaborations takes time and effort, first to identify suitable partners, then to manage these partnerships, and finally to build up the trust to develop meaningful collaboration over time (Love et al., 2014; Tsinopoulos et al., 2018). Knowledge diffusions across borders takes time (Kafouros et al., 2012). It takes time to fully comprehend and utilize knowledge acquired from international alliances (Lane et al., 2001). This makes the lessons learned from local collaborations potentially useful in developing more valuable foreign collaborations

[3]This refers to the degree of foreignness of partners in a firm's collection of immediate alliance relationships.

in the future. The knowledge gained from local/domestic networking can extend into developing foreign collaborations (Hsieh et al., 2018)—for example, lessons on partner selection and management can be used to secure and support more distant future collaborations, an effect noted by Love et al. (2014) in their analysis of how experience of previous innovation collaborations enhances the value of future collaborations. Again, this implies the effects of a time dimension on learning, with useful domestic or nearby collaborations leading to more valuable distant collaborations in the future. If this process is indeed in place, we should see a situation in which moving from less distant to more distant collaborations results in more, and more valuable, innovation at the level of the firm.[4]

There is some empirical support for this learning process from local to more distant collaborations, but generally restricted to comparisons of domestic versus foreign collaborations. Using Taiwanese and Spanish data respectively, Hsieh et al. (2018) and Kafouros et al. (2020) find that innovation collaboration with specific types of domestic partners helps firms form subsequent collaborations with foreign partners of the same type. In addition, both studies find that foreign partners are, on average, associated with higher levels of innovation than domestic partners. Moreover, there might be a network effect—international collaboration allows connections to a larger global innovation network, which can "increase the diversity of network players, locations, business models and network arrangements, creating new opportunities for knowledge diffusion and a substantial increase in the mobility of knowledge" (Ernst, 2009: vii).

However, the benefits of moving to more distant collaboration will differ depending on the novelty of the innovation. Prior research captures the degrees of novelty of product innovation (Freeman & Soete, 1997) via the development of taxonomies. They typically distinguish "radical" innovations, which are of new to the world products, from "incremental" innovations, which are new to the firm (but not to the market) improvements of existing product lines or next generation advances of products (Garcia & Calantone, 2002). We consider the degrees of product innovation novelty because their development process is different as "...what may be best practice for the development of incremental innovations may be detrimental to the development of radical innovations" (Holahan et al., 2014, p. 329). Also, the rewards to radical innovations are greater than the rewards to incremental innovation (Marsili & Salter, 2005).

[4]Of course, this learning process could also suggests that for some firms' geographic extensions to collaborations should not be pursued, or that a switch to more proximate collaborations is preferable. We allow for these scenarios in the empirical analysis.

Radical innovation requires new and unfamiliar knowledge (Schilling, 2013), which is more likely to be acquired through new distant collaboration as opposed to new domestic collaboration. But remote knowledge is never context free. Not only is it physically distant, but new knowledge is likely to be both cognitively distant (Mattes, 2012) and embedded in a cultural context that generates the knowledge and makes it valuable. This means that while the cost of accessing foreign networks and knowledge sources may be higher for an "outsider" firm, the causal ambiguity induced by the fact of becoming a part of a foreign network helps to make the knowledge acquired this way particularly valuable, as it is less able to be accessed or imitated by competitors who do not have ready access to the same networks. Causal ambiguity inhibits imitation by making it more difficult for an outsider to determine how knowledge is created and assimilated within a firm (Autio et al., 2000; Lippman & Rumelt, 1982). The uniqueness of foreign knowledge stems from that knowledge being both firm-specific and embedded in local country networks, which makes it difficult for an outsider to transplant it into another context (Kim, 2013), and more likely to create innovation radically new to the industry.

This is another example of the trade-off between costs and benefits of accessing remote knowledge networks: the costs may be high, but the rewards—the ability to protect the revenue streams arising from access to the knowledge—are correspondingly high. It is therefore reasonable to hypothesize that accepting this cost versus reward trade-off leads to more radical innovations which are new to the market rather than merely being new to the firm. These are the types of innovations where causal ambiguity is both more likely to arise (because it arises from embeddedness in foreign networks) and most likely to be valuable, because the revenue streams from the resulting innovations are most likely to be worth protecting and least likely to be imitated by rivals. This leads to our first hypothesis:

> **Hypothesis 1.** Moving towards more geographically distant collaborations increases the likelihood of radical product innovation.

Hypothesis 1 suggests that the potential benefits of accessing more remote knowledge through collaboration may be associated with radical innovation. However, the benefits of increasing the geographic scope may be less evident for incremental product innovations, where the trade-off between risk and reward in collaboration differs. It takes time to build up relationships with (distant) partners so that expanding the geographic scope of research collaboration activity, while it may permit access to knowledge not previously available, may occur at the expense of

developing and embedding the existing geographic relationships that the firm possesses. In the case of new-to-market innovation, this is a trade-off worth taking, and the benefits of increased knowledge may be regarded as offsetting the time and costs involved in embedding new and geographically distant collaborations. However, given that firms typically face limited managerial attention and "bandwidth" (Love et al., 2014; Ocasio, 1997), where causal ambiguity and the likely returns to innovation are lower it may not be worthwhile to incur the additional costs and risks of extending geographic collaboration. Instead, there is likely to be greater value in devoting limited managerial attention to maintaining the stability of established and already embedded geographic collaborations the costs and benefits of which are known, rather than developing new, more distant, more uncertain, and more resource-intensive linkages in which uncontrolled external knowledge sharing and accidental knowledge leaking is more likely (Ritala et al., 2018).

Of course, when firms devote their limited managerial attention to maintaining the stability of already embedded geographic collaborations, they are likely to be exposed to relatively familiar knowledge which will be cognitively proximate in terms of structure and, often, in terms of content (Berchicci et al., 2016). This in turn carries the risk of lock-in and over-embeddedness discussed earlier (Jean et al., 2014; Molina-Morales et al., 2014). Thus, stability in the geographic scope of collaboration is likely to be associated with incremental, new-to-business innovation, in which novelty and radical new knowledge is less valuable and causal ambiguity less of a concern than in the case of radical innovation. Here the routine nature of knowledge developed by existing, trusted relationships can be an advantage rather than a problem: firms avoid the risks and cost involved in maintaining and policing remote knowledge networks than with developing radically new knowledge. This leads to our second hypothesis:

> **Hypothesis 2.** Stability in the geography of collaborations increases the likelihood of incremental product innovation.

2.2.2 | Changing the geographic scope of collaboration and commercialization

The first two hypotheses deal with the introduction of new products, both radical and incremental in nature. However, changing the geographic scope of collaboration may also affect the successful commercialization of new product introductions. A priori one might expect that the benefits of expanding or having stability in the geographic scope of collaboration identified in the first two hypotheses might extend to the process of innovation commercialization: however, this may not be the case. On the contrary, the reverse may be true: there may be benefits in reducing the geographic scope of collaboration in order to maximize the returns to a new product introduction. There are two reasons for this.

The first arises from the beneficial properties of learning effects which persist even after the collaboration on which they are based comes to an end. Anecdotal evidence shows firms can benefit from disengaging with collaborating partners after learning enough from them and being ready to commercialize the innovation alone (Appleyard & Chesbrough, 2017). This suggests that a decrease in geographic scope of collaboration for innovation is relevant to the commercialization of innovation in international markets. This asymmetric effect on innovation of increases and decreases in a key variable has been identified elsewhere. In their analysis of the links between exporting and innovation in Italian manufacturing firms, D'Angelo et al. (2020) find evidence that while a rapid increase in export breadth reduces the probability of developing new innovative outputs, no such effects occur in the case of a decrease in firms' exporting activity. The key to this result appears to lie in the learning effects which persist even when the source of them is withdrawn: this involves knowledge from foreign markets in the case of D'Angelo et al. (2020), and knowledge from previous collaborations in the current case. Reducing geographic scope implies cutting ties with at least some former collaborators. At least in the short term, the knowledge gained from these collaborations will still be available to the parties concerned, so that the end of any given collaboration need not imply the end of innovation benefits arising from it. Indeed, there may be benefits in reducing geographic scope under some circumstances. While distant collaborations may be more knowledge-rich, they are also typically more resource-intensive and costly to maintain (Berchicci et al., 2016; Mattes, 2012). Given the limited nature of managerial attention and bandwidth (Love et al., 2014; Ocasio, 1997), periods of retrenchment from more distant collaborations allow management more time to devote to the commercialization and sales of the products developed in such relationships rather than constant preoccupation with developing new products. This in turn may explain why occasionally reducing the geographic scope of collaboration—especially from the most distant partnerships—can be accompanied by improved commercial performance from existing innovations while having no short-term effect on the firm's capacity to innovate.

The second reason why reduced geographic scope of collaboration enables innovation commercialization may be due to concerns over appropriability, which are linked to the paradox of openness (Arora et al., 2016; Laursen & Salter, 2014). While geographic openness can be beneficial

in searching for and absorbing new knowledge from product innovation, commercialization is a different process and principally concerns the need to exploit and protect the revenue streams arising from new product development activity. There is no reason to assume that the set of geographic collaborations which is optimal for knowledge sourcing and acquisition need necessarily be optimal for commercialization, where issues of appropriability loom large. Indeed, there is reason to believe this may not be the case. Laursen and Salter (2014) find that beyond some limit there is a negative relationship between the strength of emphasis a firm puts on appropriability and its breadth of innovation collaboration partners, suggesting that lower levels of external alliances may be appropriate where issues of appropriability are of greatest concern. While the Laursen and Salter analysis is cross-sectional and relates to *types* of collaboration partners, we suggest this may also be the case with regard to the geography of innovation partners through time.

