

# The effects of geographical and business proximity on affiliates' R&D investment: a proximity theory perspective

A proximity theory perspective

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## Abstract

**Purpose** – This study aims to examine the impact of geographical and business proximity between parent companies and affiliates on R&D investments in business groups. Furthermore, it compares the moderating effect of value chain participants' bargaining power and the performance-aspiration gap.

**Design/methodology/approach** – This study uses data from 411 Chinese private manufacturing listed firms affiliated with business groups. This paper conducts regression analysis using Stata 16.0 software. Additionally, this paper employs combined random effects regression models, the 2SLS method and GMM method.

**Findings** – Geographical distance between focal affiliates and parent companies is negatively related to focal affiliates' R&D. The higher the business proximity between focal affiliates and parent companies, the more R&D investments are made. Further research shows that with stronger bargaining power and a wider performance-aspiration gap, the negative relationship between geographical distance and R&D investment weakens.

**Originality/value** – This study contributes to the R&D investment literature by offering a novel perspective on why proximity influences affiliates' R&D investments in Chinese business groups. This study enriches the proximity theory by introducing business proximity as a new dimension into the framework. Furthermore, this study highlights the boundary conditions of the proximity theory by ascertaining the moderating effects of bargaining power and the performance-aspiration gap.

**Keywords** Geographical proximity, Business proximity, Proximity theory, Business group, R&D investment

**Paper type** Research paper

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## 1. Introduction

With the growing complexity of emerging economies, business groups have played an important role in global markets. In the late twentieth century, the proportion of business groups in South Korea and Europe was 68% and 49%, respectively (Belenzon and Berkovitz, 2010; Chang *et al.*, 2006) and has now surged to 95% in China. Fierce technological competition among firms relies heavily on business groups' capabilities. They can assist affiliates in overcoming R&D challenges and making informed decisions on technological investments. In 2022, the added value of the Chinese high-tech and equipment manufacturing industries increased by 10.6% and 7.9%, respectively. Simultaneously, social R&D investment intensity increased from 2.15% to 2.5%. Competition among countries has gradually shifted toward innovation, driven by business groups' innovative capabilities. In 2021, Huawei's R&D investment intensity reached 22.4%, Tencent Group's was 9.3% and Alibaba's was 6.5%. Enterprises that continue to strengthen their R&D efforts have demonstrated good performance and growth. To avoid being overtaken by technological advancements, market trends or international competition, business groups must maintain a sustained competitive advantage through increased innovation. Therefore, promoting innovation within business groups, particularly affiliates, is an important practical issue.

Research on the relationship between business group characteristics and R&D has explored three aspects. First, business group affiliates possess more R&D advantages than unaffiliated firms (Blanchard *et al.*, 2005; Filatotchev *et al.*, 2003; Guzzini and Iacobucci, 2014; Wang *et al.*, 2015). This advantage becomes particularly pronounced when institutions are of poor quality or markets are underdeveloped (Alon *et al.*, 2020; Belenzon and Berkovitz, 2010; He *et al.*, 2013). Second, affiliates' R&D investments are influenced by the characteristics of other member firms that are directly or indirectly controlled by the same parent company (He *et al.*, 2013). Third, business groups' level of diversification and political connections also influence affiliates' R&D investments (Hsieh *et al.*, 2010; Mahmood *et al.*, 2017; Manikandan and Ramachandran, 2015; Wang *et al.*, 2015). In reviewing research on the relationship between the characteristics of business groups and innovation, we discovered that studies have generally overlooked the role of relationships between members in the same business group. Affiliates' proximity to parent companies can affect its access of resources, attention from parent companies and support from the internal network (Kerai and Sharma, 2015). However, limited studies have been conducted on this topic. Furthermore, studies on corporate social networks have also neglected affiliates' geographical and social proximity within business groups (Zhang *et al.*, 2006).

Therefore, to illustrate the significance and function of proximity and clarify the mechanisms through which affiliates' geographical and business proximity influence R&D, we:

- determine how to describe affiliates' proximity in the business group's network;
- investigate how geographical and business proximity affect affiliates' R&D investment and explore potential reciprocal effects between these proximities; and
- identify external or internal conditions that moderate the relationship between proximity and R&D investment.

From a proximity theory perspective, we construct focal affiliates' geographical proximity, reflecting the spatial or geographical distance to parent companies (Harzing and Noorderhaven, 2006), and business proximity, reflecting social and cognitive proximity. Additionally, we examine the influence of geographical and business proximity on affiliates' R&D investment and the moderation of baseline relationships.

This study contributes to the literature on business groups and R&D investments in three ways. First, it expands the R&D literature by demonstrating the importance of proximity in evaluating the direct effects of business group characteristics on R&D investments. Despite ongoing research in this domain, most R&D studies on affiliates have not examined the proximity between parent-affiliates to elucidate their relationship with R&D. While some studies mention the effects of the relationship between parent companies and affiliates and the proximity between affiliates and unaffiliated firms, few have considered affiliates' innovation heterogeneity based on the proximity theory in the context of business groups in the world's largest emerging market. As proximity between parent-affiliates affects resources and support from business groups, our findings offer a novel and detailed perspective on explaining affiliates' innovation heterogeneity within the same business group than previous studies.

Second, this study enriches the proximity theory by introducing business proximity as a novel dimension within its framework – a more suitable and important dimension for illustrating knowledge spillover in R&D. To the best of our knowledge, this study is among the first to explicitly propose the concept of business proximity and examine its outcomes on R&D. By introducing this fundamental, direct and relevant dimension, we offer a contrast to past proximity theories that focus on geographical, social, organizational, cognitive and institutional proximity without delving deeper into the reasons driving knowledge spillover into R&D. Expectations of future cooperation and technological suitability are crucial for firms investing in R&D. However, past studies have overlooked business proximity as an important factor influencing cooperation and technological relevance. We focus on this proximity and provide a fresh perspective on understanding the reasons for R&D investment based on the characteristics between parent company and affiliates. Meanwhile, integrating business proximity into the proximity theory enriches its comprehensiveness.

Third, this study highlights the boundary conditions of proximity theory by ascertaining the moderating effect of bargaining power and the performance-aspiration gap. While the literature on proximity theory and R&D has primarily focused on macro-external circumstances as boundary conditions, like institutional voids and market development, it has neglected how proximity and R&D relationships may be influenced by firm-level circumstances. Thus, we provide clear evidence that bargaining power and the performance-aspiration gap affect the relationship between proximity and R&D investment in parallel. This finding has managerial implications regarding how affiliates navigate these pressures in both internal and external firm-level environments. In summary, our focus on the relationship between proximity and R&D and the contingent effects of bargaining power and the performance-aspiration gap on the baseline help us understand how affiliates make R&D decisions under interactions within business groups.

