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International collaboration and innovation: Evidence from a leading Chinese multinational enterprise

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ABSTRACT

This paper investigates the impact of international collaboration and its characteristics on the quality of the innovation of multinational enterprises (MNEs) in emerging markets. Using a unique dataset of 1428 international and comparable domestic collaboration projects over the 2010–2016 period, it finds that while international innovation collaborations are associated with high innovation quality, cultural distance has a negative effect on collaboration outcomes. Moreover, proximity to the focal firm's overseas R&D centres and the size of expenditure budgets play significant moderating roles in overcoming cultural barriers. Based on the RBV and dynamic capabilities theory, we investigate how firms from emerging markets can acquire these two crucial requisites for innovation. The characteristics of partners and intellectual property (IP) arrangements are also found to have a significant impact on the quality of innovations.

1. Introduction

Innovation plays an important role in promoting the sustained growth and competitive advantage of firms in emerging markets. However, to maintain a sustainable competitive position, firms need to develop dynamic capabilities and acquire crucial resources (Barney, 2001; Teece, 2014). Driven by increasing global competition and rapid technological shifts, emerging market firms are increasingly adopting internationalization as a strategy to strengthen their innovation performance at the global level. On the one hand, international collaboration is argued to provide an ideal platform for realizing inter-organizational learning and the enhancement of dynamic capabilities (Yao, Yang & Fisher, 2013, 2013; Teece, 2014; Zhao, Liu, Andersson & Shenkar, 2021). On the other hand, it may also enhance innovation by facilitating the acquisition of a range of resources, increasing the diversity of the knowledge pool, and improving the dynamic capabilities of collaborating partners (Narin, Stevens & Whitlow, 1991; Wagner and Leydesdorff, 2005; Fu, 2015; Fu and Li, 2016; Lee, Spanjol & Sun, 2019). To this end, leading multinational enterprises (MNEs) from emerging economies work hard to catch up to and even leapfrog the technological frontier by acquiring novel knowledge and upgrading their technological capability via international collaboration.

However, internationalization is not without challenges; the geographical and cultural gaps between countries create barriers to desired performance (Ho, Ghauri & Kafouros, 2019; Dionisio and de Vargas, 2020). In particular, the expansion of international collaboration initiated by emerging economies has been accompanied by uncertainties, given the risky nature of research collaboration. It also brings challenges due to firms' failure to understand their partners' cultural frameworks (Griffith and Harvey, 2001; Ambos and Ambos, 2009; Kang and Jiang, 2012; Zhao et al., 2021) and the problems associated with dynamic capabilities in managing, coordinating, and monitoring the various elements of the collaboration process (Oxley and Sampson, 2004; Wu Wang, Hong, Piperopoulos, & Zhuo, 2016). To tackle these challenges, some Chinese firms, especially leading MNEs, have actively engaged in international collaboration with foreign industrial and academic partners and have proactively sought novel knowledge sources by establishing overseas research centres (ORCs)

Abbreviations: GLM, Generalised Linear Models; IP, Intellectual Property; KBV, Knowledge-Based View; MNE, Multinational Enterprises; OECD, Organisation for Economic Co-operation and Development; ORC, Overseas Research Centres; PSM, Propensity Score Matching; R&D, Research and Development; RBV, The Resource-Based View; URIs, University and Research Institutes; ZIP, Zero-Inflated Poisson.

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over the past decade (Cantwell and Janne, 1999; Asakawa and Lehrer, 2003; D'Agostino and Santangelo, 2012). Although international collaboration and overseas R&D have been a global trend (OECD, 2002; Chen, Zhang and Fu, 2019), and evidence from bibliometric analyses of scientific publications suggests that there are positive benefits of international collaboration; however, there is limited evidence of its impact on focal firms, with a few exceptions (e.g., Kafouros, Wang, Mavroudi, Hong & Katsikeas, 2018).

In the context of emerging market MNEs, an increasing number of extant studies highlight the importance of access to external resources through mergers and acquisitions for enhancing innovation capacity (e.g., Kotabe and Kothari, 2016; Wu et al., 2016; He, Khan & Shenkar, 2018; Piperopoulos, Wu & Wang, 2018; Yakob, Nakamura & Ström, 2018). However, the importance of international collaboration in spurring innovation performance is understudied. Purkayastha, Kumar and Gupta (2021) argue that a configuration of learning from exports, cross-listing, and international M&A improves entrepreneurial orientation in emerging market internationalising firms using data from India. Wu et al. (2016) find that although host country institutional development enhances firm innovation performance on average, such effects are more significant for Chinese MNEs with strong absorptive capacity and for those diversifying into a larger number of countries. Kotabe and Kothari (2016) argue that an emerging market MNE's competitive advantage is based on its ability to acquire resources and absorb them to build its own advantage. Thus, our study contributes to the RBV and dynamic capability literature by confirming whether and how MNEs from emerging markets can acquire the critical resources and dynamic capabilities that are needed to innovate through research collaboration with international partners.

Against this backdrop, this paper investigates the innovation quality-enhancing effects of international collaborations by using a unique project-level database from a large Chinese MNE over the period between 2010 and 2016. In addition to examining the effects of international collaboration on the quality of innovations, in particular, the analysis focuses on uncovering the moderating factors that potentially impact the innovation effects of international collaboration. The findings suggest that international collaboration is associated with higher quality innovation than domestic collaboration. The challenges brought by different partners' cultural frameworks are revealed and found to have an undermining effect on innovation quality. However, the negative impact of geographical and cultural distances inherent to international collaborations can be eased by the presence of ORCs, which can also accelerate technology acquisition and increase the quality of innovations. In addition, the research capability of collaborators serves as an important moderator that facilitates the improvement of innovation quality. Enhanced innovation performance via international collaboration is also contingent on other factors, including innovation budget size, project selection strategies and project objectives.

This paper extends the previous literature in several respects. First, it is a pioneering study in that it examines the moderators that influence the impact of international collaboration on innovation quality in the context of emerging market firms by investigating certain characteristics of collaboration, including cultural distance, the presence of overseas R&D centres and partners' research capabilities. Second, it provides unique evidence concerning the impact of international innovation collaboration on the enhancement of dynamic capabilities in Chinese MNEs. Although there is a wealth of research on collaboration and innovation, empirical evidence on the impact of international collaboration on innovation quality in emerging economies is scarce. Third, the unique project-level dataset from the examined company allows us to minimize the identification problem, which has often been overlooked in previous studies using firm-level data across different firms (Griffith& Neely, 2009).[1] Therefore, although these data may bear some limitations and we must be cautious in generalizing our implications to all emerging market companies, our findings still offer valuable and reliable evidence on the relationship between international innovation collaboration and innovation quality and on how emerging market MNEs can improve their innovation capabilities through international collaborations.

2. Theoretical background and hypotheses

2.1. Theoretical background

The resource-based view (RBV) argues that firms can create value by merging complementary and specialized resources and capabilities (Barney, 2001; Rayport and Jaworski, 2001). Interorganizational collaborations allow firms to discover and acquire scarce, nonreplicable, and non-substitutable resources and merge them with their effective capabilities to strengthen their innovation capability and competitive advantages (Yamakawa, Peng & Deeds, 2008). In addition, the knowledge-based view (KBV) highlights that knowledge creation and transfer via interorganizational collaborations are determined by the configuration of the resources of both focal firms and their collaborators (Singh, 2004; Hedge and Hicks, 2008) and by the knowledge characteristics, e.g., complexity, tacitness, and similarities, of partners' knowledge bases (Mowery, Oxley & Silverman, 1998; Simonin, 1999). Special attention has also been given to collaboration governance structures (Oxley and Sampson, 2004; Wu et al., 2016), motives (Chen, Li & Shapiro, 2012; Kang and Jiang, 2012), host country institutions (Rodrik, 1991; Makino, Lau & Yeh, 2002; Cantwell, Dunning & Lundan, 2010; Wu et al., 2016; Liu, Deng, Wei, Ying, & Tian, 2019), and geographic diversity (Nelson, 1993; Hoskisson, , Wright, Filatotchev and Peng, 2013).