Where protection of knowledge is more important than acquiring new knowledge, specifically in the commercialization phase of the innovation process, the benefits of geographic scope are less apparent, and the upsides of geographic proximity become more obvious: it is easier to detect and deal with knowledge leakage with a geographically close collaborator than with one which is more geographically distant (Ritala et al., 2018). For example, Lioukas and Reuer (2019) find that firms are more likely to limit the scope of alliance activities when the partners are from different countries because of appropriability concerns: monitoring and control becomes more cumbersome and problematic where distance is involved. In a UK context, Love et al. (2011) finds that the optimal degree of openness to external collaborators tends to alter at different phases of the innovation cycle, with high degrees of openness being appropriate for exploratory phases but decreasing levels of external involvement becoming evident in the later, commercialization phase of innovation. This leads to our final hypothesis:

> **Hypothesis 3.** Decreasing the geographic scope of collaborations increases the commercial success of both radical and incremental product innovation.

3 | DATA AND METHODS

3.1 | UK innovation survey

The empirical analysis is based on data from UKIS. The UKIS is an official survey administered by the Office of National Statistics (ONS) and is part of the core European Community Innovation Survey (CIS). The methodology of the UKIS survey is based on the Organization for Economic Co-operation and Development's (OECD) Oslo Manual (OECD, 1997). The survey collects information about the innovation activity of firms, research and development (R&D) and collaboration for innovation, as well as key indicators about the economic activity of firms such as employment, sector, and turnover. The interpretability, reliability, and validity of the survey were evaluated by extensive pilot tests by statisticians and economists working at the Office of National Statistics prior to its use in the UK and at the European Commission before its use in several European countries (DBEIS, 2019). The UKIS questionnaire is completed by the Director, Chief Executive Officer or the R&D manager of the firm in the same way as the Yale survey (Cohen & Levinthal, 1989).

The data are collected using a stratified[5] random sample, which is drawn from the ONS Inter-Departmental Business Register (IDBR) and is representative of the total population of UK firms with 10 or more employees. The UKIS is a biennial cross-sectional survey that covers innovation activities over a three-year period.[6] On average, the UKIS survey samples approximately 30,000 UK businesses per wave with approximately 50% average response rate.[7]

The empirical analysis is based on a pseudo panel data made out of the five waves of responses collected during 2009–2017. To obtain data about changes in geographic scope of collaboration over time (wave), we had to include businesses that participated at least two waves of the UKIS survey and exclude firms that were observed only once.[8] Table 1 shows that 8990 businesses (56%) responded in two waves, 4392 (27%) in three waves, 2122 (13%) in four waves, and 517 (3%) in five waves. This allows us to create a pseudo unbalanced panel of 16,021 businesses. For those businesses that participated in two

[5]Three variables were used for the stratification: (a) Region: all nine regions in the UK were included, (b) Industry: all sectors were included (i.e., both manufacturing and services). (c) Firm size: small, medium, and large firms.

[6]The UKIS 2009 covers the period 2006–2008, the UKIS 2011 covers the period 2008–2010, the 2013 UKIS covers the period 2010–2012, the 2015 UKIS covers the period 2012–2014, and the 2017 UKIS covers the period 2014–2016.

[7]Therefore, our samples consist of about 13,000–15,000 UK businesses in each wave and the surveyed businesses come from all the major sectors of economic activity in the UK.

[8]Our focus is on *changes across time* in the geographic scope of collaboration. In order to empirically observe such changes, we need to use two-waves of the UKIS. Firms that appear in only one wave of the survey are excluded because we know nothing about how their collaboration patterns change over time. As a result, we included 16,021 businesses that participated at least two waves of the UKIS and excluded 29,166 businesses that participated in the survey only once.

TABLE 1 Number of businesses and observations in the sample.

Number of observation periods[a]	Number of businesses observed[b]	Number of observations[c]
2	8990 (56.1%)	17,980 (42.6%)
3	4392 (27.4%)	13,176 (31.2%)
4	2122 (13.3%)	8488 (20.1%)
5	517 (3.2%)	2585 (6.1%)
Total	16,021 (100%)	42,229 (100%)

Abbreviation: UKIS, UK community innovation survey.
[a]Number of UKIS survey waves used to create the unbalanced panel dataset.
[b]Number of businesses that have responded to the corresponding UKIS survey waves.
[c]Total number of observations in the corresponding UKIS survey waves.

subsequent waves of the survey, the data covers 6 years of innovation activities, which should be sufficient to determine a significant change in the collaboration strategy.

3.1.1 | Independent variables

We measure *changes in the geographic scope of collaboration* with 25 mutually exclusive binary variables. These variables deepen our understanding of the dynamic changes in the direction of geographic collaboration that a firm may pursue over time. The construction of these variables is based on a sample of 26,208[9] observations as it includes firms that are observed in at least two waves of the UKIS survey. We summarize the steps below:

First, we measure the *maximum geographic extent* of a firm's collaboration for innovation in a given time period, regardless of the type of partners involved in that collaboration. We do so not because we believe that the type or extent of partner or knowledge source does not matter—researches such as Love et al. (2014) and Criscuolo et al. (2018) clearly show it does—but because we want to concentrate clearly on the dynamics of geographic sources of knowledge through collaboration rather than the collaborator types. This measure is based on a question in the UKIS that asks companies to report "did your business co-operate on any innovation activities?" Furthermore, respondents were asked to indicate the "location of collaboration" as follows: (a) UK Regional if collaboration partners located approximately 100 miles of the business' location in the UK; (b) UK National if collaboration partners located over 100 miles of the business' location; (c) European countries if collaboration partners located in any of the EU countries; and (d) Other International countries. The *maximum geographic extent of collaboration* measure is categorical. It takes the value zero if the firm is not engaged in collaboration, 1 if the firm's most distant collaboration partners are *UK Regional* partners, 2 if the firm's most distant collaboration partners are *UK National* partners, 3 if the firm's most distant collaboration partners are located in any of the *EU* countries, and 4 if the firm's most distant collaboration partners are other *International* partners beyond the EU.

Second, we construct the key explanatory variable—*Changes in the Geographic Scope of Collaboration*—by using the *maximum geographic extent of collaboration* measure over time. In doing so we measure the dynamics (i.e., changes over time) and the direction of geographic collaboration of firms with 25 mutually exclusive binary variables. Firms can pursue one of the following broad strategies: (a) *Increasing the Geographic Scope of Collaboration*: firms may begin to collaborate for the first time or collaborate with partners in more distant locations in period (t) compared to period (t–1).[10] (b) *Stability in the Geographic Scope of Collaboration*: firms may not change the direction of their geographic collaboration between period (t–1) and period (t), that is, they persist in their initial form of collaboration or non-collaboration.[11] (c) *Decreasing the Geographic Scope of Collaboration*: firms may discontinue collaboration entirely or collaborate with partners in less distant locations in period (t) compared to period (t–1).[12] Table 2 shows how the independent variables were measured in detail.

Table 2 indicates that approximately 66% of the firms do not change the direction of their geographic collaboration, with the largest persistence patterns among those

[9]Collaboration related questions pertain only to innovating firms therefore, the construction of the geographic scope of collaboration variables is based on a smaller subset of total observations.

[10]We identified 10 mutually exclusive strategies via which firms could increase the geographic scope of collaboration: *Opening from No-collaboration to UK Regional, Opening from No-collaboration to UK National, Opening from No-collaboration to EU, Opening from No-collaboration to International, Opening from UK Regional to UK National, Opening from UK Regional to EU, Opening from UK Regional to International*, *Opening from UK National to EU, Opening from UK National to International*, and *Opening from EU to International*.
[11]We identified five mutually exclusive strategies via which firms pursue stability in the geographic scope of collaboration: *Persistent No-Collaboration*, *Persistent UK Regional, Persistent UK National, Persistent EU*, and *Persistent International*.
[12]We identified 10 mutually exclusive strategies via which firms could decrease the geographic scope of collaboration: *Closing from UK Regional to No-collaboration, Closing from UK National to No-collaboration, Closing from EU to No-collaboration, Closing from International to No-collaboration, Closing from UK National to UK Regional*, *Closing from EU to UK National*, *Closing from EU to UK Regional*, *Closing from International to UK Regional*, *Closing from International to UK National*, and *Closing from International to EU*.

TABLE 2 Independent variables: changes in the geographic scope of collaboration.