## 2. Theory and hypotheses

### 2.1 Proximity theory

When examining affiliate locations and the relationship between parent companies and affiliates, scholars (Balland *et al.*, 2015; Boschma, 2005; Hung *et al.*, 2021) have integrated the social network analysis theory into proximity theory, developing geographical, social, organizational, cognitive and institutional proximity. Geographical proximity specifically examines the impact of the spatial distance between parent and affiliate companies on innovation (Schepis, 2021), whereas social, organizational and cognitive proximity elucidate how business proximity influences innovation. Drawing on these scholars' viewpoints on the proximity theory, this study explains differences in R&D investment among affiliates within the same business group from a proximity perspective.

Proximity framework was introduced two decades ago to understand knowledge spillovers and innovation (Rallet and Torre, 1999). Empirically, proximity theory has been used to understand knowledge production, labor flow, and mergers and acquisitions in multinational corporations (Balland *et al.*, 2015). Proximity enhances network-related activities, promotes communication, and explains innovation evolution. Geographical proximity, the foundation of the proximity framework, involves spatial or physical distance between two members, facilitates interactive learning and stimulates other proximity dimensions (Zamir and Saeed, 2020). Extensive literature has shown that R&D is geographically bounded, with firms situated near resource hubs exhibiting increased willingness to innovate. Therefore, geographical proximity is conducive to innovation.

Cognitive proximity has been proposed to understand firms' absorptive capacity and learning potential (Balland *et al.*, 2015; Hung *et al.*, 2021). Innovation often requires cumulative, localized, and tacit knowledge. When companies possess relevant knowledge and similar learning capacities, they can effectively interpret information, exploit resources and collaborate on innovation. In business groups, business proximity between parent companies and affiliates forms cognitive proximity, fostering innovation and enhancing the possibility that parent companies invest in affiliates' R&D.

### *2.2 Geographical and business proximity in business groups*

As the final controller of affiliates, parent companies are positioned at the top of the hierarchy of business groups (Colpan *et al.*, 2010). Parent companies are legally independent and responsible for the strategic planning, operational coordination, resource allocation and reputation protection of holistic business groups (Bouquet and Birkinshaw, 2008; O'Donnell, 2000). Internal business group networks and affiliates' proximity can lead to differences in the decision-making, motivation and resource allocation of affiliates' R&D. Affiliates are not only members of business groups but are also autonomous (Alon *et al.*, 2018). Affiliates may take the initiative and customize their local markets (Edwards *et al.*, 2002; Ferner *et al.*, 2004). However, existing research on affiliates' proximity is limited (Li *et al.*, 2023). Scholars have focused on parent companies' shareholding ratios and subsidiaries' export share to parent companies' total exports, which does not adequately depict affiliates' position in the business groups' network. Additionally, proximity between parent companies and focal affiliates, another dimension of network characteristics, also affects resource and project allocation, thus affecting innovation and reducing the disadvantage of distance for affiliates. As innovation activities become increasingly diversified and complex, interdependence between parent companies and affiliates is required, particularly for affiliates.

### *2.3 Geographical proximity and R&D investment*

Geographical proximity implies that focal affiliates are spatially close to parent companies (Alon *et al.*, 2018; Bignami *et al.*, 2020; Chakrabarti and Mitchell, 2016; Malhotra and Gaur, 2014). Geographical distance affects technological innovation in three ways. First, geographical proximity influences language and thus business communication. Given China's vast territory and diverse dialects across regions, communication barriers exist among different dialect speakers. Spolaore and Wacziarg (2009) found that language distance limits the quality and depth of communication, thereby widening the innovation gap. Bai and Kung (2011) stated that geographically distant subsidiaries face obstacles in knowledge exchange and information communication within the group, inhibiting technological innovation.

Second, geographical distance directly affects knowledge dissemination. The greater the geographical distance, the higher the costs of knowledge diffusion, making it more

challenging for recipients to obtain accurate knowledge. [Coe et al. \(1997\)](#) highlighted that knowledge spillovers are limited by geographical regions, with greater distances of knowledge diffusion resulting in more pronounced losses and distortions. [Beck et al. \(2019\)](#) discovered a decline in technological spillovers with increasing distance. As the geographical distance between focal affiliates and parent companies widens, information asymmetry increases, leading to a gradual decrease in knowledge flow ([Harzing and Noorderhaven, 2006](#); [Presutti et al., 2019](#)). Additionally, [Kapetaniou and Lee \(2019\)](#) found that enterprises face greater challenges in absorbing new technologies the farther they are from the technological frontier market. Affiliates' weak geographical proximity affects their understanding and absorption of cutting-edge technologies, thereby inhibiting innovation.

Third, geographical distance exacerbates information asymmetry while also raising principal-agent and transaction costs. Geographical distance reduces the reliability of information transmission ([Alon et al., 2020](#)). Moreover, geographical distance discourages investors from investing in R&D due to a lack of information, administrative barriers and local relations. [Wulf \(2009\)](#) highlighted that increased distance necessitates more nodes for network connections between subsidiaries and parent companies, thereby making business group management inefficient. Consequently, investors prefer enterprises closer to parent companies. Business groups typically delegate R&D activities to affiliates at relatively close distances to mitigate overall risk, reduce human and financial costs ([Zheng and Sun, 2023](#); [Zhu et al., 2008](#)), and lower agency costs. Overall, geographical distance makes knowledge spillover challenging, increases business group supervision costs, weakens parent companies' motivation to assign R&D tasks and reduces resource support from business groups. Therefore, we propose:

- H1.* Geographical distance between parent companies and focal affiliates negatively relates to focal affiliates' R&D investment.