On the other hand, a firm's capacity to deploy and reconfigure resources and to overcome potential obstacles determines the quality of its organizational learning outcomes (Amit and Schoemaker, 1993; Grant, 1996). Extant literature has elaborated how the quantity and quality of knowledge creation via international collaboration are subject to these capabilities, e.g., absorptive capacity (Cohen and Levinthal, 1990; Lu, Zhou, Bruton & Li, 2010; Xie and Li, 2018) and managerial capability (Andersson and Evers, 2015; Helfat and Martin, 2015; Purkayastha, Manolova & Edelman, 2018; Bahl, Lahiri & Mukherjee, 2021). Therefore, interorganizational collaborations can enhance firms' innovation capability and thus influence not only the likelihood and quantity of their innovation but also the quality and diversity of the innovation that emerges from the associated collaborations (Van Wijk, Jansen & Lyles, 2008).

[1] Using project-level data from a single company offers us a unique advantage in addressing the identification problem, which is an important methodological problem that is difficult to address when normal firm-level data across different firms are used. In an empirical test of the impact of collaboration on innovation performance using data from different firms, the estimated coefficient, assumed to be positive, may also suggest that firms that are more innovative are more likely to enter a collaboration partnership, either because they are invited by others or because they are more successful in inviting others into partnership. Such an identification problem may lead to spurious results from statistical tests. However, examining this relationship using project-level data from a single company means that one side of all the partnerships is the same. Therefore, the possibility for reverse causality and the consequences of this problem are significantly minimized.

2.2. International collaboration and innovation quality

During the take-off and catch-up stages, firms mainly conduct imitative innovation (Fu, Ghauri & Sun, 2018). In emerging economies, however, a more critical challenge is how to catch up to and even leapfrog the technological frontier by generating more radical innovation. In other words, promoting innovation quality in addition to quantity has become an important issue in emerging economies. According to the relevant literature, there are two approaches to defining innovation quality. Based on the narrow definition, innovation quality mainly refers to the degree of influence of innovation output, which is usually measured by a firm's total number of patent citations (Lahiri, 2010; Hung Lien, Yang, Wu, & Kuo, 2011). According to the broad definition, however, innovation quality covers a firm's aggregated innovation performance in all fields and the quality of its overall innovation outcomes (Haner, 2002). Duan, Huang, Cheng, Yang, & Ren (2020., 2021) further extend the components of innovation quality by arguing that this concept does not refer to just the improvement of innovation performance from the quality perspective; rather, it also demonstrates a firm's capacity to convert total output to total benefit.

The transformation from imitation to innovation represents a substantial departure from existing practices and involves the disruptive creation of new concepts (Schumpeter, 1934; Ettlie, 1983). From a resource-based perspective, a firm must combine internal and external resources to extend its knowledge pool in terms of both depth and breadth (Zhou and Li, 2012). In particular, launching radical innovation requires firms to produce cutting-edge technology through not only internal R&D but also external learning and collaboration (Bao, Chen & Zhou, 2012). As indicated by Teece (1986), strategic technology collaborations with foreign partners produce novel innovation resources and enhance focal firms' technological capabilities.

From a capability perspective, inter-organizational collaboration enables firms to develop and upgrade their capabilities to sense, seize and reconfigure resources so that they can continue to innovate and keep up with rapid technological change (Buckley and Ghauri, 2004; Eng and Spickett, 2009; Petricevic and Teece, 2019; Teece, 2014). The concept of collective invention (Allen, 1983) conveys that the circulation of knowledge and information may occur more effectively among cross-organizational groups than within an individual firm or team, and that such circulation can result in knowledge accumulation and a large number of possibly high-quality inventions (Beaudry and Schiffauerova, 2011). Although proximity may reduce the transaction costs of innovation collaboration, collaboration partners in the same region are also likely to suffer from technological resemblance (Chen et al., 2019), which may curb their innovation quality (Iino, Inoue, Saito & Todo, 2021, 2021; Berliant and Fujita, 2008; Boschma, 2005). Thus, international collaboration can spur organizational learning and facilitate innovation more effectively, as it allows a focal firm to learn and internalize foreign knowledge sources that can be exploited to complement existing ones (Hamel, 1991; de Man and Duysters, 2005).

Extensive empirical evidence has shown that international collaboration stimulates knowledge flow and upgrades firms' technological capabilities, consequently enhancing their innovation performance (Mowery et al., 1998; Kim and Inkpen, 2005; Wu et al., 2016; Xie and Li, 2018; Ho et al., 2017; Liu et al., 2019). Previous studies have also investigated the extent to which international collaborations affect innovation quality, but the results are inconclusive. Some scholars have uncovered a positive association between collaboration and innovation quality, which they have measured with patent citations (Briggs, 2015; Iino et al., 2021). Using academic research output as another indicator to measure innovation quality, prior studies have also found that international collaborations, especially research collaborations, positively influence the prestige or visibility of research outputs (Narin, , Stevens & Whitlow, 1991; Levitt and Thelwall, 2010). However, others have suggested that foreign collaboration does not always benefit innovation performance (Ebersberger and Herstad, 2013) and that it may even negatively impact innovation quality (Phelps, 2010; Belderbos, Cassiman, Faems, Leten, & Van Looy, 2014, Chen et al., 2019). We thus propose the following:

Hypothesis 1. *Foreign collaborations improve innovation quality.*

2.3. Cultural distance and knowledge creation in international collaborations

The KBV implies that a heterogeneous organizational context includes different pools of resources and capabilities (Jiang, Branzei & Xia, 2016). Heterogenous knowledge and resource collaborations tend to offer more potential for resource complementarities and the stimulation of radical innovation than homogenous ones do (Dyer, Kale & Singh, 2001; Piening, Salge & Schäfer, 2016). However, sparks of radical innovation and resource complementarities are more likely to emerge in contexts where collaborators share sufficient common ground and cultural understandings (Kang and Jiang, 2012).

Cultural distance has been identified as a major obstacle for the internationalization of MNEs, including those from both advanced and emerging economies (Jean, Sinkovics & Kim, 2010). Differences in firms' cultural backgrounds significantly affect their organizational learning in cross-border activities, as these backgrounds not only represent values and beliefs but also signify perceptions of reality and information (Hofstede, 1984; Myers and Cheung, 2008; Ambos and Ambos, 2009; Jean et al., 2010). Cross-border knowledge flow and inter-organizational learning may occur effectively between two cultural frameworks that share sufficient commonality (Griffith and Harvey, 2001; Ambos and Ambos, 2009). On the other hand, the existence of cultural distance could potentially undermine the process of international collaboration and lead to the delay or failure of projects (Chen et al., 2019). Empirical evidence has shown that firms from emerging economies are inclined to invest in or establish collaborations with regions where cultural differences are smaller (Kang and Jiang, 2012).

Cultural distance also plays a critical role in facilitating the success of international collaboration. To initiate research collaborations, collaborators must share common norms and objectives, and managing projects involves close interorganizational interactions and effective communication (Bhardwaj, Diets & Beamish, 2007). When project-related problems emerge, firms need to have the capability to bridge diverse backgrounds to facilitate mutual understanding and solve these problems jointly. The successful implementation of joint projects and the generation of novel outcomes are conditional on the level of common ground that partners achieve (Ambos and Ambos, 2009). Therefore, existing cultural distance becomes a moderator that may affect the extent to which a firm can effectively access and utilize the strategic resources available from foreign partners. Large gaps in cultural distance are likely to limit collaboration outcomes and innovation quality. In contrast, the smaller the cultural distance between focal firms and their foreign partners is, the more likely it is that the firm will be able to increase its knowledge creation and competitiveness.