	Definition	Number of observations (%)
Increasing the geographic scope of collaboration		
Opening from No-collaboration to UK Regional	A binary variable that takes the value of 1 if a firm was not engaged in collaboration in the previous period ($t-1$) and opens up by collaborating with UK Regional partners in the current period (t), and 0 otherwise.	809 (*3.09*)
Opening from No-collaboration to UK National	A binary variable that takes the value of 1 if a firm was not engaged in collaboration in the previous period ($t-1$) and opens up by collaborating with UK National partners in the current period (t), and 0 otherwise.	1617 (*6.17*)
Opening from No-collaboration to EU	A binary variable that takes the value of 1 if a firm was not engaged in collaboration in the previous period (t−1) and opens up by collaborating with EU partners in the current period (t), and 0 otherwise.	525 (*2.00*)
Opening from No-collaboration to International	A binary variable that takes the value of 1 if a firm was not engaged in collaboration in the previous period ($t-1$) and opens up by collaborating with International partners in the current period (t), and 0 otherwise.	872 (*3.33*)
Opening from UK Regional to UK National	A binary variable that takes the value of 1 if a firm collaborates UK regionally in the previous period ($t-1$) and opens up by collaborating with UK National partners in the current period (t), and 0 otherwise.	200 (*0.76*)
Opening from UK Regional to EU	A binary variable that takes the value of 1 if a firm collaborates UK regionally in the previous period ($t-1$) and opens up by collaborating with EU partners in the current period (t), and 0 otherwise.	40 (*0.15*)
Opening from UK Regional to International	A binary variable that takes the value of 1 if a firm collaborates UK regionally in the previous period ($t-1$) and opens up by collaborating with International partners in the current period (t), and 0 otherwise.	60 (*0.23*)
Opening from UK National to EU	A binary variable that takes the value of 1 if a firm collaborates in the UK National in the previous period ($t-1$) and opens up by collaborating with EU partners in the current period (t), and 0 otherwise.	178 (*0.68*)
Opening from UK National to International	A binary variable that takes the value of 1 if a firm collaborates in the UK National in the previous period ($t-1$) and opens up by collaborating with International partners in the current period (t), and 0 otherwise.	188 (*0.72*)
Opening from EU to International	A binary variable that takes the value of 1 if a firm collaborates in the EU in the previous period ($t-1$) and opens up by collaborating with International partners in the current period (t), and 0 otherwise.	175 (*0.67*)
Stability in the geographic scope of collaboration		
Persistent No-collaboration	A binary variable that takes the value of 1 if a firm does not collaborate in both the previous ($t-1$) and current period (t), and 0 otherwise.	15,019 (*57.31*)
Persistent UK Regional	A binary variable that takes the value of 1 if a firm collaborates in both the previous ($t-1$) and current period (t) solely UK regionally, and 0 otherwise.	224 (0.85)
Persistent UK National	A binary variable that takes the value of 1 if a firm's maximum geographic extent is the UK National in both the previous ($t-1$) and current period (t), and 0 otherwise.	827 (*3.16*)
Persistent EU	A binary variable that takes the value of 1 if a firm's maximum geographic extent is the EU in both the previous ($t-1$) and current period (t), and 0 otherwise.	311 (*1.19*)
Persistent International	A binary variable that takes the value of 1 if a firm's maximum geographic extent is international in both previous ($t-1$) and current period (t), and =0 otherwise.	888 (*3.39*)

TABLE 2 (Continued)

	Definition	Number of observations (%)
Decreasing the geographic scope of collaboration		
Closing from UK Regional to No-collaboration	A binary variable that takes the value of 1 if a firm collaborates UK regionally in the previous period ($t-1$) and then stops all collaboration in the current period (t), and 0 otherwise.	708 (*2.70*)
Closing from UK National to No-collaboration	A binary variable that takes the value of 1 if a firm collaborates in the UK National in the previous period ($t-1$) and then stops all collaboration in the current period (t), and 0 otherwise.	1443 (*5.51*)
Closing from EU to No-collaboration	A binary variable that takes the value of 1 if a firm collaborates in the EU in the previous period ($t-1$) and then stops all collaboration in the current period (t), and 0 otherwise.	474 (*1.81*)
Closing from International to No-collaboration	A binary variable that takes the value of 1 if a firm collaborates Internationally in the previous period ($t-1$) and then stops all collaboration in the current period (t), and 0 otherwise.	855 (*3.26*)
Closing from UK National to UK Regional	A binary variable that takes the value of 1 if a firm collaborates in the UK National in the previous period ($t-1$) and then closes down by collaborating with UK regional partners in the current period (t), and 0 otherwise.	203 (*0.77*)
Closing from EU to UK National	A binary variable that takes the value of 1 if a firm collaborates in the EU in the previous period ($t-1$) and then closes down by collaborating with UK National partners in the current period (t), and 0 otherwise.	12 (*0.48*)
Closing from EU to UK Regional	A binary variable that takes the value of 1 if a firm collaborates in the EU in the previous period ($t-1$) and then closes down by collaborating with UK regional partners in the current period (t), and 0 otherwise.	29 (*0.11*)
Closing from International to UK Regional	A binary variable that takes the value of 1 if a firm collaborates Internationally in the previous period ($t-1$) and then closes down collaborating with UK regional partners in the current period (t), and 0 otherwise.	58 (*0.22*)
Closing from International to UK National	A binary variable that takes the value of 1 if a firm collaborates Internationally in the previous period ($t-1$) and then closes down by collaborating with UK National partners in the current period (t), and 0 otherwise.	205 (*0.78*)
Closing from International to EU	A binary variable that takes the value of 1 if a firm collaborates Internationally in the previous period ($t-1$) and then closes down by collaborating with EU partners in the current period (t), and 0 otherwise.	173 (*0.66*)
Total		26,208 (*100*)

Note: The number of observations is $N = 26{,}208$. This includes firms observed in at least two waves of the UKIS survey. The italic values present percentages as indicated in the first row (%).
Abbreviation: UKIS, UK community innovation survey.

firms that are not engaged in collaboration (57%). Also, it shows that 18% of the firms increased the geographic extent of their collaboration by opening up. Specifically, 6% of these firms opened up by collaborating with UK National partners, while only 3% of the firms started to collaborate with international partners. Overall, a smaller fraction of firms (16%) reduced the geographic extent of their collaboration by closing down. 5.5% of such firms discontinued collaboration with UK National partners and 3% of firms in the sample stopped collaboration with international partners.

3.1.2 | Dependent variables

We use four different dependent variables to measure innovation, all of which are standard in the literature: (a) *Product innovation New-to-Market*; (b) *Product*

innovation New-to-Business; (c) *Innovation performance* (*New-to-Market*), and (d) *Innovation performance* (*New-to-Business*) (Table 3). The UKIS questionnaire defines product innovation as the introduction of new or significantly improved characteristics that lead to improvements in quality of a good/service or the development of distinct benefits for the user. The variable *Product innovation New-to-Market* differs from *Product innovation New-to-Business*, in that in the first case UKIS asks firms to report only those goods/services introduced to the market before their competitors, while in the latter case innovations are essentially the same as those already available by competitors. Based on firms' responses, we construct a binary variable, *Product innovation New-to-Market*, which takes the value of one if a firm introduced new or significantly improved goods or services to the market before competitors and zero otherwise. 10% of the firms indicated that they introduced a product innovation before their competitors.

The binary variable *Product innovation New-to-Business* takes the value of one if a firm introduced a new good or service that was essentially the same as a good or service already available from competitors and zero otherwise. Prior research points out that the first indicator captures radical technological change while the latter indicator is associated with incremental innovation. Table 3 demonstrate that 18% of the firms introduced product innovations that were new to their business. Finally, we measure the commercial success of firms' innovation with the *Sales Innovation New-to-Market* and *Sales Innovation New-to-Business* variables. UKIS asks firms to report the proportion of their turnover derived from innovations that were new to the market and from innovation that were new to their business, respectively. The variables range between 0 and 100. Table 3 shows that 2% of firms' sale on average derive from innovations new to market, whereas almost 3% of their sales is from innovation new to their business.

3.1.3 | Control variables

We control for time-varying factors that could influence a firm's innovation. The first control variable is a binary indicator of a firm's engagement in internal and/or external R&D. "R&D develops the firm's ability to identify, assimilate, and exploit knowledge from the environment" (Cohen & Levinthal, 1989, p. 569) and help firms to complete cooperative projects successfully by improving communication and coordination between internal and external R&D (Bougrain & Haudeville, 2002). Therefore, this variable allows us to test the classic Schumpeterian hypothesis asserting that R&D exerts a positive impact upon innovation performance (Antonelli, 2000; Battisti & Stoneman, 2010; Leiponen, 2005; Veugelers & Cassiman,

TABLE 3 Dependent and control variables.

Variables	Definition	*N*	Mean (*Std. dev.*)
Dependent variables			
Product innovation New-to-Market	Binary variable that takes the value of 1 if a firm introduced a new good or service to the market before competitors, and 0 otherwise.	42,229	0.10 (*0.3*)
Product innovation New-to-Business	Binary variable that takes the value of 1 if a firm introduced a new good or service that was essentially the same as a good or service already available from competitors, and 0 otherwise.	42,229	0.18 (*0.38*)
Sales Innovation New-to-Market	Continuous variable (left and right censored) that indicates the percentage of a firm's total turnover from goods and services that were new to the market.	27,158	2.28 (*9.76*)
Sales Innovation New-to-Business	Continuous variable (left and right censored) that indicates the percentage of a business's total turnover from goods and services that were new to the business.	27,528	2.96 (9.91)
Control variables			
R&D	Binary variable that takes the value of 1 if a firm undertakes internal and/or external research and development, and 0 otherwise.	42,229	0.24 (*0.43*)
Employment (Log)	Natural logarithm of number of employees.	42,229	4.47 (*1.55*)

Note: The italic values present Standard Deviation as inidciated in the first row (*Std. dev.*).