#### *2.4 Business proximity and R&D investment*

Business proximity between parent companies and affiliates, reflecting similarities in business models and organizational operations, influences R&D resource acquisition and knowledge spillover. According to the proximity theory, which asserts that proximity positively affects resource integration processes ([Granstrand and Holgersson, 2020](#); [Jiang et al., 2020](#)), capital and labor for innovation reallocated in business groups are affected by business proximity. From a business group perspective, relevant affiliates receive more attention from and coordinate more closely with parent companies than less-relevant affiliates. [Chang and Hong \(2000\)](#) explicitly stated that parent companies tend to share group-wide resources and internalize transactions with affiliates more closely aligned with their core business. From affiliates' perspective, business proximity facilitates frequent connections and builds deep trust among affiliates and members during innovation. Therefore, for the convenience of acquiring resources, communication, and trust, focal affiliates tend to invest more in R&D. [Lähdesmäki et al. \(2019\)](#) stated that because of closely related businesses, affiliated firms feel a stronger sense of belonging to business groups and exhibit greater loyalty to parent companies. This sense of belonging motivates affiliates to engage in R&D, potentially leading to new profit avenues for holistic business groups; thus, firms are more willing to innovate.

An important premise of knowledge spillover and R&D synergy is the relevance of business scope ([Aldieri et al., 2020](#); [Balland et al., 2015](#); [Hegde and Tumlinson, 2014](#)). [Feinberg and Gupta \(2004\)](#) argued that the potential to capture knowledge spillovers and effectively utilize knowledge may affect parent companies' decisions regarding the

allocation of R&D activities to affiliates and cooperation with them. Business proximity, which results in a high overlap of knowledge, promotes knowledge absorption and improves the effect of knowledge spillover, a significant driver of R&D. Therefore, affiliates with closer business proximity tend to secure R&D projects from business groups. Additionally, related businesses are drivers that facilitate informal communication (Delorme, 2023). Parent companies and affiliates with close business proximity encounter fewer communication barriers and tend to form consistent R&D objectives. These advantages of business proximity can result in high R&D investments. Therefore, we propose the following hypothesis:

- H2. Business proximity between parent companies and focal affiliates positively relates to focal affiliates' R&D investment.

### 2.5 *The moderating effect of suppliers' bargaining power*

Affiliates close to parent companies tend to receive support from business groups, thereby improving their R&D investment. However, this effect is not homogeneous and external constraints and internal conditions may influence the effect of affiliates' proximity on R&D investment. Firms overly dependent on suppliers and customers face a competitive disadvantage (Du and Kim, 2021; Du *et al.*, 2016; Yan *et al.*, 2018). Yang *et al.* (2012) suggested that suppliers' bargaining power determines the quality and scale of external resources. When subsidiaries face strong constraints from suppliers or customers, production and marketing autonomy is weakened (Cole and Aitken, 2019). Supplier constraints may increase the marginal costs of external resources. Thus, subsidiaries located distant from parent companies initiate communication with them, attempt to reduce information asymmetry and supervision costs and actively demonstrate rent-seeking behavior to obtain internal products and resources from business groups. Considering overall interests, parent companies may focus on and support focal affiliates to avoid control by external organizations. Thus, the negative effect of focal affiliates' geographical distance on R&D investment weakens.

Additionally, affiliates may exhibit reluctance to increase their R&D investment because of their free-riding behavior. However, this reluctance can shift when they encounter supplier or customer constraints. Strong supplier constraints compel firms to create products according to suppliers' requirements, potentially reducing product quality and quantity or decision-making discretion. Furthermore, suppliers' bargaining power influences the implementation of a differentiation strategy. Provan (1993) highlighted that firms collaborating with suppliers should increase their core competencies to gain advantages in the value chain. Technological innovation promotes production process standardization, reduces material waste, expands raw material selection range and promotes vertical integration; therefore, R&D investment effectively weakens supplier threats (Kotlar *et al.*, 2014; Markóczy *et al.*, 2013; Zhu *et al.*, 2011). To gain advantage in the value chain and control the production process, affiliates' R&D motivation becomes stronger. When knowledge spillover in the business group cannot improve this condition, focal affiliates, even if far from parent companies, will increase R&D investment, thus narrowing the gap in R&D investment and affiliates' geographical distance.

When external bargaining power is stronger, the loss of pricing and product formulation rights can threaten the entire business group's interests. In such situations, affiliates and parent companies with close business proximity can increase their R&D by drawing on previously established trust and similar knowledge structures. This fosters R&D

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cooperation between affiliates and parent companies, thus maximizing knowledge spillover effects. Thus, we hypothesize:

- H3a.* Suppliers' bargaining power weakens the negative relationship between geographical distance and R&D investment.
- H3b.* Suppliers' bargaining power strengthens the positive relationship between business proximity and R&D investment.

### *2.6 The moderating effect of the performance-aspiration gap*

Decision makers typically establish a psychological satisfaction value as their aspiration level during the decision-making process, similar to how firms set periodic goals. When firm performance falls below aspiration levels, decision-makers believe that firms suffer losses (Shinkle, 2012). These losses encourage decision-makers to identify problems and take measures to achieve their expected goals. The gap between current firm performance and aspiration level can be termed as the performance-aspiration gap. When performance falls below aspiration levels, firms attempt to mitigate discrepancies by engaging in problem identification, like increasing their proclivity to undertake risky activities. By examining the causes for underperformance, firms may assimilate external knowledge, create new modes, or operate in new ways. Firm managers may also change firm routines and processes, serving product innovations. Thus, a negative performance-aspiration gap exerts pressure on firms. When performance falls below aspiration levels, firms are more likely to identify problems and accept innovation risk.

Poor firm performance prompts stakeholders to question enterprise development, leading to investor withdrawals, wavering employee belief, diminished manager confidence, and so on (Zhu *et al.*, 2013). When focal affiliates fail to achieve expected performance, despite being geographically distant from parent companies, parent companies pay increased attention and supervision to safeguard its subsidiaries. To solve managerial or operational problems, focal affiliates, regardless of their position, actively build strong relationships with parent companies, maintain communication, promptly report to parent companies and reduce agency costs resulting from geographical distance. Kim and Lui (2015) argued that parent companies should provide increased support to struggling subsidiaries as needed. To reverse deficits, subsidiaries effectively utilize available resources, seek additional policy support and improve R&D investment depending on their business group. Therefore, when the performance-aspiration gap is larger, focal affiliates are more likely to overcome the disadvantage of geographical distance, and parent companies may pay increased attention to affiliates, thereby improving R&D investment.

