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Geographic Proximity And Firm Innovation: Evidence From The Chinese Manufacturing Industry

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Abstract:

Innovation, competitive advantage, and firm performance are all positively affected by knowledge-sharing techniques. We consider the geographic proximity to research institutes as a proxy of the efficiency of knowledge sharing. We examine how and to what degree the practice of knowledge-sharing influences businesses' innovation using a sample of Chinese manufacturing companies chosen between 2009 and 2021. Thus, the relationship between corporate innovation and closeness to research institutions is investigated experimentally in this study. The decisive findings indicate that a company's ability to innovate is strongly impacted by its proximity to research institutions, which suggests that proximity may also lower coordination costs and enhance information flow efficiency. Additionally, this research reveals that institutions with a STEM (science, technology, engineering, and mathematics) concentration have a stronger correlation with information sharing and entrepreneurial innovation in the manufacturing sector. Furthermore, under similar conditions, the positive effect for non-SOEs and firms with lower R&D expenditures is more critical for firms close to research institutions. We find consistent evidence for a battery of robustness checks. Overall, the study provides insightful implications that university and research center clustering is advantageous for generating and exchanging necessary knowledge.

Keywords: *knowledge sharing; geographic proximity; research institutions; firm innovation; firm performance*

1. Introduction

In our contemporary knowledge-based economies, knowledge is a crucial intangible asset for organizations to thrive. For firms, knowledge-sharing practices are positive drivers behind innovation, competitive advantage, and firm performance [1,2]. Creating and utilizing knowledge networks w[1]ithin and across firms and giving employees access to pertinent information are all part of knowledge sharing [3,4]. Another critical component of an organization's success is its location and the concentration of surrounding resources. Pooled labor supply, financial systems in place, specialized input, and access to information flows are all factors that stimulate the concentration of firms in geographical clusters, which consequently exert their influences on corporate performance. Law & Ngai (2008) [5] argue that local financial policies also have a significant impact on how organizations perform. Similar to knowledge sharing, firms' product and service offerings and business process

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improvement have a favorable relationship with organizational success. The results underline how crucial location and knowledge sharing are interactive. For instance, industrial clustering frequently makes the collective strength more profound at the national or subnational levels. Similarly, the cluster of universities or research institutes is helpful for knowledge-creating and sharing.

The data sample in this study is created based on several considerations. First, this study focuses on China, an interesting and valuable case to examine and analyze the research question. While the Chinese economy can be characterized as an increasingly knowledge-based economy and thus also relies upon knowledge-sharing processes, it remains relatively uneven in terms of regional development [6,7]. Han & Chen (2018) [8] state that in China, specific clusters, mainly in and around the major urbanized areas, affect knowledge-sharing variance. This phenomenon evolved along research institutions' geographic spread in harmony with knowledge resources [9,10]. The cluster of these specific knowledge-rich institutes locally has proven to be a relevant determinant for developing regions that facilitate research activities [11]. Furthermore, research and development (R&D) and cross-firm innovation are increasingly important to manufacturing organizations. To mitigate the inconsistent impact of information sharing on company innovation, this research is limited to the manufacturing sector.

This study empirically investigates the relationship between proximity to research institutions and corporate innovation. The research findings, as sections 5 and 6 describe in greater detail, indicate that a company's ability to innovate is positively associated with its closeness to research institutes, which suggests that geographic proximity may decrease coordination costs and increase the effectiveness of information dissemination, as argued by Landier et al. (2007) [12]. Additionally, there are significant correlations between all firm variables and innovation inside the firm, including firm size, leverage, and cash holdings. Furthermore, universities known for emphasizing STEM disciplines—science, technology, engineering, and mathematics—are more closely linked to knowledge exchange and firm innovation in the manufacturing sector, labeling it as a positive spillover effect [13]. The conclusions of this study support the hypothesis that firms' innovation is influenced by information sharing because of the proximity of research institutes.