1999). Accordingly, *R&D* takes the value of one if a firm undertakes internal and/or external research and development, and zero otherwise. The second control variable is a measure of a firm's size, which is one of the conventional control variables used in innovation studies (Antonelli, 2000; Love & Mansury, 2007; Shan et al., 1994). Firm size is also an appropriate proxy for market power, which oftentimes affects innovation outcomes. We use the natural logarithm of number of employees—*Log* (*Employment*)—to measure a firm's size.

3.2 | Econometric approach

We test the hypotheses pertaining the dynamics of geographic collaboration (Hypothesis 1 and Hypothesis 2) with Equation 1. Specifically, we include 25 dummy variables that capture all mutually exclusive dynamic pathways of the *Changes in the Geographic Scope of Collaboration*. Table 2 provides a detailed explanation of the construction of these measures. Equation (1) allows us to test the impact of all possible dynamic strategies regarding a firm's *Changes in the Geographic Scope of Collaboration* upon the likelihood of innovation. We estimate Equation (1) with the Fixed Effect Logistic regression. The FE estimation approach examines the firm specific differences in the intercepts, for example, parameter estimates of time-invariant variables absorbed by the intercept because the time-invariant variables are specific to an entity and should not be correlated with other entity specific characteristics (Greene, 2003). The FE regression assesses the net effect of time-variant variables on the outcome variable. Thus, this estimation approach allows us to control for endogeneity that arises from unobserved heterogeneity (Wooldridge, 2002).

In Equation (1), we exclude the constant (β_0) in order to capture the impact of each dummy variable. Accordingly, Equation (1) takes the following functional form:

$$\text{Logit}\left(y_{it}^{*}\right) = \beta_1\, Changes\ Geographic\ Scope\ Collaboration_{it} + \beta_2 Controls_{it} + \delta_3\, Time_i + \delta_4\, Industry_i + u_i + \varepsilon_{it} \quad (1)$$

Where, y_{it}^{*} represents one of the two binary product innovation outputs (*Product innovation New-to-Market* and *Product innovation New-to-Business*). Where β_1 captures the effects of the changes in the geographic scope of collaboration and β_2 captures the effects of the control variables. δ_3 and δ_4 denote the time and industry fixed effects, which are uncorrelated with the idiosyncratic random error term ε_{it}.

In Equation (2) we assess the impact of the *Changes in the Geographic Scope of Collaboration* (Hypothesis 3) upon the commercial success of firms' innovation, that is, *Sales Innovation New-to-Market* and *Sales Innovation New-to-Business*. Both variables are measured in percentages, therefore, we estimate a Tobit regression to account for both right and left censored dependent variable. Accordingly, Equation (2) takes the following functional form:

$$\text{Tobit}\left(y_{it}^{*}\right) = \beta_1\, Changes\ Geographic\ Scope\ Collaboration_{it} + \beta_2\, controls_{it} + \delta_3\, Time_i + \delta_4\, Industry_i + \varepsilon_{it} \quad (2)$$

Where β_1 captures the effects of the changes in the geographic scope of collaboration and β_2 captures the effects of the control variables. δ_3 and δ_4 denote the time and industry fixed effects, which are uncorrelated with the idiosyncratic random error term ε_{it}.

4 | RESULTS

4.1 | Preliminary analysis: Transition probability matrix

We first present the transition probability matrix (TPM) to analyze the *transitioning from one geographic scope to another*, and to demonstrate that a firm's direction of geographic collaboration does change over time. Table 4 shows that businesses increase, decrease, or maintain stability in the direction of geographic collaboration. Moreover, the transition probabilities describe the probabilities of moving from *No-collaboration* to *UK Regional collaboration*, from *UK Regional collaboration* to *UK National collaboration*, from *UK National collaboration* to *EU collaboration*, and from *EU collaboration* to *International collaboration* as well as stability in each state during the period 2009–2017.

Our results unravel three key patterns with regards to the dynamics of geographic collaboration: (a) most firms seek stability by no-collaborating or by persisting in collaborating with international partners; (b) a substantial percentage of firms revert to no-collaboration, suggesting that Appleyard and Chesbrough's (2017) concept of "reversion" also applies to the geographic scope of collaboration; (c) if we focus solely on those firms that are already engaged in collaboration we observe that most firms, which change their collaboration, move toward more distant collaborations.

Specifically, the diagonal cells of a TPM denote the persistence effect, that is, the percentage of firms that

TABLE 4 Transition probability matrix: maximum geographic extent of collaboration.

	No-collaboration $_{(t)}$	UK regional collaboration $_{(t)}$	UK National Collaboration $_{(t)}$	EU collaboration $_{(t)}$	International collaboration $_{(t)}$	Total
No-Collaboration $_{(t-1)}$	15,019 (79.71%)	809 (4.29%)	1617 (8.58%)	525 (2.79%)	872 (4.63%)	18,842 (100%)
UK Regional Collaboration $_{(t-1)}$	708 (57.47%)	224 (18.18%)	200 (16.23%)	40 (3.25%)	60 (4.87%)	1232 (100%)
UK National Collaboration $_{(t-1)}$	1443 (50.83%)	203 (7.15%)	827 (29.13%)	178 (6.27%)	188 (6.66%)	2839 (100%))
EU Collaboration $_{(t-1)}$	474 (42.47%)	29 (2.60%)	127 (11.38%)	311 (27.87%)	175 (15.68%)	1116 (100%)
International Collaboration $_{(t-1)}$	855 (39.24%)	58 (2.66%)	205 (9.41%)	173 (7.94%)	888 (40.75%)	2179 (100%)
Total	18,499 (70.59%)	1323 (5.05%)	2976 (11.36%)	1227 (4.68%)	2183 (8.33%)	26,208 (100%)

Note: The TPM represents the probabilities of transitioning from one geographical scope of collaboration to another between time $t-1$ (column) and t (row).
Abbreviation: TPM, transition probability matrix.

continue in the same state. Persistence might be strong or weak (Clausen et al., 2012; Tavassoli & Karlsson, 2015).[13] Our results show strong persistence among closed firms, as 80% of the firms that did not engage in collaboration in two consecutive periods. There is also a strong persistence among firms collaborating internationally, as 41% of the firms that previously collaborated with *International* partners continued to collaborate with *International* partners. Yet, there is weak persistence among firms that collaborated with *UK Regional* partners in the previous period as only 18% of them continue to collaborate with *UK Regional* partners in the next period. Weak persistence is observed among those firms that collaborated with *UK National* partners and firms that collaborated with *EU* partners as well (29% and 28%, respectively).

The columns to the right of the diagonal cells in Table 4 indicate that firms move toward more geographically distant collaborations. We observe that only 20% of firms with no-collaboration in the previous period started to collaborate. If we focus on firms that are engaged in collaboration in at least two periods, we observe that most firms are increasing their maximum geographic extent of collaboration. 13% of the firms that collaborated with *UK National* partners in the previous period have increased their geographic extent of collaboration, by collaborating with *EU* (6%) or *International* (7%) partners. Finally, 16% of the firms that collaborated with *EU* partners in the previous period have increased the geographic extent of their collaboration with *International* partners.

The columns to the left of the diagonal cells in Table 4 indicate halting collaboration or a decrease in the maximum geographic extent of collaboration. Our findings show that 57% of the firms that collaborated with *UK Regional* partners in the previous period subsequently ended their collaborations. An almost equally large share of firms previously collaborated with *UK National* partners stopped collaborations in the next period (51%). A smaller share of firms that had collaboration with EU partners (42%) and collaboration with international partners (39%) decided to discontinue collaboration in the next period. Among firms that engaged in collaboration in at least two periods, we observe that a very small share of firms decreased their geographic extent of collaboration. Specifically, only 7% of the firms that previously collaborated with *UK National* partners decreased their geographic extent of collaboration to *UK Regional* partners. 14% of the firms that previously collaborated with *EU* partners and 20% of the firms that previously collaborated with *International* partners reduced their geographic extent of collaboration.

4.2 | Regression results: Fixed effects Logistic & Tobit panel data analyses

First, Table 5 (model 1, column 1) reports the findings pertinent to Hypothesis 1. The results indicate that increasing the geographic scope of collaboration is associated with a higher probability of introducing a *Product innovation New-to-Market* (or radical product innovation). The FE logistic regression (model 1) controls for unobserved time-invariant heterogeneity. Not surprisingly, the results show that opening up from *No-collaboration* to *UK Regional collaboration*, from *No-collaboration* to *UK National collaboration*, from *No-collaboration* to *EU Collaboration* and from *No-collaboration* to *International collaboration* is associated with a higher probability of introducing a radical product innovation. These results are statistically

[13]When the sum of the diagonal values is equal to or greater than 100% and the single diagonal values of the TPM matrix are larger than 50% then this is evidence of strong persistence. Alternatively, when the sum of the diagonal values is equal to or greater than 100% but not all diagonal values are greater than 50% this is evidence of weak persistence.

TABLE 5 Estimation results: changes in the geographic scope of collaboration and product innovation.