When affiliates with different business scopes from parent companies fail to achieve their desired goals, they may encounter significant problems in resource allocation and risk management because of the disadvantage in resource endowment compared to affiliates closer to parent companies. Greve (2008) suggested that firms risk tolerance improves when they face business difficulties. When the performance-aspiration gap is larger, these firms are more likely to adjust their strategies to mitigate losses, and affiliates operating in distinct domains are more willing to implement strategies with high risks and rewards, like R&D investment. Essentially, the performance-aspiration gap weakens the negative influence of proximity on R&D investment. When the performance-aspiration gap increases, differences in parent companies' support and subsidiaries' R&D motivation resulting from proximity factors are narrowed, weakening the negative effect of proximity on R&D, and strengthening the positive effect. When some affiliates fail to achieve the expected

performance, parent companies are more likely to prioritize those closely aligned to their core business, providing support and solutions like increased R&D investment. Hence, we propose the following hypotheses:

- H4a.* The performance-aspiration gap weakens the negative relationship between geographical distance and R&D investment.
- H4b.* The performance-aspiration gap strengthens the positive relationship between business proximity and R&D investment.

Our conceptual model is as follows (Figure 1).

### 3. Research design

#### 3.1 Sample and data

This study employs data from private manufacturing companies listed on the Shanghai and Shenzhen stock exchanges in China from 2016 to 2019. Dependent and independent variables were manually extracted from annual reports, while control variables were obtained from the CSMAR database. Certain data undisclosed in the annual report were obtained from the Baidu and Straight Flush websites. The data underwent screening by excluding (1) ST stocks; (2) stocks where the ultimate controller cannot be determined; and (3) companies that did not disclose R&D investment, supplier procurement proportion, and customer sales proportion. Finally, unbalanced short panel data from 1126 observation samples from 411 firms were obtained.

#### 3.2 Measures

*3.2.1 Independent variables.* To measure *R&D*, we calculate R&D intensity as the ratio of R&D expenditure to firms' operating revenue in the current year (Belenzon and Berkovitz, 2010; Guzzini and Iacobucci, 2014; Li et al., 2023).

*3.2.2 Dependent variables.* *Geographical distance between focal affiliates and parent companies (GD)* is used to measure geographical proximity, following Chakrabarti and Mitchell's (2016) measurement. First, we identified the corresponding parent company for focal affiliates. Second, we searched annual reports and employed TianYan and Baidu Search to identify prefecture-level cities where the parent company and focal affiliate are located. Third, we measured distance by calculating the meters between the coordinates of the two cities using Baidu maps. As distance is non-directional, the variable is non-negative and the natural logarithm of the distance is employed in the regression. Smaller geographical distance indicates greater geographical proximity.

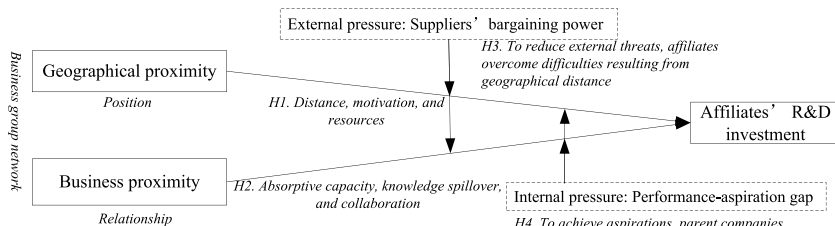


Figure 1.  
Conceptual model

Source: Figure created by authors

*Business proximity between focal affiliates and parent companies (Related)* is a virtual variable. Based on the industry classification code of the CSRC in 2020, when a listed firm's industry code overlaps with that of the head firm or business group, the business proximity value is one, otherwise it is zero.

**3.2.3 Moderating variables.** We measure *supplier constraints (Sup5)* as the proportion of purchases from the top five suppliers to the total purchase amount. Similarly, we measure *customer constraints (Cus5)* by the proportion of sales from the top five customers to total sales.

*Performance-aspiration gap* is used to help firms compare and assess their performance from multiple aspects. These comparisons (gaps) generate various feedback for firms, thereby affecting their responsiveness and shaping forward-looking decisions. [Manzaneque et al. \(2020\)](#) proposed two types of performance-aspiration gaps: industrial and historical. The industrial performance-aspiration gap measures the gap between firms' actual performance and that of its competitors within the same industry during the same period ([Joseph and Gaba, 2015](#)). The historical performance-aspiration gap reflects the gap between firms' past and actual performance. Industrial aspiration levels reflect comparisons with comparable peer firms, offering a benchmark for focal firms. Historical aspiration levels reflect firms' past performance and may serve as a forecast for the future.

*Industrial performance-aspiration gap (Gap1)* is the decline in expected industrial Return on Equity (ROE) relative to actual industrial ROE. This variable indicates instances where expectations are not achieved when the value is greater than zero. A higher value denotes a greater aspiration gap. *Historical performance-aspiration gap (Gap2)* is based on the ROE of the past five years. We measure this variable by calculating the difference between the expected historical ROE (average ROE of the past five years) and actual ROE.

**3.2.4 Control variables.** The measurements of control variables are shown in [Table 1](#).

## 4. Results

### 4.1 Descriptive statistics and correlation analysis

Descriptive statistics of the variables are presented in [Table 2](#). The average *R&D intensity* is 7.132, indicating that the average proportion of R&D expenditure of listed companies to operating revenue is 7.132%. The average geographical distance is 2.329, with a median value of 0, indicating that half of the listed affiliates are in the same city as their parent company. For samples with above- and below-average R&D investment, the average *GD* are 1.314 and 2.514, respectively, indicating that affiliates with higher R&D investment are geographically closer to their parent company.

[Table 3](#) presents the results of the correlation analysis of the main variables. A negative correlation coefficient ( $-0.157$ ) between *GD* and *R&D intensity* suggests that shorter geographical distances are associated with higher R&D investment. The correlation coefficient between *Related* and *R&D intensity* is 0.143.

### 4.2 Regression analysis of geographical proximity, business proximity and R&D

Before conducting the empirical test, a 2% tail reduction processing was applied to all data. Subsequently, we performed a common regression and calculated the variance inflation factor (VIF) value to test multicollinearity. The results indicate VIF values within six, indicating the absence of significant collinearity issues. Regression was conducted to test the relationship between affiliates' *GD*, business proximity, R&D intensity, and variations in these relationships under different internal and external situations. The results are presented in [Table 4](#).