Hypothesis 2. *Cultural distance negatively impacts the innovation effect of international collaboration.*

2.4. The role of overseas research centres (ORCs) in international innovation collaboration

Similar to the undermining impact of cultural distance, negative externalities may also arise during inter-organizational collaboration, as potential agency costs are associated with firms' capability to manage and coordinate scattered innovation activities (Oxley and Sampson, 2004; Wu et al., 2016). The integration of knowledge across different regions or countries also makes joint projects difficult to implement (Szulanski, 1996), which is why R&D is one of the least mobilized and internationalized activities within firms (Berry, 2014). However, leading MNEs can tackle these challenges by setting up domestic and overseas RCs (Castellani and Pieri, 2013).

Inevitably, ORCs are assumed to be risky and costly in nature and subject to the technological capability and absorptive capacity of the corresponding firms (Cohen and Levinthal, 1990; Xie and Li, 2018). Such a proactive innovation strategy, however, allows a firm to directly embed and integrate into the innovation ecosystems of technological frontiers (Cantwell, 2017; Dunning, 1995; Cantwell et al., 2010; Kim and Inkpen, 2005). Combining these idiosyncratic international knowledge bases via ORCs helps emerging firms gain direct access to new and complementary resources and capabilities that help them remove learning obstacles and enhance their innovation quality (Howells, James & Malik, 2003; Bruche, 2009).

The establishment of an ORC can effectively reduce the cultural and capability distances between an emerging-country firm and its foreign collaborators through the construction of a social network with local institutions and the integration of location-specific advantages across the focal country (Liu and Chen, 2012; Steinberg, Procher and Urbig, 2017; Liu et al., 2019). ORCs make it easier for firms to interact with local institutions (Ambos and Ambos, 2009; Hoskisson et al., 2013); gather capabilities, such as new ideas, products and processes; and reduce the gap between themselves and their industry peers (Gerybadze and Reger, 1999). Moreover, ORCs provide a platform that allows firms to integrate into industry-leading companies' innovation systems and appropriate their competitors' resources, including the knowledge embedded in talent (Lewin, Massini & Peeters, 2009; Steinberg et al., 2017). Thus, ORCs may play a critical role in shaping international collaboration and innovation quality.

Empirical evidence on R&D internationalization and ORCs has mainly focused on location choice (Liu and Chen, 2012), motivations (Oxley and Sampson, 2004; Steinberg et al., 2017), and organizational governance (Asakawa and Lehrer, 2003; Oxley and Sampson, 2004; Liu et al., 2019). The mechanism through which ORCs facilitate knowledge creation, especially in relation to improving innovation quality, via interorganizational collaborations is still under-explored. Therefore, we propose the following:

Hypothesis 3A. *The geographic distance between a collaborator and the focal company's overseas R&D centre may negatively affect the quality of international collaboration. The shorter this geographic distance is, the better the innovation quality.*

Hypothesis 3B. *The geographic distance between a collaborator and the focal company's overseas R&D centre positively moderates the undermining effect of cultural distance on innovation quality.*

2.5. Partner and different types of capabilities, knowledge and skills

Interorganizational collaboration, especially that via overseas expansion, serves as a 'springboard' enabling emerging-country firms to acquire and upgrade their technological capability and consequently improve their innovation quality (Wu et al., 2016; Xie and Li; 2018). To enhance competitiveness, it is essential for firms from emerging countries to develop the ability to choose appropriate partners and form effective collaboration (Simonin, 1999; Oxley and Sampson, 2004; Piening et al., 2016). University and research institutes (URIs) and industry collaboration, as important forms of international collaboration, provide emerging-country firms with a unique opportunity to gain access to diverse knowledge resources (Etzkowitz and Leydesdorff, 2000; Lundvall, 1988; Corsi, Fu & Külzer-Sacilotto, 2020) and enable channels to generate cutting-edge innovation that can be industrially adapted and commercially exploited (Wagner and Leydesdorff, 2005).

The knowledge pools of URIs can be more diverse than those of industrial partners, as URIs primarily conduct fundamental research that aims to expand the scope of the existing knowledge pool (Corsi et al., 2020). Accordingly, establishing innovation collaboration with URIs can assist a firm greatly in upgrading its innovation quality, as URIs can help with responsibilities such as applying for radical patents, assessing new technological fields, and launching new products (Perkmann et al., 2011). URIs normally enter collaborations as the central players (Beaudry and Shiffauerova, 2011; Foray and Lissoni, 2010). Academics from URIs are often able to stimulate knowledge flow through their broad networks. Their relatively diverse knowledge resources in the areas of science and technology may contribute to the technological capability of emerging-country firms and improve their innovation collaboration outcomes (Beaudry and Shiffauerova, 2011). This is especially true for foreign URIs. Gaining access to such a knowledge pool enables emerging-country firms to overcome their weaknesses in relation to their stock of knowledge and acquire complementary technological assets (Chesbrough, 2006). To respond to the need for collaboration with industries, capable URIs have also designed corresponding organizational solutions designed to facilitate the operation of collaborations, including technology transfer offices and university incubators (Comacchio et al., 2012; Villani, Rasmussen & Grimaldi, 2017).

While the underlying motives, performance impacts, and obstacles of URI-industry collaborations have been widely studied across developed economies (Chau, Gilman & Serbanica, 2017; Corsi et al., 2020), their impact on firms' technological capability and innovation quality in emerging-country contexts, especially in relation to the moderating role of foreign URIs in the relation between international collaboration and focal firms' innovation quality, is still very unexplored. Even when firms undertake joint research projects with URIs, which allow them to tap into external resources and complementary assets that are normally outside their industry boundaries, the extent to which such collaboration can enhance innovation quality is contingent on collaborators' knowledge stock, research experiences and technological capabilities (Chen et al., 2019; Corsi et al., 2020; Iino et al., 2021). Therefore, we propose the following:

Hypothesis 4. *The innovation quality of collaboration with foreign URIs is positively associated with the corresponding collaborators' research capability.*

3. Data and model specification

3.1. Data

The data for this study consist of a unique project-level dataset containing all 6893 joint research collaboration projects conducted by a single large Chinese MNE named ABC from 2010 to 2016. The advantage of such a database with a large number of research collaboration projects that are all from one company is that one side of the collaborations can be held constant. This enables us to greatly reduce the identification problem between the innovation capabilities of collaborators and the likelihood of collaboration and hence allows us to make an unbiased estimation.

ABC is a leading global equipment and solutions provider in the digital sector. It operates an international business, currently covering more than 170 countries and serving almost one-third of the world's population. The company has consistently invested heavily in R&D activities. According to its annual report, ABC spent approximately 15% of its total revenue on R&D in 2015, while the average R&D intensity of China's top 500 companies was only 1.48%.[2] To increase the breadth of its technological collaboration, ABC actively explores collaboration opportunities with partners outside of China, especially with those from leading technology countries, such as the USA, Great Britain, Canada, France, Germany, Japan, and Singapore. The company is now one of the world's top patent applicants. ABC has embraced open innovation and has funded a large number of joint innovation projects with external

[2] See China News, http://www.chinanews.com/it/2016/08-28/7986586.shtml

partners around the world. These collaborators come from top universities and leading international companies. Hence, the company represents a good case for the study of the innovation impact of international collaboration among Chinese companies. After data cleaning, the final dataset includes 714 projects involving international collaboration from 2010 to 2016.[3]