	Model 1 logistic fixed effect		Model 2 Tobit	
Variables	**(1) Product innovation New-to-Market**	**(2) Product innovation New-to-Business**	**(3) Sales innovation New-to-Market[a]**	**(4) Sales innovation New-to-Business[b]**
Increasing the geographic scope of collaboration				
Opening from No-collaboration to UK Regional	0.88*** (0.23)	0.76*** (0.14)	2.20 (2.51)	5.80*** (1.75)
Opening from No-collaboration to UK National	1.04*** (0.15)	0.98*** (0.11)	4.70*** (1.67)	6.10*** (1.21)
Opening from No-collaboration to EU	0.94*** (0.20)	0.83*** (0.16)	6.91*** (2.39)	7.52*** (1.82)
Opening from No-collaboration to International	0.84*** (0.16)	0.75*** (0.13)	12.49*** (1.86)	6.21*** (1.48)
Opening from UK Regional to UK National	−0.19 (0.30)	0.84*** (0.21)	2.22 (3.95)	10.92*** (2.82)
Opening from UK Regional to EU	−0.34 (0.49)	−0.12 (0.41)	2.37 (7.05)	7.40 (5.26)
Opening from UK Regional to International	−0.51 (0.49)	0.23 (0.39)	12.33** (5.56)	4.38 (4.24)
Opening from UK National to EU	0.66** (0.26)	−0.02 (0.22)	9.40*** (3.19)	2.51 (2.62)
Opening from UK National to International	0.46* (0.24)	−0.14 (0.21)	6.11** (3.10)	1.82 (2.59)
Opening from EU to International	0.23 (0.23)	0.09 (0.22)	13.31*** (3.02)	3.381 (2.62)
Stability in the geographic scope of collaboration				
Persistent No-collaboration	−0.49*** (0.12)	−0.24*** (0.07)	−13.63*** (1.33)	−9.21*** (0.87)
Persistent UK Regional	0.21 (0.30)	0.61*** (0.23)	2.35 (3.72)	6.11** (2.66)
Persistent UK National	−0.25 (0.16)	0.26** (0.12)	1.18 (1.95)	6.53*** (1.40)
Persistent EU	−0.01 (0.23)	0.38* (0.20)	5.45** (2.68)	4.30** (2.01)
Persistent International	0.02 (0.15)	0.24*** (0.13)	10.30*** (1.65)	5.36*** (1.35)
Decreasing the geographic scope of collaboration				
Closing from UK Regional to No-collaboration	−1.44*** (0.33)	−1. 10*** (0.16)	−22.97*** (5.41)	−4.29* (2.56)
Closing from UK National to No-collaboration	−1.22*** (0.19)	−1.20*** (0.12)	−7.58*** (2.68)	−4.71*** (1.77)
Closing from EU to No-collaboration	−1.30*** (0.26)	−0.89*** (0.18)	−1.13 (3.78)	−0.95 (2.7)
Closing from International to No-collaboration	−1.05*** (0.19)	−0.99*** (0.14)	−3.2 (2.82)	−8.33*** (2.34)
Closing from UK National to UK Regional	−0.69** (0.31)	0.15 (0.22)	−0.28 (3.97)	9.24*** (2.66)
Closing from EU to UK National	−0.08 (0.31)	−0.23 (0.25)	8.63** (3.83)	3.94 (3.10)
Closing from EU to UK Regional	0.53 (0.58)	0.01 (0.56)	17.26** (7.95)	5.61 (6.88)
Closing from International to UK Regional	−0.27 (0.46)	0.71* (0.41)	6.20 (6.11)	8.37** (4.78)
Closing from International to UK National	0.05 (0.25)	−0.16 (0.21)	8.12*** (3.36)	4.24 (2.59)
Closing from International to EU	−0.02 (0.23)	−0.12 (0.22)	9.43*** (3.13)	6.30*** (2.64)
R&D	1.50*** (0.08)	1.25*** (0.06)	30.80*** (0.81)	21.11*** (0.56)
Log (Employment)	−0.14 (0.08)	−0.08 (0.06)	−3.49*** (0.24)	−1.93*** (0.17)
Industry dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Chi^2	1384.86***	1822.15***		
Hausman Test Chi^2 [c]	479.2***	10.42**	–	–
LR test of sigma_u = 0 [d]	–	–	208.47***	113.10***
N[e]	7472	13,260	27,156	27,526

[a]Percentage of turnover due to product innovation new to the market.
[b]Percentage of turnover due to product innovation new to the business.
[c]The Hausman rejects the null hypothesis that unique errors (ui) are not correlated with the regressors.
[d]The Likelihood-ratio test of sigma_u rejects the null hypothesis that the panel level variance component is unimportant.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

significant 1% level and assert that opening up the geographic scope of collaboration from no-collaboration increases the likelihood of introducing radical product innovation regardless of the geographic location of the partners. More importantly and directly relevant to our Hypothesis 1, the results indicate that increasing the geographic scope of collaboration from *UK National collaboration* to *EU collaboration* (*Opening from UK National to EU*, $\beta = 0.66$, $p < 0.05$) and from UK *collaboration* to *International collaboration* (*Opening from UK National to International*, $\beta = 0.46$, $p < 0.1$) is associated with a higher probability of introducing a radical product innovation. In addition, the results provide strong evidence asserting that persisting in no-collaboration (i.e., *Persistent No-collaboration*, $\beta = -0.49$, $p < 0.01$) or discontinuing collaboration (i.e., *Closing from UK Regional to No-collaboration*, $\beta = -1.44$, $p < 0.01$; *Closing from UK National to No-collaboration*, $\beta = -1.22$, $p < 0.01$; *Closing from EU to No-collaboration*, $\beta = -1.30$, $p < 0.01$; *Closing from International to No-collaboration*, $\beta = -1.05$, $p < 0.01$) are associated with a lower probability of introducing a radical product innovation. Moreover, reducing the geographic scope collaboration from *UK collaboration* to *UK Regional collaboration* (*Closing from UK National to Regional*, $\beta = -0.69$, $p < 0.05$) is associated with a lower probability of introducing a radical product innovation.

Second, Table 5 (model 1, column 2) reports the findings for Hypothesis 2. The results indicate that maintaining stability in the geographic scope of collaboration has a greater effect than increasing the geographic scope of collaboration for *Product Innovation New-to-Business* (or incremental product innovation). Here we observe that, as in the case of radical product innovations, opening up the geographic scope of collaboration from no-collaboration is associated with a higher probability of introducing an incremental product innovation regardless of the geographic location of the partners. In addition, we observe that opening up from *UK Regional collaboration* to *UK National collaboration* ($\beta = 0.84$, $p < 0.01$) is associated with a higher probability of introducing an incremental product innovation. More importantly, the results indicate that maintaining stability in the geographic scope of collaboration (*UK Regional collaboration*, $\beta = 0.61$, $p < 0.01$; *UK National collaboration*, $\beta = 0.26$, $p < 0.05$; *EU collaboration*, $\beta = 0.38$, $p < 0.10$; I*nternational collaboration*, $\beta = 0.24$, $p < 0.01$) is associated with higher probability of introducing an *incremental product innovation*. By contrast stability in *No-collaboration* ($\beta = -0.24$, $p < 0.01$) is associated with lower probability of introducing an *incremental product innovation*. In addition, we observe that discontinuing collaboration (*Closing from UK Regional to No-collaboration*, $\beta = -1.10$, $p < 0.01$; *Closing from UK National to No-collaboration*, $\beta = -1.20$, $p < 0.01$; *Closing from EU to No-collaboration*, $\beta = -0.89$, $p < 0.01$; *Closing from International to No-collaboration*, $\beta = -0.99$, $p < 0.01$) is associated with lower probability of introducing an *incremental product innovation*.

Third, Table 5 (model 2, columns 3 & 4) presents the findings of the Tobit regression (model 2) pertinent to Hypothesis 3. The results indicate that decreasing the geographic scope of collaboration increases the commercial success of both radical and incremental product innovations. The results pertaining to opening up from no-collaboration to collaboration are in line with the previous findings indicating that opening up the geographic scope of collaboration from no-collaboration increases the commercial success of both radical and incremental product innovations regardless of the geographic location of the partners. This is hardly surprising as we would expect that collaboration with more distant partners is almost always more beneficial than no collaboration at all.

In addition, we observe that firms opening-up from *UK Regional to International* ($\beta = 12.33$, $p < 0.05$), from *UK National to EU* ($\beta = 9.4$, $p < 0.01$), from *UK National to International* ($\beta = 6.1$, $p < 0.05$) and from *EU to International* ($\beta = 13.31$, $p < 0.01$) were able to increase the proportion of their *sales* derived from *radical product innovations but not incremental product innovations*. While this may seem contradictory to the Hypothesis 3, it is actually in line with a priori expectations since a decrease in geographic scope of collaboration for innovation is relevant for firms that already have established collaborative links with international partners, including the EU partners. Indeed, the result show that firms that reduced the geographic scope of their collaboration from *EU to UK National* ($\beta = 8.63$, $p < 0.05$) or from *EU to Regional* ($\beta = 17.26$, $p < 0.05$) as well as from *International to UK National* ($\beta = 8.12$, $p < 0.01$) or from *International to EU* ($\beta = 9.43$, $p < 0.01$) were able to increase the proportion of their *sales* derived from radical innovation (*New-to-Market innovation*, column 3). Likewise, firms that reduced the geographic scope of their collaboration from *UK National to UK Regional* ($\beta = 9.24$, $p < 0.05$) or from *International to UK Regional* ($\beta = 8.37$, $p < 0.01$) or from *International* to the *EU* ($\beta = 6.30$, $p < 0.01$) were able to increase in the proportion of their *sales* derived from incremental innovation (*New-to-Business innovation*, column 4). Combined, these results provide strong evidence for Hypothesis 3.