Understanding the knowledge-sharing linkages between research institutions and firms cannot be overstated. The conventional rationale suggests that knowledge-sharing strategies are effective catalysts for innovation, competitive advantage, and firm performance [14]. Due to the research institutes' proximity, this study offers various meaningful, detailed insights on the value of knowledge sharing and corporate innovation. The aim is not merely an attempt to advance the discipline by sharing new perspectives on this phenomenon. However, it is also an inspiration for industry leaders who may appreciate the depth of the presented findings. In particular, the outcomes that confirm the practical importance of research institutes' nearness for corporations to increase innovative operations lead to a warm confirmation for corporations' managements to actively incorporate this perspective into their considerations when deciding on (re)locating their firm when valuing

innovation so highly. For more background on these location strategies, see Alcacer & Chung (2007) [15].

The rest of the paper is organized as follows. Section 2 examines pertinent scholarly works. A series of theories are developed in Section 3. The development of the variables and sample data is explained in Section 4. The study's primary results and summary data are presented in Section 5. Robustness checks and heterogeneity analysis are reported and discussed in Section 6. The paper's conclusion is covered in Section 7, along with some possible applications.

2. Literature Review

2.1 Knowledge sharing

Researchers have more recently started to acknowledge the organizational components of innovation, such as the acceptance of new information systems, the enhancement of production and service processes, or the introduction of new human resource management techniques (e.g., Singh et al. (2021) [16]). For this specific study topic, a large body of literature suggests a research model that suggests knowledge sharing not only directly improves performance but also has certain limitations and is inadequate to provide strong results on the original research issue [17]. Rather, it should also emphasise how it affects innovation, which in turn affects firm performance, as suggested by Wang et al. (2014) [18]. However, in other circumstances, the opposite—a failure to transmit knowledge—also holds true.. Despite their best efforts, success has eluded efforts to improve business knowledge transfer. It is becoming increasingly apparent that even when organizational procedures ease transfer processes, people frequently refuse to share their knowledge [19].

Wang and Noe (2012) characterize information sharing as an information focused action that empowers representatives to share information and add to information application, development, and, at last, the organization's upper hand [20]. Put in an unexpected way, an organization's ability to change and use information might influence how much it inno-vates, including growing new ways to deal with tackling issues and new items for fast reactions to showcase de-mands [4]. Knowledge sharing could be better valued by assessing this interplay, allowing academics and professionals to manage their organization's knowledge resources better. Employees constantly need to draw on the implicit knowledge (skills or experience) of their coworkers or look for explicit information (standardized approaches or practices existing in the firm) in order to better complete innovative jobs [21]. Lin (2007) stresses that this situation is why firms need to manage their knowledge resources carefully [21], which has led to heightened attention from scholars and professionals, who emphasize the importance for organizations to identify, accumulate, create accurately, and share knowledge [22].

2.2 Firm location and firm performance

Studies by Kafouros et al. (2018) and Molina-Azorin et al. (2010) demonstrate how differences in value generation and value capture processes, which affect firm performance, are connected with geographic location [23,24]. As Liao et al. (2010) [25] found, location per-

formance shows that a company can create market segments about service quality and operational efficiency when it develops, produces, or sells new items more quickly than its rivals since the information included in these innovations is not readily available to rivals. As a result, innovation speed ensures that firms may respond to their environments more quickly and cheaply by launching new products, which, as Tidd et al. (2005) show, ultimately improves company performance [26]. This level of innovation may indicate that the advantages in accomplishing knowledge integration across numerous sites generally outweigh any possible downsides [27] from access to various ideas and skills from various locations. Similarly, Almeida and Kogut (1999) show that personal mobility catalyzes the spreading of knowledge throughout different geographical areas [28]. The location effects are thus vulnerable to varying local financial market conditions [29].

Alebrahem (2018) concludes that regulatory restrictions and stock market conditions have causal effects on businesses' economic behavior and financial ramifications, complicating the relation between economic markets and geographical dispersion [30]. Studies show that stock market coverage is affected by firms' geographic location. Several studies have shown notable effects of local coverage on firm visibility and a demonstrated influence of geographic proximity on analyst coverage decisions for U.S. companies (O'Brien et al., (2015) [31] offers an illustrative example). Existing findings note how geographic proximity affects firms' economic circumstances and is consequentially vital in the management strategies to decide on favorable locations.