3.2. Model specification and variables

In the literature, innovation is measured with several different indicators (Hagedoorn and Cloodt, 2003; Dziallas and Blind, 2019; Ponta, Puliga & Manzini, 2021). Some of them may effectively capture the quantity aspect of innovation but fail to uncover the quality aspect. R&D expenditures capture the physical inputs of innovation, whereas its outputs are normally measured with other quantity measures, such as the number of patents or new product sales (Griliches, 1998; Hausman, Hall & Griliches, 1984; Dosi, 1988; Janger, Schubert, Andries & Rammer, 2017). It is commonly acknowledged that new product sales capture only products or services that are successfully commercialized (Hitt, Hoskisson & Hicheon, 1997; Brouwer and Kleinknecht, 1999), possibly ignoring the aspect of technological value. Previous studies have attempted to measure innovation quality by using patent-related indicators, including patent family size (Lanjouw, Pakes & Putnam, 1998), patent citations (Trajtenberg, 1990; Phelps, 2010), number of claims (Lanjouw and Schankerman, 2004), patent review status (Wang et al., 2010), or indices combining several patent indicators (Bonaccorsi and Thoma, 2007). Given the project-level nature of our data, the number of patents applied for or granted seems to be more suitable for the current research, especially because we examine the digital industry, where patents represent a useful tool for intellectual property protection. However, the quality and novelty of the innovation of leading MNEs are not necessarily fully reflected by their patent numbers. Therefore, in the current study, innovation quality is measured with a dichotomous indicator provided by ABC, *Outstanding_Outcome*, which is computed based on the number of important patents granted over the course of a collaboration project. Instead of considering the patent office from which a patent was granted, an individual patent is evaluated by ABC based on its importance level, and the variable takes the value of 1 if it is classified as an important patent and 0 otherwise. This indicator is therefore thought to better reflect the technological quality of innovation outputs from the perspective of ABC.[4]

To test the proposed hypotheses, we specify that the quality of the innovation of project i is determined by a series of factors, including collaboration, project and partner characteristics:

$$Y_i = \alpha + \beta_1 Cultural\_Distance_i + \beta_2 R\&D\_Centre_i + \beta_3 University_i + \beta_4 Budget_i + \beta_5 Z_i + \varepsilon_i \quad (1)$$

where $Z_i = (Open\_Call_i, IPR\_Sharing_i, Previous\_Collaboration_i, Tech\_R\&D_i)$, where Y_i denotes the innovation quality of foreign collaborative project i, which is denoted by *Outstanding_Outcome*. ε_i captures the idiosyncratic error. *Cultural_Distance* is an index capturing the cultural distance between China and the focal partner's country of location. This index is computed based on the six measures of Hofstede's cultural dimension theory (Coelho, 2011), namely, power distance, individualism, masculinity, uncertainty avoidance, long-term orientation, and indulgence. Specifically, the distances between China and each collaborator's country with respect to these six cultural dimensions are calculated. Given that the differences between these indices can be either positive or negative, the distance is computed by taking the positive square roots of the squared differences. Then, we employ a factor analysis to construct a single cultural distance index by following the principal component approach to factor analysis. *R&D_Centre* denotes the logarithm of the distance from the focal collaborator to the nearest R&D centre set up by ABC in the partner's region. Knowledge spillovers are geographically bound (Varga, 2000). A negative association has been uncovered by Funke and Niebuhr (2000), who show that the intensity of spillover effects declines by 50% with a 30-kilometre increase in geographical distance. Therefore, the extent to which the spillovers of ABC's R&D centre can benefit the outcome of a collaboration is subject to the geographical distance between the corresponding partner and the colocated R&D centre.

To distinguish between partner types, we categorize the collaborations as university collaborations or industry collaborations. *University* is a dummy that equals one if the focal collaborator comes from a university and research institute (URI) and zero if the collaborator comes from an enterprise. To further capture the importance of the collaborators' research capability, *University_Top100* is constructed based on the partner URIs' global rankings. *University_Top100* is a dummy variable that equals one if the focal collaborator comes from a Top 100 QS ranked academic institution and zero otherwise. $Budget_i$ is the logarithmic value of the project budget. Collaboration expenditures are expected not only to directly affect the initiation, progress and outcome of the projects but also to influence resource allocations and project capability construction, which may indirectly moderate the factors determining the quality of outcomes (Brouwer and Kleinknecht, 1999; Janger et al., 2017; Ponta et al., 2021).

Following the existing literature (Cassiman et al., 2010; Schwartz et al., 2012), Eq. (1) also controls for a series of project characteristics (*Z*) that may affect the quality of project innovation outcomes. *Select* is measured with a dummy that equals one if ABC selects the collaborator of the focal project through an open call and zero otherwise. *IP_Sharing* is measured with a dummy variable that equals one if the intellectual

[3] The data are cross sectional in nature. We have investigated whether it is possible to construct a panel dataset. However, given the nature of the data, which describe collaboration projects taking place during different years, and the outputs of the research, which mostly only appear at the end of each project, it is not possible to construct a panel dataset. We have thus concluded that a cross-sectional format is suitable for the dataset. Moreover, pooling cross-sections is not unusual in the literature, particularly when population survey data are used. For example, Antolin and Bover (1997) use individual data from the Migration Survey, pooling independent cross-sections from 1987 to 1991 to estimate the effect of personal characteristics and regional economic factors on regional migration in Spain. This is a good example of pooling cross-sections. This method allows them to combine the strengths of independent individual-level data with those of time-series modelling to facilitate the simultaneous estimation of a wide range of potential effects on regional migration in Spain. The same merits of pooled cross-sections can be applied in our study. In addition, any research projects with partners located in Hong Kong, Macao and Taiwan are not included in the final dataset.

[4] An alternative measure for innovation quality, *SCORE,* is also used in the robustness check section. It is another indicator developed by ABC to quantitatively assess the quality of innovation, and it is a number assessed by a technical evaluation committee within ABC ranging from 0 to 100.

property (IP) is solely owned by ABC and zero otherwise, and *Previous_Collaboration* is measured with a dummy variable that equals one if ABC has previously cooperated with the focal partner and zero otherwise. *Tech_R&D* indicates whether the collaboration is motivated by a need to conduct technical R&D; it is a dummy variable taking the value of one if the collaboration mode is technical R&D and zero otherwise.

To evaluate the impact of international collaboration and ORCs on the quality of capability acquisition and joint innovation outputs, we sought to identify comparable collaboration projects involving domestic partners and to compare the quality of innovation outputs from these two types of collaboration. We used propensity score matching (PSM) (Caliendo and Kopeinig, 2008; Abadie and Imbens, 2016) to construct the matched sample. Specifically, we required the matched projects to have the same collaboration mode,[5] to have been conducted in the same year, to have received engagement from the same departments and to have worked with the same institution types.[6] Then, a score was generated for each project based on the corresponding predicted value from the probit regression[7]. Following Fang, Tian and Tice (2014), we employed one-to-one nearest neighbour PSM without replacement. The matched sample consisted of 1428 observations, with 714 foreign and 714 domestic projects. The sample combining both foreign and domestic projects was regressed with an extended specification of Eq. (1):

$$Y_i = a + b_1 University_i + b_2 Budget_i + b_3 International_i + b_4 Z_i + e_i \tag{2}$$

where $International_i$ is a dummy variable that equals one if the collaborator of project i is from a foreign country and zero if the collaborator is from mainland China. Cultural distance and the distance from the focal foreign partner to ABC's ORC in the same region are not included in Eq. (2) because these two variables do not exhibit variations across domestic projects.

A balanced sample test was conducted, and the results are presented in Appendix A. The percentage of bias across the covariates is generally within 10% for the matched group. The t tests also failed to reject the null hypothesis, suggesting that the two covariates are equal in the treated and control groups. The standardized percentage bias across the covariates of both the matched and unmatched groups is plotted on the figure presented in Appendix B. The results suggest that the matching process significantly decreased the imbalance in the samples. As *Budget* is a continuous measure, a comparison of the kernel density distribution of the matched and unmatched groups is also displayed in the figure presented in Appendix C.