Variable type	Variable	Symbol	Definition and measurement
Dependent variables	R&D investment	R&D	The ratio of R&D expenditure to operating revenue of focal firms in the current year
Independent variables	Geographical distance	GD	The natural log of meters between coordinates of affiliate's city and parent company's city
	Business proximity	Related	If the affiliate's business scope is related to parent company, it is one, otherwise it is zero
Moderator	Supplier's constraints	Sup5	The proportion of purchase from top five suppliers to the total purchase amount
	Customer's constraints	Cus5	The sales proportion from top five customers to total sales
	Industrial performance aspiration gap	Gap1	Decline in expected industrial ROE relative to the actual industrial ROE
	Historical performance aspiration gap	Gap2	Differences between the expected historical ROE and the actual ROE
Control variables	Concurrent post	Concur	When the chairman is the CEO, <i>Concur</i> is one, otherwise it is zero
	Board size	Director	Number of directors
	Executives' share	Ex_share	Ratio of the number of shares held by executives to the total number of shares
	Firm size	Size	Natural log of company assets
	Financial leverage	Lev	Ratio of company's liabilities to assets
	Return on assets	ROA	Ratio of net profit to total assets
	Monetary fund	Cash	Ratio of cash, bank deposits and other monetary fund to total assets at the end of the period
	Operating cash flow	Operate	Ratio of operating cash flow to operating income
Financing cash flow	Finance	Ratio of financing cash flow to operating income	

**Table 1.** Variable definitions **Source:** Table created by authors

Model (1) in Table 4 examines the relationship of *GD* and focal affiliates' *R&D intensity*. The results show that the coefficient of *GD* is significantly negative ( $\beta = -0.347, p < 0.01$ ), indicating that *GD* is negatively correlated with *R&D intensity*. This suggests that geographically closer affiliates may invest more funds to R&D activities. After including moderators to the model (shown in Models 3–6), the relationship between *GD* and *R&D intensity* remains valid, indicating that the results are robust. Thus, *H1* is verified.

Model (2) in Table 4 examines the relationship between affiliates' *Related* and R&D intensity. The results reveal that the coefficient of *Related* is significantly positive ( $\gamma = 0.703, p < 0.05$ ), indicating that *Related* is positively correlated with R&D intensity, thereby verifying *H2*. When affiliates' businesses are closely aligned with that of parent companies, the possibility of information and resource sharing increases, as is the degree of collaborative R&D within the business group.

### 4.3 Moderating effect of supplier and customer bargaining power

Model (3) in Table 4 examined the moderating effect of supplier bargaining power on the relationship between *GD* and *R&D intensity*. We included *Sup5* and the interaction of *Sup5* and *GD* to Model (1) to obtain Model (3). *Sup5* has a significant negative correlation ( $\beta_2 = -0.025, p < 0.01$ ) with *R&D intensity*, which appears inconsistent with the corporate behavior theory's explanation of the relationship between external control threats and

Variables	Total sample				Above-average R&D		Below-average R&D		
	Mean	Median	Max	Min.	SD	Mean	SD	Mean	SD
R&D	7.132	4.489	98.985	0	9.035	16.092	13.288	3.698	1.668
GD	2.329	0	15.733	0	5.019	1.314	3.790	2.514	5.192
Related	0.217	1	1	0	0.870	0.424	0.84	0.138	0.87
Sup5	38.391	35.15	97.1	2.3	18.504	40.60	19.43	37.55	18.08
Cus5	30.722	26.37	88.41	2.25	18.956	31.61	18.67	30.38	18.99
Gap1	0.000	-3.349	58.515	-30.347	17.303	-4.88	15.19	1.87	17.70
Gap2	0.000	-0.004	28.551	-29.423	5.054	-0.04	4.50	0.02	5.25

**Note:**  $N = 1,126$ , including 312 samples above average R&D and 814 samples below average R&D

**Source:** Table created by authors

**Table 2.**  
Descriptive statistics

R&D. The coefficient of the interaction ( $GD * Sup5$ ) was not significant ( $\beta_3 = 0.0016, p > 0.1$ ), indicating a less prominent moderating effect of  $Sup5$ . Model (4) tested the moderating effect of customer constraints on the relationship between  $GD$  and R&D intensity. We included  $Cus5$  and the interaction of  $Cus5$  and  $GD$  into Model (1) to obtain Model (4). The coefficient of the interaction is positive but not significant ( $\beta_3=0.0015, p > 0.1$ ), indicating a less prominent moderating effect of  $Cus5$ .

The explanations for these findings are as follows. Managers react to increasing bargaining power through problem solving that could guarantee greater future independence from external constraints. Generally, increasing R&D investment is an approach to problem solving. However, R&D is a long-term activity. Focal firms have difficulty mitigating supplier threats through R&D in the short term. Therefore, some managers may invest funds in activities like seeking alternative suppliers or customers in the short term, thereby increasing management costs rather than R&D investment. This suggests that an increase in supplier bargaining power does not significantly boost R&D investment over the same period in empirical analysis.

Innovation is a fundamental strategy for addressing supplier threats in the long run. Therefore, we conducted a regression analysis of supplier threat on lagged R&D investment. We found that the coefficient of  $Sup5$  on lag  $R\&D$  investment is positive in Model (9) in Table 4 ( $\beta_2 = 0.027, p < 0.05$ ), consistent with the aforementioned reasoning for H3a. Therefore, H3a is partially verified.

Subsequently, we examine the moderating effects of external constraints on the relationship between business proximity and R&D. The coefficient of the interaction between business proximity and supplier bargaining power in Model (7) is significantly positive ( $\beta = 0.023, p < 0.05$ ). This indicates that when external suppliers have strong bargaining power, affiliates' R&D investment – more relevant to the business group – increases. This aligns with corporate behavior theory, suggesting that when subsidiaries face external constraints, they may seek different avenues to mitigate them.