5 | DISCUSSION: GEOGRAPHIC PATHWAYS TO COLLABORATION

The results of Table 5 provide support for Hypothesis 1 and indicate that increasing the geographic scope of

collaboration is associated with a higher probability of introducing a radical product innovation, and that reducing the geographic scope of collaboration is associated with an improvement in commercial success of such innovations. There is also support for Hypothesis 2 that incremental product innovations and their commercial success is aided by pursuing stability in the geographic scope of collaboration. Hypothesis 3 is also supported as our results point out that decreasing the geographic scope of collaboration does not affect the likelihood product innovation (either radical or incremental), but *it does* increase the commercial success of product innovations. More generally, the empirical results can be distilled into six identifiable strategic "pathways" with respect to the dynamics of geographic collaboration. These are presented in Table 6, each with its own summarized innovation outcomes as identified by the results of Table 5.

The first two strategic pathways involve *increasing* the geographic scope of collaboration, which is beneficial for new-to-market product innovation. The first of these implies increasing geographic scope by engaging in collaboration where none previously existed. This result is in line with a wealth of evidence asserting that external collaboration is beneficial for innovation (inter alia Laursen & Salter, 2006; Love et al., 2014). Accordingly, this pathway proves to be universally beneficial for firms that did not previously have any collaboration. *Where* the firm begins collaborating is less important than the fact it does so: the coefficients in Table 5 show little variation between the various levels of geographic distance among collaborators. Moreover, there is no need for a gradual increase in the geographic scope of collaboration. Our evidence suggests that whether an initially closed firm adopts a gradual, incremental path toward collaboration or quickly moves to more geographically distant partnerships have little effect on innovation outcomes: collaboration is invariably beneficial.

The other pathway involves increasing geographic scope where some collaboration already exists. Where it has an effect, this is invariably positive, although some forms of increased geographic scope have no innovation effect. Again, however, the strategic choice of the maximum geographic scope of collaboration can cause clear differences between new-to-market and new-to-business innovation. For the former, moving only to the more geographically distant collaborations yields improvement is the commercialization of radical product innovation, while new-to-business innovations benefit only from stability in the geographic scope of collaboration. This indicates that a strategy involving engaging with distant collaborators to access geographically distant pools of knowledge leads to the development of radical new-to-market product innovations.

The next two pathways relate to *stability*, in which the maximum geographic level of collaboration remains unchanged between periods. While the persistent non-collaboration strategy applied by non-collaborators is unambiguously detrimental to all forms of innovation, collaborative firms can benefit from pursuing a persistence strategy that maintains stability in the geographic scope of collaboration. Maintaining the same geographic scope in successive years affords more time to establish effective collaboration and to absorb and utilize new knowledge acquired from the different locations. While such a strategy can consistently produce benefits in terms of new-to-business innovation, it is unsuitable for firms wishing to pursue radical new-to-market innovation. Stability is a "double-edge" sword: the spatial lock-in caused by continuous use of the same geographic extent seems to build up a lock-in situation that prevents the search for radically new ideas among UK companies. Thus, maintaining stability leads firms to regularly introduce products which are new to the firm concerned, but which do not challenge the market in terms of novelty.

TABLE 6 Pathways to geographic collaboration[a].

Pathways		Product innovation outcomes			
		New-to-Market (likelihood)	New-to-Market (sales)	New-to-Business (likelihood)	New-to-Business (sales)
Increasing the geographic scope	1. From no previous collaboration	++	++	++	++
	2. Within collaboration	+	++	+	+
Stability in the geographic scope	3. No collaboration	--	--	--	--
	4. Within collaboration	0	+	++	++
Decreasing the geographic scope	5. To no collaboration	--	--	--	--
	6. Within collaboration	0	++	0	+

Note: Key: ++ Consistently positive effect. + Some positive effect. 0 No effect. - Some negative effect. -- Consistently negative effect.
[a]Based on results of Table 5.

The final two pathways involve *decreases* in geographic scope. These are perhaps the most intriguing pathways, and the ones which produce apparently counterintuitive results. Since increasing geographic scope improves innovation likelihood and sales, one might expect that decreasing scope has the reverse effect. This is certainly the case where a firm reverts to a position of non-collaboration having previously engaged in some form of geographic collaboration: this is universally linked to reductions in innovation performance. However, for firms which reduce but do not eliminate their collaboration scope, no such negative effects are evident. Reducing the geographic scope of collaboration has no identifiable effect on the likelihood of innovation, and clear evidence of *positive* effects on innovation sales both new-to-business and new-to-market. Anecdotal evidence shows firms can benefit from disengaging with collaborating partners after learning enough from them and being ready to commercialize the innovation alone (Appleyard & Chesbrough, 2017). Likewise, the results suggest the decrease in geographic scope of collaboration for innovation is relevant to the commercialization of innovation in international markets.

This asymmetric effect on innovation of increases and decreases in a key variable has been identified elsewhere. In their analysis of the links between exporting and innovation in Italian manufacturing firms, D'Angelo et al. (2020) find evidence that while a rapid increase in export breadth reduced the probability of developing new innovative outputs, no such effects occurred in the case of a decrease in firms' exporting activity. The key to this result appears to lie in the learning effects which persist even when the source of them is withdrawn: this involves knowledge from foreign markets in the case of D'Angelo et al. (2020), and knowledge from previous collaborations in the current case. Reducing geographic scope of collaboration implies cutting ties with at least some former collaborators. At least in the short term, the knowledge gained from these collaborations will still be available to the parties concerned, so that the end of any given collaboration need not imply the end of innovation benefits arising from it. Indeed, there may be benefits in reducing geographic scope under some circumstances. While distant collaborations may be more knowledge-rich, they are also typically more resource-intensive and costly to maintain (Berchicci et al., 2016; Mattes, 2012). Given the limited nature of managerial attention and bandwidth (Love et al., 2014; Ocasio, 1997), periods of retrenchment from more distant collaborations allow management more time to devote to the commercialization and sales of the products developed in such relationships rather than constant preoccupation with developing new products. This in turn may explain why reducing the geographic scope of collaboration—especially from the most distant partnerships—can be accompanied by improved commercial performance from existing innovations while having no short-term effect on the firm's capacity to innovate. This is consistent with a strategy of alternating between high and low levels of geographic collaboration through time, a spatial strategy which has Appleyard and Chesbrough's (2017) concept of "reversion" at its extreme.

6 | CONCLUSIONS

This article extends prior literature on the proximity of innovation by incorporating insights from the geography of innovation and collaboration for innovation literatures. Specifically, we build on the idea that experience of previous innovation collaborations enhances the value of future collaborations (Love et al., 2014), by introducing *space* into the *time* dimension of collaboration. This spatial dimension relates to the strategic acquisition of local knowledge through collaboration at geographically distant locations. Hence this study contributes to the literature as it uncovers that the value of innovation increases when firms with prior experience in domestic or nearby collaboration move toward more distant collaborations. We argue that such a strategy is particularly valuable as it allows firms to tap into distant and diverse pools of local knowledge giving rise to significant innovations. Rivals are less prone to imitate such knowledge due to causal ambiguity (as this knowledge is tacit arising from embeddedness in foreign networks).

By concentrating on within-firm dimensions of collaboration over time, the results offer new insights into the dynamics of geographic collaboration and the effects of heterogeneous geographic collaboration strategies upon innovation. First, we show that UK firms use largely different geographic collaboration strategies over time. Specifically, more often firms *maintain stability* in collaborating with partners in the same location. We also ascertain that firms *change* the direction of their geographic collaboration strategy by either moving toward distant collaboration (e.g., from UK national to international collaboration) or by moving toward closer collaboration (e.g., from international to UK regional collaboration). Second, we determine which geographic collaboration strategies over time stimulate different types of innovation. We show that while moving toward distant collaboration is crucial for innovation, especially radical innovation, it is not the most widely used strategy. Instead, our evidence shows that stability of the spatial scale collaboration is often the strategic choice of firms, which, in turn drives a series of incremental innovations.

Our results are useful to managers as they allow us to discern the relative merits of different "pathways" to innovation collaboration through time. We contend that not all

firms should move toward distant geographic collaboration. One pathway to innovation collaboration is characterized by a strategy that maintains the necessary stability of the spatial scale of collaboration that allows firms to engage on continuous improvements in their innovations. Another pathway to innovation collaboration is marked by a strategy that increases in the geographic extent of collaboration; such move is more appropriate for reinforcing radical changes in the innovation process. However, periods of retrenchment can be useful, allowing firms to concentrate on the commercialization of new products arising from the more distant collaborations without compromising the firm's ability to innovate.

There are several managerial implications arising from the pathway analysis. First, the selected dynamic pathway should fit with the innovation strategy of the firm. For example, stability on geographic scope, unless it is with the most international of collaborators, is unlikely to provide the knowledge base for radical, market-disrupting innovations. Correspondingly, however, the costs of developing such a strategy are not worth incurring if more modest product improvements are the preferred approach. Second, there is clear evidence from the pathways of precisely *which* changes in international cooperation are beneficial for different forms of innovation. For new-to-business innovation, stability (in any form of geographic collaboration) and modest increases in the most local forms of geographic collaboration (i.e., regional to national) prove useful. By contrast, for new-to-market innovation, stability in geographic collaboration is only worthwhile if it relates to the most international forms of collaboration, and the same is true of the effects of increasing geographic scope: for UK firms, moving to collaboration with EU partners and beyond is what matters for new-to-market innovation, both in terms of innovation likelihood and innovation intensity. This means that firms maintaining stability in the geographic scope of collaboration in absence of international partners can face the "radical innovation spatial lock-in" (Molina-Morales et al., 2014).