3.3. Estimation approaches

Given the count nature of our data and the nontrivial proportion of *Outstanding_Outcome* observations equal to zero, we employ the Zero-Inflated Poisson (ZIP) approach, which assumes a distribution that is a combination of a Poisson distribution and a logit distribution (Cameron and Trivedi, 2013; Hilbe, 2014). Each project (observation) therefore has two possible outcomes: *Outstanding_Outcome* count is either zero or non-zero. Suppose that the probabilities of the two cases are p and $1 - p$, respectively. The probability distribution of the ZIP of *Outstanding_Outcome* is given as:

$$\Pr(Outstanding\_Outcome_i = j) = \begin{cases} p_i + (1 - p_i)\exp(-\mu_i) & if\ j = 0 \\ (1 - p_i)\dfrac{\mu_i^{Y_i} exp(-\mu_i)}{Y_i!} & if\ j > 0 \end{cases} \tag{3}$$

The Poisson component includes the set of explanatory and control variables from Eq. (1).

$$\mu_i = exp(\alpha + \beta_1 International_i + \beta_2 Budget_i + \beta_3 University_i + \beta_4 R\&D\_Centre_i + \beta_5 Cultural\_Distance_i + \beta_6 Z_i + \varepsilon_i) \tag{4}$$

The logit link function p is given by $p = \frac{\lambda_i}{1+\lambda_i}$, where

$$\lambda_i = \exp(\delta + \theta_1 Patent\_Purpose_i + \nu_i) \tag{5}$$

The logistic component includes a regressor that determines whether *Outstanding_Outcome* $= 0$. The dummy variable *Patent_Purpose* is added to the logistic equation, taking the value of one if the objective of corresponding collaboration is to generate patents. As *Outstanding_Outcome* defines the importance of the specific patents attached to a project, it is plausible to assume that collaborations initiated with non-patent objectives are unlikely to produce patents as a project outcome.

4. Empirical results

4.1. Descriptive statistics

Table 1 shows the definitions of the variables and their corresponding summary statistics. In the sample, the average value of *Outstanding_Outcome* is 0.11. The mean of the cultural distance proxy is 0.81, and it ranges from 0 to 1, showing that there are relatively large differences between the cultural framework of ABC and those of its foreign collaborators. This is also reflected in the fact that the majority of the foreign collaborators of ABC are from Europe and North America. The average distance from a collaborator to ABC's ORC in the same country is 636 miles (5.69 logarithmic value).[8] A total of 55% of the collaborations are established with academic institutions, such as universities or research institutions.[9] The average project budget is 143 thousand Chinese yuan (5.48 in logarithmic form). Approximately 13% of the projects are conducted with partners that have previously collaborated with ABC.

Table 2 shows the evolution of the geographical dispersion of the examined research partnerships over time. This table shows that ABC's innovation collaboration increased rapidly over the sample period. In addition to its partnerships inside China, ABC's international collaborations increased significantly; these increased in number from 4 in 2010 to 227 in 2015.[10] This rapid increase in collaboration could be a sign of a process producing disruptive innovations (Wan, Williamson & Yin, 2015). The second feature of ABC's innovation collaboration is the geographic dispersion of its partners. In 2015, ABC had partners in 24 countries, but in 2010, it had partners in only 1 country. This suggests

[5] ABC engages in four types of collaboration with its partners: the ABC Innovation Research Program, technical consultation, technical development and technical research.

[6] ABC mainly cooperates with two different types of institutions: universities and enterprises.

[7] The dependent variable is equal to one if the collaborator is from a foreign country and zero otherwise. The independent variables include *Collaboration_Objective*, which equals one if the objective of the project is patent application and zero otherwise; *Open_Call*, which equals one if ABC selects the collaborator of the focal project through an open call and zero otherwise; *Project_Priority*, which equals one if ABC prioritizes this project and zero otherwise; and *Budget*, which is measured as the natural logarithm of the focal project budget amount. *University* takes the value of 1 if the collaborator is a university and *Department* denotes the department dummies.

[8] Not all international collaborations are linked to ORCs in our study. The difference between non-ORC collaborations and ORC collaborations is that there is no ORC near the foreign partner in the former case, whereas there is an ORC near the foreign partner (i.e., both are located in the same region) in the latter case.

[9] URIs are not ORCs. URIs are university and research institutes independent of ABC; they are ABC's collaborators. ORCs are overseas research centres specifically set up and owned by ABC.

[10] The data were compiled before the end of accounting year 2016 and did not show the full picture of ABC's international collaboration projects for 2016. Therefore, the description of the trend in project numbers covers 2010 to 2015.

Table 1
Variable definitions and summary statistics.

Variables	Definitions	Mean	S.D.	Min.	Max.
Outstanding_Outcome	The number of granted important patents over the course of the project.[i]	0.11	1.12	0	17
Cultural_Distance	An index capturing the cultural distance between China and the focal partner's country of location and computed based on the six measures of Hofstede's cultural dimension theory.[ii]	0.81	0.84	0	1.94
R&D_Centre	The geographical distance between the focal collaborator and ABC's research centre in the same region (miles) divided by the host country size (square kms.)	0.16	0.81	0	4.35
University	A dummy variable that equals one if the collaborator comes from an academic institution (i.e., university) and zero if it comes from an enterprise.	0.55	0.50	0	1
University_Top100	A dummy variable that equals one if the collaborator comes from a Top 100 QS ranked academic institution (i.e., university) and zero otherwise.	0.16	0.37	0	1
Budget	The log of the budget amount of the project in thousands of RMB.	5.48	1.31	1.10	6.71
Open-Call	A dummy variable that equals one if ABC selects the collaborator of the focal project through an open call and zero otherwise.	0.01	0.08	0	1
IP_Sharing	A dummy variable that equals one if the IP is solely owned by ABC and zero otherwise.	0.60	0.49	0	1
Previous_Collaboration	A dummy variable that equals one if ABC has previously cooperated with the focal partner and zero otherwise.	0.13	0.33	0	1
Tech_R&D	A dummy variable that equals one if the motive for collaboration is technical research and development and zero otherwise.	0.79	0.41	0	1
Patent_Purpose	A dummy variable that equals one if the purpose of the project is patent application and zero otherwise.	0.38	0.49	0	1
SCORE	The project score assigned by ABC's technical evaluation committee.	85.11	7.15	50	100
International (Eq. (2))	A dummy variable that equals one if the collaborators are from outside of mainland China and zero otherwise.	0.50	0.50	0	1

Notes:
[i] Details regarding the definition of 'Important patents' are given in Section 3.2.
[ii] The minimum is 2.51e-10: a short geographic distance between the collaborator and ORC in a relatively large country. Details regarding the calculation of the index are provided in Section 3.2.

Table 2
Number of foreign countries engaged in R&D collaboration.

	2010	2011	2012	2013	2014	2015	2016
Number of countries	1	5	11	26	22	24	18
No. of collaborations with universities	4	7	24	73	124	122	41
No. of collaborations with Top 100 universities	1	2	9	19	29	40	14
No. of collaborations with non-universities	0	4	19	55	86	105	50
No. of total collaborations	4	11	43	128	210	227	91

that ABC has rapidly diversified its knowledge partners. This geographical diversity in ABC's collaborations was maintained from 2013 throughout the remainder of the sample period. During the time-frame analysed, a diversification in partner types also occurred, usually through the inclusion of universities and non-universities as partners in most of the countries where collaborations existed. Despite the wide geographic dispersion observed, Europe, North America and East Asia attracted most of ABC's collaboration investments.

Evident increasing trends are also observed in the number of URI collaborations and industrial collaborations. ABC's international collaboration was initially dominated by URIs, and it grew from 4 projects in 2010 to 122 projects in 2015. During the 5-year survey period, ABC's research collaboration with industrial partners expanded rapidly, growing from no projects in 2010 to 105 projects in 2015. This large-scale international innovation collaboration, together with the heavy investment that the company has made in in-house R&D, has rapidly enhanced ABC's innovation capabilities and moved it to the frontier of the digital industry.

4.2. Estimation results

Table 3 presents the empirical results, in which innovation quality is regressed against a set of factors specified in Eq. (1). Models 1–4 in Table 3 present the zero-inflated Poisson (ZIP) regression that uses *Outstanding_Outcome* to proxy innovation quality for our sample of 714 foreign collaboration projects. The marginal effects are reported, and robust standard errors are given in parentheses to control for potential heteroskedasticity. The logit link function regression results are also included in the lower panel of the table. The negative and significant coefficients of *Patent_Purpose* imply that projects with the objective of generating patents are negatively associated with the likelihood of

Table 3
Zero-inflated poisson regression (marginal effects).