2.3 Research gap and contribution

Knowledge sharing and the fact that it is closely associated with geographical features and a firm's overall performance is hardly challenged. Although existing studies have investigated how knowledge exchanges between firms [11] and between academics [32], this understanding, however, fails to determine how and to what extent this mechanism affects a firm's economic health, making it imperative to develop an approach that can measure and quantify the relationship between knowledge sharing from the academics to the industries, firm geographic location, and firm innovation. This study's essential contribution demonstrates that knowledge sharing influences firm performance through geographical location (proximity to research institutes). Few researchers have examined the underlying link between knowledge sharing and corporate performance [18,33]. This research proposes an empirically tested theoretical model to close this gap. It will demonstrate that knowledge sharing directly affects competitive advantage and indirectly affects firm performance by encouraging (re)locating locations nearer to knowledge clusters. Specifically, this research intends to advance this understanding by investigating knowledge sharing through the university-industry linkages (for context, see, for example, Guerrero et al. (2019) [34] and Heffner & Sharif (2008) [35]). Such findings illustrate how firm location might improve performance through thoughtful innovation and knowledge exchange processes.

3. Hypothesis development

Generally, extant findings indicate that knowledge sharing and overall business operations are directly or indirectly related to a firm's geographic location. Although technological advancement has improved communication efficiency, face-to-face communications are

still substantial in knowledge sharing. It is not surprising that geographic remoteness causes obstacles during collaboration and communications, which reduce the efficiency of knowledge sharing. Previous studies have shown that knowledge sharing is essential between firms [11] and academics [32]. It is rational to expect that proximity to research institutions enhances knowledge-sharing activities. In the mean time, the positive connection between information sharing and firm advancement is irrefutable (clever bits of knowledge by e.g., Hussein et al. (2016) [36]; Lin, 2007 [21]). The principal speculation **(H1)** is the accompanying:

H1: Proximity to research institutions is positively associated with firm innovation.

With the overall assumption that corporate geographic location influences firm innovative performance, many other factors can affect the importance of knowledge sharing and the efficiency of firm innovation. For instance, a firm innovation capacity is externally dependent on establishing and actively developing an independent research and development department. R&D expenses, as a potential key factor for the amount of knowledge sharing, can be measured [37,38]. Liu & Ma (2019) underline that geographic proximity to knowledge influences firms' innovative performance [39]. Since firms have diverging incentives based on whether or not there are research institutions in their proximity (see, for example, Gao et al., 2008 [40]), funds allocated to R&D may also affect the incentives to establish collaborations with research institutions [32], which is a financial factor that can be quantitatively measured, and, thus, consequently, can determine a firm's innovation, as illustrated in Corral de Zubielqui et al. (2019) [41]. In summary, the positive effect of a firm's nearness to research institutions will be more evident in the situation in which that firms spend less on R&D expenses because, as literature has suggested, these firms should face more severe implications from their geographical location for access to knowledge [42,43]. The second hypothesis (**H2**) is the following:

H2: The positive effect of proximity to research institutions is more pronounced when firms spend less on R&D expenses.

Moreover, based on the existing literature by Cassi and Plunket (2014) [44], Steinmo & Rasmussen (2016) [45], a firm's organizational type impacts its innovation. In other words, inter-organizational proximity is relevant here, and a firm's organizational structure partly determines this [46]. To mitigate the unfavorable circumstances of a firm's reduced knowledge sharing, lack of motivation to innovate, and risk-averse managerial styles should be addressed at the core of the matter. More specifically, Bozec & Dia (2015) confirmed that the governance structure, disclosure, and the impact of equity structure all affect firm innovation [47]. Concerning SOEs, there is less incentive for firm innovation, caused by an overall relative inflexible market position due to the organizational and financial ties to government departments. The opposite is true for non-SOEs, which are, in principle, more risk-taking on a managerial level, and, therefore, tend to demonstrate a higher willingness to innovate.

Generally, studies show that SOEs are less prone to invest in innovation processes, and the managers are more inclined to demonstrate more risk-averse behavior, negatively affecting knowledge sharing. As a result, the proximity to research institutions thus depends on the

type of firm. In summary, non-SOEs experience more positive effects if located nearer to research institutions than those that are not. The third hypothesis (**H3**) is:

H3: The positive effect of proximity to research institutions is more pronounced when firms are non-SOEs.