#### 4.4 Moderating effect of performance-aspiration gap

We examine the moderating effect of the *industrial performance-aspiration gap*; the results are shown in Model (5). The coefficient of the cross-multiplication of  $Gap1$  and  $GD$  is significantly positive ( $\beta_3 = 0.0043, p < 0.05$ ), indicating that as the aspiration gap widens, the relationship between  $GD$  and  $R\&D$  weakens. Therefore, H4 is verified. When affiliates encounter internal operating dilemmas, the aspiration gap prompts managers to identify and solve problems. The primary strategy employed is to increase R&D investment to improve product quality, as evidenced by the positive coefficient of industrial aspiration in

Variables	R&D	GD	Related	Sup5	Cus5	Gap1	Gap2
R&D	1						
GD	-0.157***	1					
Related	0.143***	-0.251***	1				
Sup5	0.061**	-0.047***	0.080***	1			
Cus5	-0.029	-0.043	-0.117***	0.141***	1		
Gap1	-0.198***	0.076***	-0.093***	-0.192***	-0.067**	1	
Gap2	0.008	-0.005	0.005	-0.038	-0.016	0.292***	1

**Table 3.**  
Correlations of the  
main variables

**Notes:**  $N = 1126$ ; \* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$  (Two-tailed tests of significance)  
**Source:** Table created by authors

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent	R&D	R&D	R&D	R&D	R&D	R&D	R&D	R&D	L. R&D
GD	-0.347*** (-3.95)								-0.210** (-2.57)
Related		0.703** (2.00)							
Sup5			-0.269** (-2.36)						
GD*Sup5									
Cus5			-0.025*** (-3.11)						
GD*Cus5									
Gap1									
GD*Gap1									
Gap2									
GD*Gap2									
Related* Sup5									
Related*Gap2									
Concur	-1.647*** (-4.11)	-0.576* (-1.71)	-1.424*** (-4.32)	-1.470*** (-4.45)	-1.505*** (-4.65)	-1.487*** (-4.53)	-1.492*** (-4.52)	-1.605*** (-4.87)	-0.019 (-1.14)
Director	-0.117 (-0.76)	0.080 (0.67)	0.003 (0.03)	-0.015 (-0.12)	-0.036 (-0.31)	0.005 (0.04)	-0.027 (-0.23)	0.006 (0.05)	-0.498 (-1.00)
Ex_share	0.002 (0.17)	0.031*** (3.04)	0.024** (2.40)	0.023** (2.31)	0.022** (2.31)	0.019* (1.97)	0.019* (1.84)	0.015 (1.46)	-0.129 (-0.82)
Size	0.789* (1.96)	0.167 (0.56)	0.098 (0.33)	0.158 (0.53)	0.366 (1.28)	0.379 (1.29)	0.107 (0.36)	0.344 (1.17)	0.0187 (1.31)
Lev	-7.369*** (-4.40)	-5.456*** (-4.02)	-5.787*** (-4.34)	-5.670*** (-4.23)	-5.301*** (-4.58)	-11.48*** (-6.09)	-5.752*** (-4.32)	-11.37*** (-6.04)	0.278 (0.73)
ROA	-17.76*** (-5.30)	-13.50*** (-5.75)	-14.07*** (-6.08)	-13.41*** (-5.76)	-14.87*** (-6.48)	-13.33*** (-6.00)	-14.21*** (-6.15)	-13.81*** (-5.97)	-3.817** (-2.15)
Cash	0.0183 (0.02)	0.532 (0.54)	0.607 (0.63)	0.479 (0.49)	-0.399 (-0.42)	0.218 (0.23)	0.723 (0.75)	0.406 (0.42)	0.744 (0.21)
Operate	-0.649 (-0.33)	-0.71 (-0.42)	1.438 (0.89)	1.126 (0.69)	1.29 (0.81)	1.062 (0.66)	1.524 (0.94)	0.864 (0.53)	1.45 (1.02)
Finance	-3.259*** (-5.33)	-2.607*** (-4.65)	-2.605*** (-4.65)	-2.514*** (-4.45)	-2.319*** (-4.18)	-2.348*** (-4.20)	-2.602*** (-4.65)	-2.395*** (-4.26)	3.132 (1.14)
Cons	-1.467 (-0.18)	4.451 (0.71)	10.07 (1.62)	8.763 (1.41)	16.92*** (2.76)	4.929 (0.81)	8.02 (1.28)	4.766 (0.77)	0.288 (0.17)
R-sq	0.174	0.093	0.112	0.102	0.111	0.112	0.116	0.131	0.110
Chi2	124.7***	101***	136.33***	132.44***	197.66***	147.79***	139.7	143.4	140.9***

Notes: N = 1,126; t-statistics in parentheses; \*p < 0.1; \*\*p < 0.05; \*\*\*p < 0.01 (Two-tailed tests of significance)

Source: Table created by authors

**Table 4.** Multiple regression results on R&D: proximity and interactions between proximity and moderating variables

Model (5) ( $\beta_2=0.468, p < 0.01$ ). Additionally, when operational issues occur in focal affiliates, even if they are distant from the parent company, increased attention and direct capital and talent support is provided by the head. Thus, the performance-aspiration gap weakens the negative correlation between *GD* and *R&D*. The coefficient of the cross-multiplication of *Gap2* and *GD* ( $\beta_3=0.0052, p < 0.05$ ) is positive in Model (6), consistent with the moderating direction of the industrial aspiration gap. Therefore, *H4* is verified.

The interaction coefficient between business proximity and the historical expectation gap of affiliates in Model (8) is not significant ( $\beta=-0.019$ ). This indicates that, when affiliates encounter internal operational difficulties, the relationship between business proximity and R&D does not change significantly. Comparing Models (3) to (6) in Table 4, we observe that the impact of affiliates' own performance-aspirations on R&D is more significant when they face the bargaining power of external suppliers or customers.

## 5. Supplementary tests

### 5.1 Joint effect of geographical and business proximity

This study conducted an interactive regression analysis of geographical and business proximity to reveal their joint impact on focal affiliates' R&D. The regression results are shown in Model (1) Table 5. The coefficient of the interaction between geographical distance and business proximity is significantly positive ( $\beta = 0.082, p < 0.10$ ). This indicates that when geographical distance is relatively large, affiliates are disadvantaged in terms of structural embedment. However, relational embeddedness can compensate for the shortcomings of structural embedding and alleviate the negative impact of geographical distance. Consequently, maintaining a good relationship with the parent company is an important way to obtain internal resources. We compared the coefficients of *GD* and *Related*, and found that geographical distance significantly impacts R&D than business proximity.

### 5.2 The effect of proximity on innovation performance and quantity

To further test the results of this study and evaluate the impact of the two types of proximity on innovation efficiency and effectiveness, we included three dependent variables: innovation quantity, quality, and performance. Following Li et al. (2023), we employed the total number of patents and inventions as proxy variables for innovation quantity and quality, respectively. Moreover, the total number of inventions and utility patents are used to measure innovation performance. The logarithms of these three variables were adopted for regression. The regression results are presented in Models (2) and (3) in Table 5. The coefficient of *GD* [ $\beta = -0.395$  in Model (2),  $p < 0.05$ ;  $\beta = -0.632$  in Model (3),  $p < 0.05$ ] is significantly negative and consistent with *H1*. The coefficient of *Related* ( $\beta = 1.069, p < 0.05$ ) is significantly positive in Model (2) in Table 5.