Dependent variable:*Outstanding_Outcome*	**Foreign collaboration projects**				**Foreign & domestic collaboration projects**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
International					0.052**
					(0.024)
Cultural_Distance	-0.009*	-0.008*	-0.051*	-0.026**	
	(0.006)	(0.004)	(0.026)	(0.011)	
R&D_Centre	-0.005*	-0.004*	-2.211**	-0.002*	
	(0.003)	(0.002)	(1.116)	(0.001)	
University	0.005				0.026
	(0.005)				(0.016)
University_Top100		0.004*	0.014	0.005**	
		(0.002)	(0.009)	(0.003)	
Budget	0.003	0.002**	0.016**	-0.000	0.002
	(0.002)	(0.001)	(0.008)	(0.000)	(0.005)
*Cultural_Distance*R&D_Centre*			-4.262**		
			(2.151)		
*Cultural_Distance*Budget*				0.003**	
				(0.001)	
Open_Call	-0.100**	-0.089**	-0.259**	-0.067**	-0.670***
	(0.040)	(0.038)	(0.110)	(0.028)	(0.174)
IP_Sharing	0.005*	0.004*	0.009**	0.004**	0.055***
	(0.003)	(0.002)	(0.004)	(0.002)	(0.021)
Previous_Collaboration	-0.153**	-0.119**	-0.331**	-0.102**	-0.075***
	(0.061)	(0.050)	(0.139)	(0.041)	(0.028)
Tech_R&D	0.006**	0.003	0.025**	0.004**	0.058*
	(0.003)	(0.002)	(0.011)	(0.002)	(0.030)
Inflate					
Patent_Purpose	0.012***	0.009***	0.025***	0.008***	0.116***
	(0.004)	(0.003)	(0.008)	(0.003)	(0.027)
Observations	714	714	714	714	1428

Notes: The marginal effects are reported, and robust standard errors are given in parentheses. *** $p<0.01$, ** $p<0.05$, and * $p<0.1$. Constant terms are included in all the regressions but are not reported in the marginal effect results table.

Outstanding_Outcome being equal to zero. As there is an excess number of *Outstanding_Outcome* observations equal to zero, the ZIP approach is acknowledged to be more appropriate than Poisson regression. the coefficients of *Cultural_Distance*, which is a proxy for cultural distance, are persistently negative and significant. A short cultural distance enhances innovation quality, whereas a longer distance undermines the possibility of knowledge creation. This finding verifies the proposition that cultural distance negatively affects the quality of innovation from research collaboration (H2). If the potential moderating effects that are captured by the interaction terms are unaccounted for, a one-unit increase in the cultural distance gap is expected to lead to an approximately 0.8-0.9 percent decline in *Outstanding_Outcome* (Models 1 and 2).

The presence of an R&D centres in the region of the focal collaborator also plays an important role in affecting innovation quality. The negative coefficients of *R&D_Centre* imply that when international collaboration is undertaken near an overseas ABC R&D centre, the project can directly produce outstanding outcomes. Accordingly, the distance between a collaborator and the local R&D centre in its country may negatively affect the quality of innovation from research collaboration (H3A). In terms of the magnitude, a one-mile reduction in the geographic distance from the foreign collaborator to ABC's ORC as a ratio of the corresponding host country size (square kms.) yields approximately 0.2-0.4 percent increase in *Outstanding_Outcome*. To capture the potential moderating effect of the distance to an ORC, the interaction term *Cultural_Distance*R&D_Centre* is also added to Eq. (1), and the estimated results are reported in Model 3. The negative and significant value of the interaction term suggests a replacement effect between cultural distance and distance to an R&D centre. The existence of a large cultural distance between ABC and a foreign collaborator negatively impacts *Outstanding_Outcome*, yet this undermining effect can be effectively moderated by a shorter distance between the collaborator and ABC's overseas R&D centre in the same region (H3B).

The impact of *University* on *Outstanding_Outcome* is positive but nonsignificant (Model 1), indicating that the innovation quality of research collaboration with URIs does not differ from that of collaboration projects with industrial partners. However, the research capability of collaborators plays an important role in facilitating knowledge creation during collaboration. The quality of innovation from research collaboration is positively associated with the corresponding partner's research capability, which is proxied by the studied partner URIs' global university rankings. *University_Top100* is significant in Models 2 and 4, implying that the positive innovation quality effect of collaborating with URIs is contingent on the corresponding partner's research capability. Innovation in collaboration with a foreign top-100 URI is likely to boost *Outstanding_Outcome* by 0.4-0.5 percentage points. A collaborator's capability is positively associated with the quality of its innovation collaboration (H4).

The innovation quality of foreign collaborations depends on project expenditures (Brouwer and Kleinknecht, 1999), as reflected by the significant coefficient of *Budget*. Increased investments in innovation do not automatically guarantee higher innovation output; due to the risky and costly nature of innovation, a sufficient budget is necessary to produce quality innovation. This is particularly true in the digital industry, where competition in relation to technological development is fierce (Duysters and Hagedoorn, 2001). A one-percentage-point increase in a collaboration project budget is expected to yield a 0.2 percentage point increase in innovation quality. Moreover, the interaction term *Cultural_Distance*Budget* in Model 3 implies that the effect of R&D expenditures on innovation quality can be undermined by the existence of large cultural distance.

Regarding an investigation of the extent to which innovation quality is affected by foreign and domestic research collaborations, Model 5 presents ZIP results based on Eq. (2) and the sample combining foreign and domestic projects. Consistent with the extant literature (Li et al., 2010; Kafouros and Forsans, 2012; Jiang et al., 2016; Piening et al., 2016), these results show that international collaboration encourages innovation. The coefficient of *International* is positive and significant across all the specifications, suggesting that foreign collaboration improves innovation quality (H1). In comparison to domestic projects, international collaboration serves as an effective channel through which to enlarge a firm's knowledge pool, enhance its technological capability, and consequently unlock its potential to enhance innovation quality. Leading firms from emerging countries are able to benefit from the knowledge flow stimulated by international collaborations. The heterogeneous knowledge pools and resources offered by foreign collaborators can also effectively complement the existing ones held by focal firms. Regarding the other factors that may affect the outstanding outcomes of international collaboration, the findings are generally consistent for both the foreign project sample (Models 1-4) and the full sample (Model 5). Collaboration partner selection strategies affect *Outstanding_Outcome*. Adopting an open-call selection strategy seems to reduce innovation quality. The same undermining effect has been observed in previous collaboration settings. In contrast, sole ownership arrangements of intellectual property rights and collaborations with the purpose of technological R&D stimulate the quality of innovation collaborations with both foreign and domestic partners.

4.3. Robustness checks

Patents sometimes cannot fully reflect the intellectual capital that is created by innovation activities, as firms have different propensities to patent (Brouwer and Kleinknecht, 1999). Leading industrial firms may also face a dilemma in disclosing their core knowledge, as such information may enable their competitors to develop similar competitive innovations (Hall, Helmers, Rogers & Sena, 2014). Hence, they may opt to keep novel knowledge secret (Cohen et al., 2002; Hall et al., 2014).