4. Methods

This section illustrates the data sources, sampling criteria, and main variables' construction. After identifying these elements, it provides the regression specifications for examining the relationship between the proximity to research institutions and firm innovation.

4.1 Sample

This study first collects the list of universities belonging to Project 211[2] to obtain data on the proximity to research institutions. Universities belonging to Project 211 are more likely to have high capacity of innovation. In order to improve the research standards of comprehensive universities and foster socioeconomic development plans, the Ministry of Education of China launched Project 211 in 1995 to establish comprehensive universities and colleges. This study gathers relevant university data from the Ministry of Education of China, which annually provides a complete overview of its operations. The complete data set is manually selected from this organization's database. Detailed information on firm performance and other relevant firm characteristics are all acquired from the China Stock Market and the Accounting Research (CSMAR) database, which is accessible to select and export data.

For the proposed analysis of firm performance, the attention is on the period after the global financial crisis. This period between 2009 - 2021 allows for more accurate sampling and analysis. When collecting the data, the sample is limited to manufacturing firms listed on the Shanghai Stock Exchanges (SHSE) and the Shenzhen Stock Exchanges (SZSE). This study also excludes firms subject to special treatment (ST) because these firms do not necessarily represent accurate and verifiable performance indicators within the scope of this study.

4.2 Variables

Concerning the variables of this study, the dependent variable is innovation-based performance Patent, measured as the natural logarithm of the number of patents granted for a firm in a year, and this study uses the following specification to test H1 empirically:

$$\mathrm{Patent}_{it+1} = \alpha_0 + \alpha_1 \mathrm{University211}_{it} + \sum_{m=2}^{n} \alpha_m \, \mathrm{Control}_{it} + \varepsilon_{it} \quad (1)$$

The independent variable of key interests is University211, measured as the natural logarithm of one plus the number of universities belonging to the 211 Project in a city. Specifically, the control variable is the size of the firm (Size), measured by the natural logarithm of the book value of total assets, financial leverage (Leverage), measured as the total liabilities divided by total assets, firm cash holdings (Cash), and measured by the ratio of firm

[2] Project 211 universities are regarded as the tier 1 universities in China. The name for the project comes from an abbreviation of the slogan " In preparation for the 21st century, successfully managing 100 universities".

cash to firms' total assets. Moreover, to test H2 and H3, this study employs the following two regression specifications:

$$\text{Patent}_{it+1} = \alpha_0 + \alpha_1 \text{University211}_{it} * \text{RD}_{it} + \alpha_2 \text{University211}_{it} + \alpha_3 \text{RD}_{it} + \sum_{m=4}^{n} \alpha_m \text{Control}_{it} + \varepsilon_{it} \quad (2)$$

$$\text{Patent}_{it+1} = \alpha_0 + \alpha_1 \text{University211}_{it} * \text{SOE}_{it} + \alpha_2 \text{University211}_{it} + \alpha_3 \text{SOE}_{it} + \sum_{m=4}^{n} \alpha_m \text{Control}_{it} + \varepsilon_{it} \quad (3)$$

To be precise, RD is defined as R&D expenditures to sales, and SOE indicates whether a firm is a SOE or not. Appendix A provides detailed definitions of all variables.

5. Results

5.1 Summary statistics

Table 1 records the synopsis measurements. By and large, a firm has 37.48 licenses conceded in a schedule year. The typical worth of University211 is 4.34, showing that in urban communities with publicly recorded firms, the typical number of colleges that have a place with 211 tasks is 4.34. Firms in the example have normal complete resources of 2218 million RMB, normal firm influence of 0.31, and a typical money holding proportion of 0.24.