Third, the benefits of accessing distant pools of knowledge notwithstanding, increased distance in collaboration is not always optimal. While total "reversion" to a closed strategy is inimical to innovation (c.f. Appleyard & Chesbrough, 2017), periods in which the firm consolidates with less geographic distance in its collaboration can be useful in enhancing the commercialization of new products, without reducing the firm's capacity to produce new products—at least in the short term. Since reduced geographic collaboration must have been preceded at some point by an increase,[14] this does give some credence to the suggestion that firms will have periods of increased and decreased geographic collaboration and can benefit as a result. For instance, this could be another form of cycling strategy—between increased and reduced geographic openness—that might be assist firm's innovation alike firm's high-speed cycling strategy—between exploratory and exploitative R&D—that benefits firm's performance when they operate in technologically dynamic contexts (Mavroudi et al., 2020). Finally, a slow, incremental path to international collaboration is neither commonplace nor necessarily optimal. The results of the transition probability matrix (Table 4) and the FE Logistic regression (Table 5) suggest that switching from non-collaboration to a highly international set of collaborations is not uncommon and can have significantly positive effects on innovation.

[14]Unless the firm is "born global" in collaboration terms.

7 | LIMITATIONS

Inevitably our empirical research has limitations which must be acknowledged. First, the sample of this study is limited to the UK firms, which includes a representative sample of firms from England, Scotland, Wales, and Northern Ireland. Therefore, generalizability of the results is limited to these countries only. Future studies could carry out a similar or perhaps a comparative analysis using other country specific innovation surveys which exists throughout the EU, that is, CIS to evaluate the generalizability of this study. Second, we consider only one aspect of proximity, geographic. While the evidence suggests that geographic proximity facilitates the establishment of other forms of proximity (Balland et al., 2015), we cannot dismiss the possibility that some of the identified effects arise from cognitive, organizational, social, or institutional proximities (Hansen, 2015).

Third, our measures of distance in collaboration are relatively crude, encompassing just four categorical measures (regional, national, EU, and international), and we concentrate solely on the maximum geographic extent of collaboration. While this has the advantage of focus and simplicity, we know nothing of the complexity of collaborative arrangements *within* each responding firm, nor do we examine the potential interactions between local and more distant collaborations at the firm level. For example, a firm may increase the geographic scope of its collaborations while simultaneously altering the composition of its network of collaborators: we cannot readily distinguish the potential compositional effect from the geographic one.

Fourth, while we are able to determine certain aspects of the dynamics of collaboration, we must be duly circumspect in this regard. We know nothing of the internal firm dynamics of the process of collaboration and how it changes over time: it will require detailed

longitudinal analysis of specific collaborations or projects to investigate this, a research program that would usefully complement our large-scale analysis. We can therefore shed little light on the potential long-term effects of increases or decreases in the geographic scope of collaboration. For example, while our results suggest that reversion to no-collaboration is unequivocally associated with reduced innovation performance, it would be premature to regard this as some kind of "failure" without knowing what a specific collaboration was designed to achieve, and the timeframe within which this outcome was expected. It is inevitable that some collaborations will underperform, and there is increasing evidence that "failure" in terms of abandoned innovation is associated with high innovation performance (Leoncini, 2016; Tsinopoulos et al., 2019).

Finally, although we have gone to considerable lengths to allow for the effects of endogeneity arising from unobserved heterogeneity in our fixed-effects estimations, we can never entirely discount such effects having an effect on the relationship between changes in geographic collaboration and innovation.

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CONFLICT OF INTEREST STATEMENT

The authors confirm that there is no conflict of interest.

ETHICS STATEMENT

This research is conducted according to the principles of academic excellence, community, integrity, inclusiveness, and professionalism. All authors abide by high ethical standards.

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REFERENCES

Antonelli, C. 2000. "Collective Knowledge Communication and Innovation: The Evidence of Technological Districts." *Regional Studies* 34(6): 535–547.

Appleyard, M. M., and H. W. Chesbrough. 2017. "The Dynamics of Open Strategy: From Adoption to Reversion." *Long Range Planning* 50(3): 310–321.

Argote, L., and E. Miron-Spektor. 2011. "Organizational Learning: From Experience to Knowledge." *Organization Science* 22(5): 1121–1367.

Arora, A., S. Athreye, and C. Huang. 2016. "The Paradox of Openness Revisited: Collaborative Innovation and Patenting by UK Innovators." *Research Policy* 45(7): 1352–61.

Arranz, N., and C. Fernandez de Arroyabe. 2008. "The Choice of Partners in R&D Cooperation: An Empirical Analysis of Spanish Firms." *Technovation* 28(1–2): 88–100.

Autio, E., H. J. Sapienza, and J. G. Almeida. 2000. "Effects of Age at Entry, Knowledge Intensity, and Imitability on International Growth." *Academy of Management Journal* 43(5): 909–924.

Baker, W. E., and J. M. Sinkula. 1999. "The Synergistic Effect of Market Orientation and Learning Orientation on Organizational Performance." *Journal of the Academy of Marketing Science* 27(4): 411–427.

Balland, P. A., R. A. Boschma, and K. Frenken. 2015. "Proximity and Innovation. From Statics to Dynamics." *Regional Studies* 49(6): 907–920.

Battisti, G., and P. Stoneman. 2010. "How Innovative Are UK Firms? Evidence from the Fourth UK Community Innovation Survey on Synergies between Technological and Organizational Innovations." *British Journal of Management* 21(1): 187–206.

Berchicci, L., J. P. J. de Jong, and M. Freel. 2016. "Remote Collaboration and Innovative Performance: The Moderating Role of R&D Intensity." *Industrial and Corporate Change* 25(3): 429–446.

Bertrand, O., and M. J. Mol. 2013. "The Antecedents and Innovation Effects of Domestic and Offshore R&D Outsourcing: The Contingent Impact of Cognitive Distance and Absorptive Capacity." *Strategic Management Journal* 34(6): 751–760.

Borgatti, S. P., and D. S. Halgin. 2011. "On Network Theory." *Organization Science* 22(5): 1168–81.

Bougrain, F., and B. Haudeville. 2002. "Innovation, Collaboration and SMEs' Internal Research Capacities." *Research Policy* 31: 735–747.

Callois, J.-M. 2008. "The Two Sides of Proximity in Industrial Clusters: The Trade-off between Process and Product Innovation." *Journal of Urban Economics* 6: 146–162.

Clausen, T., M. Pohjola, K. Sapprasert, and B. Verspagen. 2012. "Innovation Strategies as a Source of Persistent Innovation." *Industrial and Corporate Change* 21(3): 553–585.

Cohen, W. M., and D. A. Levinthal. 1989. "Innovation and Learning: The Two Faces of R&D." *Economic Journal* 99(397): 569–596.

Criscuolo, P., K. Laursen, T. Reichstein, and A. Salter. 2018. "Winning Combinations: Search Strategies and Innovativeness in the UK." *Industry and Innovation* 25: 115–143.

D'Angelo, A., P. Ganotakis, and J. H. Love. 2020. "Learning by Exporting under Fast, Short-Term Changes: The Moderating Role of Absorptive Capacity and Foreign Collaborative Agreements." *International Business Review* 29(3): 101687.

DBEIS. 2019. U.K. Innovation Survey. Department of Business, Energy & Industrial Strategy, London https://www.gov.uk/government/collections/community-innovation-survey

Erkelens, R., B. van den Hooff, M. Huysman, and P. Vlaar. 2015. "Learning from Locally Embedded Knowledge: Facilitating Organizational Learning in Geographically Dispersed Settings." *Global Strategy Journal* 5(2): 177–197.

Ernst, D. 2009. "A New Geography of Knowledge in the Electronics Industry? Asia's Role in Global Innovation Networks." *Policy Studies* 54: 1–64.

Fiol, M., and M. A. Lyles. 1985. "Organizational Learning." *Academy of Management Review* 10(4): 803–813.

Freel, M. 2003. "Sectoral Patterns of Small Firm Innovation, Networking and Proximity." *Research Policy* 32(5): 751–770.

Freeman, C., and L. Soete. 1997. *The Economics of Industrial Innovation*. London and New York: Routledge.

Garcia, R., and R. Calantone. 2002. "A Critical Look at Technological Innovation Typology and Innovativeness Terminology: A Literature Review." *Journal of Product Innovation Management* 19(2): 110–132.

Gittelman, M. 2007. "Does Geography Matter for Science-Base Firms? Epistemic Communities and the Geographic of Research and Patenting in Biotechnology." *Organization Science* 18(4): 724–741.

Glückler, J. 2013. "Knowledge, Networks and Space: Connectivity and the Problem of Non-interactive Learning." *Regional Policy* 47(6): 880–894.

Granovetter, M. 1983. "The Strength of Weak Ties: A Network Theory Revisited." *Sociological Theory* 1: 201–233.

Greene, W. H. 2003. *Econometric Analysis*. Upper Saddle River, New Jersey: Pearson Education, Inc..

Guile, D., and S. M. Fosstenløkken. 2018. "Introduction to the Special Issue: Knowledge Dynamics, Innovation and Learning." *Industry and Innovation* 25(4): 333–38.

Hansen, T. 2014. "Juggling with Proximity and Distance: Collaborative Innovation Projects in the Danish Cleantech Industry." *Economic Geography* 90(4): 375–402.