In a robustness test, we adopt an alternative indicator - *SCORE* - developed by ABC to measure the quality of the innovation achieved by collaboration projects. It is a number determined by a technical evaluation committee within ABC and ranges from 0 to 100. The committee is an independent third-party evaluation committee within the firm and is made up of internal senior executives, technical experts, and executive project managers. These evaluators assign each project a score according to the novelty of its granted patents and other relevant achievements. This measure provides us with an alternative with which to quantitatively measure the novelty of project outcomes. The evaluation and scoring of individual projects follows a strict internal procedure within ABC. Hence, our adoption of *SCORE* as a measure of the novelty of innovation is believed to be relatively objective.[11]

Model 6 in Table 4 presents the results with *SCORE* as the dependent variable in Eq. (1), which is estimated based on a generalized linear model approach. The results regarding the key variables are generally consistent with the results produced in Table 3. Cultural distance exists as an undermining factor that negatively affects the innovation quality of international collaboration (H2). The greater the distance from a collaborator to the corresponding ABC ORC is, the less novel its innovation, as measured by SCORE (H3). Collaborating with a top-100 foreign URI consistently stimulates the creation of novel knowledge (H4).[12]

Given the focus of *SCORE* on different aspects of project outcome novelty, some of the control variables, including *Previous_Collaboration* and *Tech_R&D,* show effects that are different from those of *Outstanding_Outcome*. While joint research projects with external organizations aim to create codified knowledge, ABC may prefer to patent (*Outstanding_Outcome*) the produced inventions. When project outcomes involve tacit knowledge, keeping this knowledge secret or combining both patenting and secrecy to protect it may be preferred (Arora, 1997; Belleflamme and Bloch, 2014). As IP is directly linked to codified knowledge, holding the sole ownership of IP (*IP_Sharing*) improves *Outstanding_Outcome*, whereas this effect is absent across the *SCORE* models. Similarly, *Tech_R&D* is observed to be positively associated with *Outstanding_Outcome,* but this association becomes negative when innovation quality is measured with *SCORE.*[13]

To further evaluate the consistency of the findings, we undertake several other robustness checks by employing different estimation approaches and model specifications. Model 7 in Table 4 presents the coefficients resulting from regressing Eq. (1) with a zero-inflated negative binomial, whereas Model 8 includes department dummies. Model 9 presents the results of using the natural logarithm of the distance between the focal collaborator and ABC's R&D centre (*R&D_Centre, log*) in the same region. The estimated coefficients across the different models are highly consistent with those in Table 3. Model (10) presents the ZIP estimation results, including *Project_Length,* measured in months. The estimated coefficients of the other variables are generally consistent. However, the coefficient of *Project_Length* is nonsignificant.

Similar specifications (Models 11–13) with alternative measures are also estimated on the sample combining 1428 foreign and domestic projects, and these results are compared with those of Model 5 in Table 3, which uses *Outstanding_Outcome* as a measure of innovation quality. The Generalised Linear Models (GLM) results are presented in the right panel of Table 4. In line with the findings obtained from Model 5, the impact of international collaboration on innovation quality is significantly positive. The estimated coefficients are highly consistent, as are those of the specifications with *Department dummies* (Model 12) and *Project_Length* (Model 13). Again, this finding verifies Hypothesis 1, suggesting that international collaboration acts as an effective technological sourcing channel that encourages knowledge flow and promotes enhanced innovation quality.

5. Discussion and conclusion

Due to their latecomer status and limited domestic knowledge bases, emerging country firms, including leading MNEs, work hard to form external knowledge-creation collaborations and face crucial decisions related to choosing appropriate partners. This paper investigates the impact of international collaboration on the quality of innovation in leading MNEs from emerging markets. We give special attention to the mechanism underlying international collaboration and innovation quality by focusing on challenges related to cultural distance and the conditions required to successfully manage international collaborations. A unique project-level database obtained from a large MNE allows us to gain an in-depth understanding of the cross-border innovation collaboration of leading industry players in emerging economies and provide insights into how emerging-country MNEs can enhance their innovation quality through international innovation collaboration.

5.1. International collaboration stimulates innovation quality

Consistent with prior studies (Kogut and Singh, 1988; Yao, Yang & Fisher, 2013; Briggs, 2015), we find that firms actively engage in

[11] The reason SCORE is not adopted as the main measure of innovation quality is because of the relatively small variation in the measure. As shown in Table 1, the average score of the sample projects is 85.11 with a standard deviation of 7.15, and most of the projects receive scores in the range of 80–90. Such small variations across the sample may affect the consistency of empirical estimations.

[12] Following common practice (e.g., Price and Sanders, 1995; Antolin and Bover, 1997, among others), we also include time dummy variables to take account of any possible variations in all of the other independent variables identified in the model. The major results remain unchanged and are available upon request.

[13] To mitigate concerns on endogeneity between innovation quality and international collaboration, we also include the GDP per capita of the focal partner's city as an instrumental variable. This endogeneity test does not reject the null hypothesis of no endogeneity. The main results remain the same and are available upon request.

Table 4
Robustness check (marginal effects).

Dependent variable: *SCORE*	Foreign collaboration projects					Foreign & domestic collaboration projects		
	(6) *SCORE (GLM)*	(7) *Zero-Inflated Negative Binomial*	(8) *Department Dummy*	(9) *R&D_Centre, log*	(10) *Project_Length*	(11) *SCORE (GLM)*	(12) *Department Dummy*	(13) *Project_Length*
International						0.031***	0.031***	0.031***
						(0.009)	(0.009)	(0.009)
Cultural_Distance	-0.027***	-0.015*	-0.001**	-0.003**	-0.015*			
	(0.007)	(0.008)	(0.000)	(0.001)	(0.008)			
R&D_Centre, ratio	-0.028***	-0.007*	-0.000**		-0.007*			
	(0.009)	(0.004)	(0.000)		(0.004)			
R&D_Centre, log				-0.003***				
				(0.001)				
University_Top100	0.049***	0.007*	0.000*	0.004**	0.004	0.021	0.020	0.020
	(0.018)	(0.004)	(0.000)	(0.002)	(0.003)	(0.015)	(0.015)	(0.015)
Budget	0.000	0.003**	0.000**	0.001*	0.003*	0.002	0.002	0.002
	(0.005)	(0.001)	(0.000)	(0.000)	(0.002)	(0.004)	(0.004)	(0.004)
Project_Length					0.000			0.000**
					(0.000)			(0.000)
Open_Call	-0.079***	-0.230**	-0.009***	-0.221***	-0.129**	-0.110*	-0.108*	-0.108*
	(0.030)	(0.096)	(0.003)	(0.078)	(0.055)	(0.057)	(0.057)	(0.057)
IP_Sharing	0.015	0.006*	0.000*	0.008***	0.007*	0.010	0.008	0.008
	(0.013)	(0.003)	(0.000)	(0.003)	(0.004)	(0.010)	(0.010)	(0.010)
Previous_Collaboration	0.064***	-0.169**	-0.013***	-0.181***	-0.176**	0.062***	0.060***	0.061***
	(0.014)	(0.071)	(0.005)	(0.067)	(0.075)	(0.010)	(0.010)	(0.010)
Tech_R&D	-0.030**	0.005	0.000	0.011**	0.007	-0.035***	-0.035***	-0.037***
	(0.014)	(0.003)	(0.000)	(0.004)	(0.004)	(0.010)	(0.010)	(0.010)
Inflate								
Patent_Purpose		0.015***	0.001***	0.020**	0.014***			
		(0.005)	(0.000)	(0.008)	(0.005)			
Observations	714	714	714	714	714	1,428	1,428	1,428

Notes: The marginal effects are reported, and robust standard errors are given in parentheses. *** p<0.01, ** p<0.05, and * p<0.1. Constant terms are included in all the regressions but are not reported in the marginal effect results table. We also add year dummies to control for possible variations in all of the other independent variables identified in the model. The main results are similar and available upon request.

interorganizational collaborations, both domestically and internationally, to gain access to valuable external resources (Jean et al., 2010; Iino et al., 2021), improve their knowledge diversity and overcome internal resource limitations. The findings of the current study demonstrate that international collaboration is more likely than domestic collaboration to enhance the innovation quality and reinforce the competitiveness of leading MNEs from emerging markets. The knowledge pool of a domestic collaborator may overlap with that of the focal firm to a great extent, as they interact with similar suppliers, customers and competitors while operating in similar environments. Therefore, such collaboration may not generate large knowledge synergies. In contrast, international collaborations establish an ideal platform to realize knowledge exchanges and generate better quality innovation between partners due to foreign collaborators' diversified knowledge, their distinct knowledge characteristics and the competitive environments in which they operate (Belderbos et al., 2004). International collaboration could also provide emerging-country firms with varied R&D experiences (Danzon, Nicholson & Pereira, 2005).