### 5.3 Endogenous test

Considering the impact of unknown variables on geographical distance and R&D investment to minimize the endogeneity problem, we use the average value of geographical distance (*GDinstrument*) between focal affiliates and parent companies in the same industry as the instrumental variable through the two-stage least square method (2SLS) for further regression. The regression results are presented in Model (4) in Table 5. The coefficient of *GD* ( $\beta = -2.267, p < 0.01$ ) is significantly negative and consistent with *H1*.

When affiliates possess strong R&D capabilities, it may extend its main business, thus affecting its correlation with parent companies. Therefore, we constructed the average value of the business proximity of affiliates in the same region (*Rinstrument*) as the instrumental variable using 2SLS for regression. The results are shown in Model (5) of Table 5, the

Dependent	(1) R&D	(2) Quantity	(3) Performance	(4) R&D	(5) R&D	(6) R&D	(7) R&D	(8) R&D
GD	-0.268** (-2.20)	-0.385** (-2.32)	-0.632** (-2.03)	-2.267*** (-4.57)	5.536*** (3.59)	63.00*** (2.89)	-0.308*** (-3.15)	
Related	0.698 (1.36)	1.069** (2.56)	0.52 (1.28)					
GD* related	0.082* (1.69)							
Sup5			-0.081 (-0.89)					
GD* Sup5			0.006 (0.84)					
Ftype								0.015** (2.36)
Concur	-1.710*** (-4.26)	-0.216 (-1.31)	0.228 (0.56)	-0.983 (-1.53)	-3.366*** (-4.39)	-24.89*** (-2.74)	-0.779 (-1.40)	-1.543*** (-4.65)
Director	-0.12 (-0.77)	0.03 (0.56)	0.010 (0.08)	-0.202 (-1.11)	-0.271** (-2.00)	-1.273 (-1.03)	-0.032 (-0.17)	-0.022 (-0.18)
Ex_share	-0.025 (-0.21)	-0.025 (-0.89)	0.059 (1.06)	-0.061*** (-2.92)	-0.121*** (-3.02)	-1.584*** (-2.77)	-0.009 (-0.03)	0.019* (1.82)
Size	0.811** (2.01)	0.376*** (3.09)	0.19 (0.69)	0.633 (1.39)	0.515* (1.65)	6.856* (1.95)	0.253 (0.52)	0.286 (0.96)
Lev	-7.095*** (-4.22)	0.583 (1.02)	-0.34 (-0.32)	-3.192 (-1.36)	-4.923*** (-3.19)	-18.1 (-1.26)	-2.589 (-1.15)	-5.825*** (-4.34)
ROA	-18.15*** (-5.41)	0.798 (0.47)	0.056 (0.02)	-0.223 (-0.03)	-20.57*** (-3.94)	-62.85 (-1.57)	-9.456*** (-2.04)	-13.81*** (-5.88)
Cash	0.029 (0.02)	-0.222 (-0.28)	-0.84 (-0.62)	6.121*** (2.86)	9.044*** (6.28)	4.584 (0.35)	2.001 (0.95)	0.279 (0.29)
Operate	-0.848 (-0.43)	0.256 (0.27)	1.706 (0.83)	4.721 (0.90)	11.08*** (2.45)	51.85 (1.56)	-1.622 (-0.57)	1.441 (0.88)
Finance	-3.259*** (-5.33)	-0.038 (-0.08)	0.003 (0.07)	-3.575*** (-2.21)	-4.095*** (-3.20)	-25.05 (-1.17)	-3.441*** (-3.52)	-2.493*** (-4.38)
_cons	-2.697 (-0.32)	0.618 (0.18)	7.306 (1.02)	-1.093 (-0.12)	-2.196 (-0.34)	-136.3* (-1.85)	4.752 (0.47)	4.686 (0.75)
N	1126	1126	1126	1126	1126	703	670	1106
R-sq	0.176	0.222	0.347	-	-	-	0.101	0.112
chi2	126.5	124.89	73.8	92.92	151.7	111.41	116.47	121.42
p	3.06E-21	0.001	0.009	1.41E-15	1.70E-27	0.0326	6.99E-05	2.60E-21

Notes: *t*-statistics in parentheses; \**p* < 0.1, \*\**p* < 0.05, \*\*\**p* < 0.01 (Two-tailed tests of significance)

Source: Table created by authors

**Table 5.** Multiple regression results on R&D: Interactions between two proximity types and alternative measures for R&D and proximity

significance of the main variables is consistent with *H2*. Additionally, lagged first-order *R&D intensity* was used as the tool variable, and the iterative GMM method was used to test for endogeneity. The results are shown in Model (6) and remain consistent with the main results.

#### 5.4 Robustness tests

This study's sample includes cases where listed affiliate firms are the ultimate holding legal entity for business groups. This subset was removed, and the regression was repeated. The regression results are shown in Model (7) in Table 5, indicating that the impact of *GD on R&D intensity* remains significant ( $\beta = -0.308$ ,  $p < 0.01$ ). Moreover, the measurement of *business proximity between parent companies and focal affiliates* relies on manual collection and comparison. Therefore, to ensure the reliability of the results, the business attribute of the controlling shareholder (*Ftype*; *Ftype*'s value is zero when the controlling shareholder is an investment enterprise and one when a business operation enterprise) was employed as an alternative for *Related* in the robustness test. The regression results, presented in Model (8), show a significant coefficient for *Ftype* ( $\beta = 0.015$ ,  $p < 0.05$ ), consistent with that of *Related*. These results prove that the empirical tests in this study are robust and reliable.

## 6. Discussion and conclusion

### 6.1 Discussion

Although many studies have examined the impact of proximity on R&D, most focus on the macro level and analyze causal mechanisms from a geographical economy perspective. Few studies have focused on the specific proximity in a holistic business group network. Inspired by this research gap, we incorporated proximity theory and social network analysis to examine the impact of affiliates' proximity on R&D investment.