Hansen, T. 2015. "Substitution or Overlap? The Relations between Geographic and Non-spatial Proximity Dimensions in Collaborative Innovation Projects." *Regional Studies* 49(10): 1672–84.

He, Z. L., and P. K. Wong. 2012. "Reaching out and Reaching within: A Study of the Relationship between Innovation Collaboration and Innovation Performance." *Industry and Innovation* 19: 539–561.

Holahan, P. J., Z. Z. Sullivan, and S. K. Markham. 2014. "Product Development as Core Competence: How Formal Product Development Practices Differ for Radical, more Innovative, and Incremental Product Innovations." *Journal of Product Innovation Management* 31(2): 329–345.

Hsieh, W. L., P. Ganotakis, M. Kafouros, and C. Wang. 2018. "Foreign and Domestic Collaboration, Product Innovation Novelty, and Firm Growth." *Journal of Product Innovation Management* 35(4): 652–672.

Huber, G. P. 1991. "Organizational Learning: The Contributing Processes and the Literatures." *Organization Science* 2(1): 88–115.

Jean, R. J., R. R. Sinkovics, and T. P. Hiebaum. 2014. "The Effects of Suppliers Involvement and Knowledge Protection on Product Innovation in Customer-Supplier Relationships: A Study of Global Automotive Suppliers in China." *Journal of Product Innovation Management* 31(1): 98–113.

Jiménez-Jiménez, D., and R. Sanz-Valle. 2011. "Innovation, Organizational Learning, and Performance." *Journal of Business Research* 64(4): 408–417.

Kafouros, M., J. H. Love, P. Ganotakis, and P. Konara. 2020. "Experience in R&D Collaborations, Innovative Performance and the Moderating Effect of Different Dimensions of Absorptive Capacity." *Technological Forecasting and Social Change* 150: 119757.

Kafouros, M. I., P. J. Buckley, and J. Clegg. 2012. "The Effects of Global Knowledge Reservoirs on the Productivity of Multinational Enterprises: The Role of International Depth and Breadth." *Research Policy* 41(5): 848–861.

Kesidou, E., R. Narasimhan, S. Ozusaglam, and C. Y. Wong. 2022. "Dynamic Openness for Network-Enabled Product and Process Innovation: A Panel-Data Analysis." *International Journal of Operations & Production Management* 42(3): 257–279.

Kim, M. 2013. "Many Roads Lead to Rome: Implications of Geographic Scope as a Source of Isolating Mechanisms." *Journal of International Business Studies* 44(9): 898–921.

Lane, P. J., J. E. Salk, and M. A. Lyles. 2001. "Absorptive Capacity, Learning, and Performance in International Joint Ventures." *Strategic Management Journal* 22: 1139–61.

Laursen, K., and A. Salter. 2006. "Open for Innovation: The Role of Openness in Explaining Innovative Performance among UK Manufacturing Firms." *Strategic Management Journal* 27(2): 131–150.

Laursen, K., and A. Salter. 2014. "The Paradox of Openness: Appropriability, External Search and Collaboration." *Research Policy* 43(5): 867–878.

Lavie, D., and S. R. Miller. 2008. "Alliance Portfolio Internationalization and Firm Performance." *Organization Science* 19(4): 623–646.

Leiponen, A. 2005. "Organization of Knowledge and Innovation: The Case of Finnish Business Services." *Industry and Innovation* 12(2): 185–203.

Leoncini, R. 2016. "Learning-by-Failing: An Empirical Exercise on CIS Data." *Research Policy* 45: 376–386.

Lioukas, C. S., and J. J. Reuer. 2019. "Choosing Between Safeguards: Scope and Governance Decisions in R&D Alliances." *Journal of Management* 46(3): 359–384.

Lippman, S. A., and R. P. Rumelt. 1982. "Uncertain Imitability: An Analysis of Interfirm Differences in Efficiency Under Competition." *Bell Journal of Economics* 13(2): 418–438.

Love, J. H., and M. A. Mansury. 2007. "External Linkages, R&D and Innovation Performance in US Business Services." *Industry and Innovation* 14(5): 477–496.

Love, J. H., S. Roper, and J. R. Bryson. 2011. "Openness, Knowledge, Innovation and Growth in UK Business Services." *Research Policy* 40: 1438–52.

Love, J. H., S. Roper, and P. Vahter. 2014. "Learning from Openness: The Dynamics of Breadth in External Innovation Linkages." *Strategic Management Journal* 35: 1703–16.

Marsili, O., and A. Salter. 2005. "'Inequality' of Innovation: Skewed Distributions and the Returns to Innovation in Dutch Manufacturing." *Economics of Innovation and New Technology* 14(1–2): 83–102.

Mattes, J. 2012. "Dimensions of Proximity and Knowledge Bases: Innovation between Spatial and Non-spatial Factors." *Regional Studies* 46: 1085–99.

Mavroudi, E., E. Kesidou, and K. Pandza. 2020. "Shifting Back and Forth: How Does the Temporal Cycling between Exploratory and Exploitative R&D Influence Firm Performance?" *Journal of Business Research* 110: 386–396.

Molina-Morales, F. X., P. M. Garcia-Villaverde, and G. Parra-Requena. 2014. "Geographic and Cognitive Proximity Effects on Innovation Performance in SMEs: A Way through Knowledge Acquisition." *International Entrepreneurship and Management Journal* 10(2): 231–251.

Morgan, K. 2004. "The Exaggerated Death of Geography: Learning, Proximity and Territorial Innovation Systems." *Journal of Economic Geography* 4: 3–21.

Nasirov, S., Q. Li, and Y. Kor. 2021. "Converting Technological Inventions into New Products: The Role of CEO Human Capital." *Journal of Product Innovation* 38(5): 522–547.

Nooteboom, B. 1999. "Innovation and Inter-Firm Linkages: New Implications for Policy." *Research Policy* 28(8): 793–805.

Ocasio, W. 1997. "Towards an Attention-Based View of the Firm." *Strategic Management Journal* 18: 187–206.

OECD. 1997. Oslo Manual: The Measurement of Scientific and Technological Activities, Proposed Guidelines for Collecting and Interpreting Technological Innovation Data http://www.oecd.org/dataoecd/35/61/2367580.pdf

Oerlemans, L. A. G., M. T. H. Meeus, and F. W. M. Boekema. 2001. "Firm Clustering and Innovation: Determinants and Effects." *Papers in Regional Science* 80: 337–356.

Powell, W. W., K. W. Koput, and L. Smith-Doerr. 1996. "Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology." *Administrative Science Quarterly* 41(1): 116–145.

Ramadani, V., R. D. Hisrich, H. Abazi-Alili, L.-P. Dana, L. Panthi, and L. Abazi-Bexheti. 2019. "Product Innovation and Firm Performance in Transition Economies: A Multistage Estimation Approach." *Technological Forecasting and Social Change* 140: 271–280.

Ritala, P., K. Husted, H. Olander, and S. Michailova. 2018. "External Knowledge Sharing and Radical Innovation: The Downsides of Uncontrolled Openness." *Journal of Knowledge Management* 22(5): 1104–23.

Roper, S., and J. H. Love. 2018. "Knowledge Context, Learning and Innovation: An Integrating Framework." *Industry and Innovation* 25(4): 339–364.

Roper, S., J. H. Love, and K. Bonner. 2017. "Firm's Knowledge Search and Local Knowledge Externalities in Innovation Performance." *Research Policy* 46: 43–56.

Scalera, V. G., A. Perri, and T. J. Hannigan. 2018. "Knowledge Connectedness within and across Home Country Borders: Spatial Heterogeneity and the Technological Scope of Firm Innovations." *Journal of International Business Studies* 49: 990–1009.

Schilling, M. A. 2013. *Strategic Management of Technological Innovation*. New York: McGraw-Hill.

Shan, W., G. Walker, and B. Kogut. 1994. "Interfirm Cooperation and Startup Innovation in the Biotechnology Industry." *Strategic Management Journal* 15(5): 387–394.

Tavassoli, S., and C. Karlsson. 2015. "Persistence of Various Types of Innovation Analyzed and Explained." *Research Policy* 44(10): 1887–1901.

Tippins, M. J., and R. S. Sohi. 2003. "IT Competency and Firm Performance: Is Organizational Learning a Missing Link?" *Strategic Management Journal* 24(8): 745–761.

Tsinopoulos, C., C. M. P. Sousa, and J. Yan. 2018. "Process Innovation: Open Innovation and the Moderating Role of the Motivation to Achieve Legitimacy." *Journal of Product Innovation Management* 35(1): 27–48.

Tsinopoulos, C., J. Yan, and C. M. P. Sousa. 2019. "Abandoning Innovation Activities and Performance: The Moderating Role of Openness." *Research Policy* 48(6): 1399–1411.

van Beers, C., and F. Zand. 2014. "R&D Cooperation, Partner Diversity, and Innovation Performance: An Empirical Analysis." *Journal of Product Innovation Management* 31: 292–312.

Vanhaverbeke, W., R. Belderbos, G. Duysters, and B. Beerkens. 2015. "Technological Performance and Alliances over the Industry Life Cycle: Evidence from the ASIC Industry." *Journal of Product Innovation Management* 32(5): 842–573.

Veugelers, R., and B. Cassiman. 1999. "Make and Buy in Innovation Strategies: Evidence from Belgian Manufacturing Firms." *Research Policy* 28(1): 63–80.

Wooldridge, J. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.

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