5.2. Cultural distance

An understanding and appreciation of heterogeneous cultural frameworks improve learning and knowledge creation (Hofstede, 1984; Ambos and Ambos, 2009; Jean et al., 2010). The challenges imposed by different cultural frameworks on international collaboration persistently exist and should not be ignored. Heterogenous collaborations involving knowledge and resources tend to spark more novelties if collaborators share sufficient common ground and cultural understandings (Kang and Jiang, 2012; Piening et al., 2016). Our study confirms that differences in firms' cultural backgrounds significantly affect their organizational learning and innovation outcome quality; however, this can be overcome through high-quality international collaboration and certain partner characteristics. The challenges induced by great cultural distances not only hamper innovation quality but also undermine the innovation effect of project inputs, e.g., budgets. MNEs may therefore adopt different strategies to ease the challenges posed by cultural distance, including activities designed to promote interpersonal communication, understanding and mutual trust and thus improve the quality of innovation.

5.3. Distance to R&D centre

This finding illustrates that establishing research centres near overseas collaborators allows ABC to participate in the innovation ecosystems of its host countries, which include the technological frontiers in advanced economies. Interacting with local organizations and utilizing resources embedded in these innovation ecosystems benefit ABC's technological capability and positively affect its novel knowledge creation processes. Moreover, ORCs can reduce the negative impact of both the geographical and cultural distances inherent to international collaboration and hence improve the performance of international innovation; this transpires partly through the capability enhancement of emerging market firms, as ORCs allow them to better sense and seize technological opportunities. These ORCs also become a natural conduit, facilitating knowledge exchanges between host country innovation systems and emerging market firms. The presence of overseas R&D positively moderates the effect of cultural understanding between focal firms and foreign collaborators. The establishment of overseas R&D centres can also be treated as an effective way to induce interpersonal communication and understanding, which eventually benefits the future expansion of international collaborations.

5.4. Partners' capabilities, knowledge and skills

The resources and objectives of research collaborations vary across different types of partners, which leads to heterogeneity in innovation performance. Industrial collaborations are inclined to focus on practical and urgent issues, which makes them more oriented towards problem solving than university collaborations. Generally, academic partners are involved in basic, forefront research that is believed to catalyse novel elements of outcomes. Their diverse knowledge pools can also offer complementary resources and technologies to leading firms from emerging countries. Our findings show that collaborations with foreign universities assist in the improvement of innovation quality, but such improvement is subject to collaborators' technological and research capabilities (Corsi et al., 2020). Conducting joint research projects with top-ranked foreign universities, which feature large talent pools and high levels of technological capability, can lead to more success in enhancing innovation quality. However, working with academic partners does not always guarantee outstanding outcomes, given that the research conducted and types of technology created in academic institutions are not necessarily patent- and market-oriented.

5.5. Managerial implications

The findings of this research also have important managerial implications. First, this study confirms that leading Chinese MNEs have upgraded their innovation capabilities through international collaborations. Although at present it is considered that China is pursuing the 'globalization of innovations' within the world economy, Chinese firms are still learning through international collaborations. Therefore, the managers of these firms should strategically seek increased international openness in innovation and foster greater transparency in international innovation collaborations. Second, these firms should be equipped with the compatible capability to manage and coordinate collaborations with foreign partners from different cultural backgrounds (Xie and Li, 2018; Bahl et al., 2021). In particular, the abilities to identify challenges and remove obstacles related to cultural distance are vital to the success of international collaboration. Last but not least, setting up ORCs is not only a way to tap into superior knowledge but also an effective way to enhance dynamic capabilities through greater interpersonal interactions between researchers, which are important for knowledge coproduction and for the further development of balance in relation to global technological power.

5.6. Limitations

Admittedly, this research has some limitations. Accurately measuring the quality of innovation has always been a challenge in the existing literature. The indicator used in the current research, *Outstanding_Outcome*, is believed to capture the quality of outcomes from the perspective of the focal firm, ABC. However, it cannot represent the true market value and quality of a project outcome. Future research may adopt an alternative indicator, e.g., the citations attached to the patent, to measure the quality of innovation. While the evidence shows that the local presence of an ORC facilitates more effective international innovation collaborations, due to data limitations, it does not show whether the scale and innovation capacity of ORCs are important in moderating the outcome of collaborative innovation projects. Future research should further explore the impacts of different characteristics of ORCs on the relationship between international collaboration and innovation. Similarly, the current project-level dataset does not distinguish between types of collaborators other than URIs across different projects. Future research should investigate the relationship between diversity and innovation quality. Moreover, the current study used project-level data from a single industrial leading Chinese firm. Therefore, the results and implications cannot be generalized to other firms from emerging economies. In addition, complementary in-depth case studies should be carried out to reveal the mechanisms through which ORCs support headquarters' international collaborations and enhance the overall innovation capabilities of MNEs.

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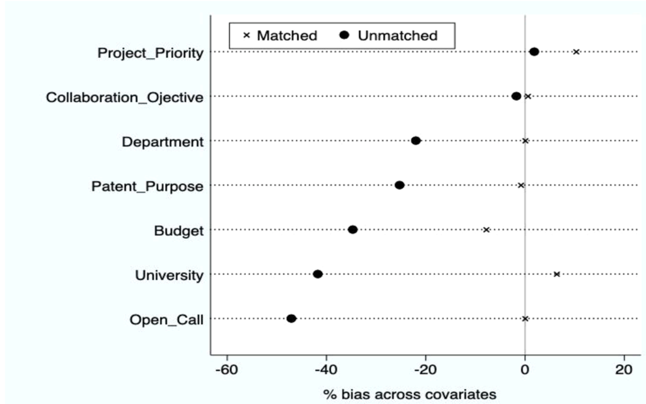
Appendix A. Balanced sample test.

	Unmatched/ Matched	Mean Treated	Control	% bias	% reduction |bias|	t test t	p>|t|
Budget	U	5.29	5.72	-34.70		-8.95	0.00
	M	5.29	5.38	-7.80	77.40	-1.51	0.13
University	U	0.44	0.64	-41.70		-10.37	0.00
	M	0.44	0.41	6.40	84.80	1.38	0.17
Patent_Purpose	U	0.33	0.45	-25.30		-6.21	0.00
	M	0.33	0.34	-0.90	96.60	-0.19	0.85
Open_Call	U	0.01	0.11	-47.10		-10.45	0.00
	M	0.01	0.01	0.00	100.00	0.00	1.00
Project_Priority	U	0.02	0.02	1.90		0.46	0.64
	M	0.02	0.01	10.30	-454.50	2.73	0.01
Department	U	2.34	3.12	-22.00		-5.30	0.00
	M	2.34	2.34	0.00	99.90	0.01	0.99
Collaboration_Objective	U	2.97	2.99	-1.70		-0.42	0.67
	M	2.97	2.97	0.60	67.50	0.14	0.89

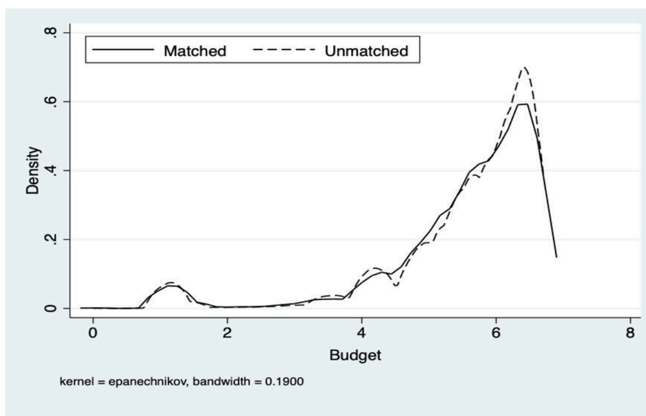
Notes: *Collaboration_Objective* takes a value of 1 if the objective of the project is patent application and 0 otherwise; *Project_Priority* takes a value of 1 if ABC prioritizes this project and 0 otherwise; and *Department* denotes the department dummies.

Appendix B. Standardized % bias across the covariates.



.

Appendix C. Kernel density estimate.



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