Based on unbalanced panel data from 1126 manufacturing private listed companies, the following findings are drawn. First, geographical distance not only affects the preference of the "supporting hand" of parent companies but also affects the resources available to affiliates. When focal affiliates are geographically closer to parent companies, parent companies' supervision cost decreases, and motivation for knowledge spillover improves, resulting in greater technological innovation willingness among affiliates. Second, a higher business proximity between parent companies and focal affiliates increases the possibility of resource sharing and collaborative R&D within the group, encouraging affiliates to carry out R&D activities. Third, with strengthened external value chain constraints, geographically distant affiliates and more business relevant affiliates may gain increased R&D support from business groups, thereby enhancing their R&D activities. Fourth, the internal performance-aspiration gap moderates and weakens the negative impact of geographical distance on R&D investments. Specifically, affiliates that have met performance objectives are more affected by geographical distance in their R&D decisions compared to those that have not.

### 6.2 Theoretical implications

The theoretical implications of this study encompass three aspects. First, it expands the R&D literature by highlighting the importance of proximity when evaluating the direct effect of business group characteristics on R&D investments in China. To date, most studies on affiliate R&D have not examined the proximity between parent-affiliates in elucidating their relationship with R&D. While some studies have referred to the antecedents of R&D regarding the relationship between parent-affiliates (Belenzon and Berkovitz, 2010; Bouquet and Birkinshaw, 2008; Guzzini and Iacobucci, 2014) and the proximity between affiliates and

unaffiliated firms (Balland *et al.*, 2015), few have considered affiliates' innovation heterogeneity in the same business group based on proximity theory in the context of the world's largest emerging market. This study uncovers how proximity influences resource flow and knowledge spillover in business groups. One advantage of business groups in emerging markets is their ability to supplement imperfect markets. This function largely depends on the association between business group members. This study shows that the correlation formed by proximity facilitates resource flow and knowledge sharing, addressing the shortcomings of research on proximity theory at micro dimensions.

Second, to the best of our knowledge, this study is among the first to explicitly propose business proximity and examine R&D outcomes. It enriches proximity theory by introducing business proximity as a new dimension within the framework, which is a more appropriate and important dimension for illustrating knowledge spillover in R&D. Past proximity theory studies focus on geographical, social, organizational, cognitive and institutional proximity, without deeply exploring the factors underlying knowledge spillover as a catalyst for R&D. We build business proximity based on Balland *et al.* (2015) and propose a new dimension to explore how knowledge structure and operation patterns between controllers and affiliates can affect R&D investment. Therefore, this study makes proximity theory more comprehensive.

Third, we explicitly addressed firm-level constraints in terms of bargaining power and the performance-aspiration gap. While past research has primarily examined macro-external circumstances as boundary conditions, like institutional voids and market development (Du *et al.*, 2022; Manikandan and Ramachandran, 2015; Wang *et al.*, 2015), we focus on the perspectives of value chain participants and pressures from shareholders and stakeholders to examine how they influence the baseline relationship. We prove that both bargaining power and the performance-aspiration gap can lead to problem-solving activities and influence the relationship between proximity and R&D. Therefore, this study expands the boundary conditions of proximity theory.

### 6.3 Managerial implications

Members of the same business group cooperate and compete. The status and geographical distance of affiliates in business group networks affect their relationships and, consequently, resource acquisition. The managerial implications of this study are as follows. On one hand, affiliates should actively improve their relationship with parent companies and increase the embedding of relationships in the business group network to mitigate and compensate for geographical distance disadvantages. Given the challenge of changing geographical distance, affiliates can establish intangible proximity advantages by formulating reporting mechanisms to parent companies, increasing information exchange and deepening integration with the group's business. Particularly, in innovation-driven markets, innovation may lead to new industry opportunities. Through the application, approval, and reporting of R&D projects to parent companies, affiliates can obtain more opportunities, information, and experience. Simultaneously, informal activities like private banquets and joint sports can strengthen affiliates' ties with parent companies. Practically, attention should be given to affiliates' subjective initiative in business group networks to achieve a win-win situation in cooperation and competition with other members.

On the other hand, business groups should recognize the impact of geographical distance on the R&D enthusiasm and support of affiliates. When establishing affiliates or conducting mergers and acquisitions, parent companies should fully consider the combination of geographical and business factors, selecting suitable regions with the lowest cost for different business.

#### 6.4 *Limitations and future research*

We acknowledge several limitations in this study and anticipate that it will lay the groundwork for future research. First, our goal in studying proximity across member firms is to investigate differences among affiliates and explore the effect of affiliates' advantages on R&D. However, this effect may vary depending on environmental characteristics, particularly in emerging economies. Although we examine firm-level characteristics (supplier bargaining power and the performance-aspiration gap) as moderating conditions, other economy-level factors like dysfunctional competition, complex environments (Du and Kim, 2021; Du *et al.*, 2016), and institutional instability may offer valuable insights. Emerging economies are characterized by institutional instability and imperfect markets, significantly increasing enterprises' transaction costs (Du *et al.*, 2022). Business groups internalize transactions through internal capital market, compensating for immature external markets to some extent (Belenzon and Berkovitz, 2010; Carney *et al.*, 2011; Khanna and Yafeh, 2007). Thus, when complex environments and institutional instability impose operational challenges, affiliates can seek help from business groups. Based on this, affiliates with proximity advantages can obtain additional resources. In short, uncertain and institutionally unstable environments boost proximity effects. Thus, the characteristics of emerging economies offer a rich area for future research on the contingency of proximity effects.

Second, the characteristics of affiliates in business group networks may also include technological overlap between focal affiliates and parent companies, the degree of vertical integration across affiliates, and the association between affiliates' and parent companies' executives. The diversification of business group characteristics is formed by homogeneity or heterogeneity across affiliates, which is an important field for further research to reveal the role of the internal market and mechanisms for creating significant advantages in emerging economies. Thus, further research could focus on the impact of the different characteristics of business group networks on R&D.

Finally, owing to data limitations, information on parent companies' business scope were obtained through a manual search of annual reports. We measured business proximity by considering member firms' main business scope code, the most reliable data currently available. Many listed affiliates operate in multiple primary business areas. Future research could collect more business scope codes and construct multidimensional business proximity indicators to test the proximity theory.

#### 6.5 *Conclusions*

Despite ongoing research regarding the impact of proximity on R&D, most studies have not examined different types of proximity between parent-affiliates to elucidate their relationship with R&D. Affiliates may still don't know how to utilize proximity to promote R&D decision. We examine the impact of geographical and business proximities between parent companies and affiliates on R&D in business groups. Furthermore, we compare the moderating effect of value chain participants' bargaining power and the performance-aspiration gap. By integrating proximity theory and social network analysis in business group network, our study offers a novel perspective on why proximity influences affiliates' R&D investments and highlights the boundary conditions of proximity theory.

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