Table 1 Summary statistics

Variables	**N**	**Mean**	**SD**	**25%**	**Median**	**75%**
Main Variables						
Patent	4131	37.48	78.32	6	15	36
*University*211	4131	4.34	7.64	0	1	5
Control Variables						
Size	4131	21.52	1.01	20.82	21.34	22.03
Leverage	4131	0.31	0.18	0.16	0.28	0.43
Cash	4131	0.24	0.17	0.12	0.20	0.33

5.2 Main findings

This section empirically examines the relationship between the proximity to research institutions and firm innovation after controlling for a battery of controls associated with firm characteristics. Table 2 reports relapse results for various slacked models, which catch the effect of closeness to investigate institution’s on firm advancement. As shown in both columns of Table 2, University211 is significantly positively associated with Patent at the 5% confidence level. The results indicate that proximity to research institutions positively impacts a firm’s innovation capacity and implies that geographic proximity could reduce coordination costs and improve the efficiency of knowledge sharing. Also, all firm characteristics, including firm size, leverage, and cash holdings, also have significant associations with firm innovation. Overall, the results support the first hypothesis (H1).

Table 2 Geographic proximity and firm innovation

	(1)	(2)

Dep. Variable:	$Patent_{t+1}$	$Patent_{t+2}$
$University211_t$	0.005**	0.006**
	(2.34)	(2.47)
$Size_t$	0.406***	0.402***
	(6.71)	(6.14)
$Leverage_t$	0.790***	0.792***
	(6.73)	(6.75)
$Cash_t$	0.598***	0.603***
	(4.89)	(4.95)
Intercept	-6.030***	-6.003***
	(-4.13)	(-4.04)
Year dummies	Yes	Yes
No. of obs.	4131	4025
Adj. R^2	0.216	0.214

Notes: This table presents the relationship somewhere in the range of University211 and Patent by multivariate relapse examination. The reliant variable is Patent. See Supplement A for variable definitions. The fakers for year-fixed impacts are remembered for every one of the sections however not announced. Standard mistakes (grouped) by firm and t-values are introduced in brackets. Measurable significance at the 10%, 5%, and 1% levels is shown by *, **, and ***, separately.

5.3 Endogeneity Problem: Within-City Proximity to Research Institutions

Since universities belonging to Project 211 are more likely to be located in more economically developed cities (e.g., provincial capital cities) in China, one may have questions whether it is economic development rather than proximity to research institutes really affects firm innovation. To address the concern on endogeneity issues, this study looks at the intra-city distance to research institutes. Specifically, if firms located closer to research institutes, even within the same city, the efficiency of knowledge sharing and communication would improve firms' capacity of innovation. This study further defines two dummies, Distance20, which equals one if the linear distance between a firm and its closest research institutes is within 20km, and zero otherwise; Distance20_40, which equals one if the linear distance between a firm and its closest research institutes is between 20km to 40km, and zero otherwise.

Table 3 Intra-city proximity and firm innovation

	(1)	(2)
Dep. Variable:	$Patent_{t+1}$	$Patent_{t+2}$
$Distance20_t$	0.012***	0.010***
	(2.98)	(2.75)
$Distance20\_40_t$	0.005*	0.003*
	(1.78)	(1.68)
$Size_t$	0.298***	0.269***
	(3.87)	(3.54)
$Leverage_t$	0.744***	0.713***
	(6.12)	(5.36)
$Cash_t$	0.590***	0.577***

	(4.53)	(4.12)
Intercept	-5.721***	-5.671***
	(-3.67)	(-3.00)
Year dummies	Yes	Yes
No. of obs.	4131	4025
Adj. R^2	0.217	0.215

Notes: This table presents the relationship between Distance20, Distance20_40 and Patent by multivariate relapse investigation. The reliant variable is Patent. See Reference section A for variable definitions. The fakers for year-fixed impacts are remembered for every one of the sections however not revealed. Standard mistakes (grouped) by firm and t-values are introduced in brackets. Statisti-cal importance at the 10%, 5%, and 1% levels is demonstrated by *, **, and ***, separately.

6. Heterogeneity analysis and robustness check

6.1 Heterogeneity analysis

The previous section discussed the overall statistical results which support the first hypothesis. This section investigates the heterogeneous effect of proximity to research institutions on firm innovation. As shown in Table 3, the relation between the proximity to research institutions and firm innovation is consistent with the assumption presented in section 5.2, which is in line with findings presented by, for example, Rao et al., 2015 [48]. As the first two columns display, the coefficient of the interaction term University211*RD is significantly negative at the 5% confidence level, indicating that the positive effect of proximity to research institutions is less important when firms spend more on R&D expenses and thereby reflecting some of the conclusions drawn by Steinmo and Rasmussen (2018) [45]. The results support the second hypothesis (H2). Meanwhile, as shown in the second two columns, the coefficient of the interaction term University211*SOE is significantly negative at the 1% confidence level, indicating that the positive effect of proximity to research institutions is less important when firms are SOEs. The results support the third hypothesis (H3).

Summarizing the analysis above, in conclusion, there is significant evidence that clusters and proximity of universities enhance firms' innovative performance thanks to the relative ease of knowledge sharing. Nevertheless, the conclusion should not be that such ease of knowledge sharing would be affected by firm activities and ownership structure.

Table 4 Heterogeneity analysis on the relationship between proximity to research institutions and firm innovation

	(1)	(2)	(3)	(4)
Dep. Variable:	$\boldsymbol{Patent_{t+1}}$	$\mathbf{Patent_{t+2}}$	$\mathbf{Patent_{t+1}}$	$\mathbf{Patent_{t+2}}$
University211_t	-0.003**	-0.007***		
$* \text{RD}_t$	(-2.32)	(-2.63)		
University211_t			-0.078***	-0.081***
$* \text{SOE}_t$			(-6.22)	(-6.22)

$University211_t$	0.007**	0.004**	0.041**	0.035**
	(2.43)	(2.02)	(2.53)	(2.15)
RD_t	0.006**	0.011**		
	(2.38)	(2.49)		
SOE_t			-0.430***	-0.455***
			(-5.70)	(-5.97)
$Size_t$	0.407***	0.424***	0.418***	0.436***
	(5.72)	(6.56)	(5.08)	(5.99)
$Leverage_t$	0.785***	0.731***	0.808***	0.761***
	(6.67)	(6.18)	(6.85)	(6.42)
$Cash_t$	0.593***	0.517***	0.585***	0.511***
	(4.85)	(4.29)	(4.81)	(4.26)
Intercept	-6.037***	-6.648***	-6.244***	-6.873***
	(-4.68)	(-5.34)	(-4.02)	(-5.75)
Year dummies	Yes	Yes	Yes	Yes
No. of obs.	4131	4025	4131	4025
Adj. R^2	0.216	0.200	0.224	0.208

Notes: This table presents the relationship somewhere in the range of University211 and Patent by multivariate relapse examination. The reliant variable is Patent. Key factors are the cooperation term University211*RD and University211*SOE, separately. See Ap-pendix A for variable definitions. The fakers for year-fixed impacts are remembered for every one of the segments however not announced. Standard blunders are bunched by firm, and t-values are introduced in enclosures. Measurable importance at the 10%, 5%, and 1% levels are demonstrated by *, **, and ***, individually.

6.2 Robustness check

Since the research progress has become more advanced, manufacturing firms' knowledge sharing and firm innovation are more related to the universities, which primarily focus on science, technology, engineering, and mathematics (STEM) disciplines. This development is relevant because as China has applied planned economy models for several decades by now, the assumption is that the driving forces behind firm innovation can be traced back to earlier efforts to promote this type of educational institute has been fruitful.

The claim that proximity to research institutions positively correlates to firm innovation finds its ground in the metrics and scores presented in Table 4. TechUniversity211 is the natural logarithm of one plus the number of technical universities in a city that belongs to the 211 Project.

The robustness check is applied to test this study's first hypothesis (i.e., H1) and to illustrate that the overall results persist. In cities in which technology universities that belong to the 211 Project operate, as table 4 shows, the coefficient of TechUniversity211 is significantly positive at the 1% confidence level, implying that firms' innovation levels are positively related to the number of research institutes in their proximity. Conclusively, the implications of this study confirm the expected principle that knowledge sharing, due to the proximity of research institutes, affects firms' innovation. As a good and relevant nu-

ance, the distinction between standard universities and universities that offer STEM education does lead to varying results, with the latter leading to a higher level of firm innovation.

Table 5 Robustness checks on the relationship between proximity to research institutions and firm innovation

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Variable:	**$Patent_{t+1}$**	***$Patent_{t+1}$***	**$Patent_{t+1}$**	***$Patent_{t+1}$***	**$Patent_{t+1}$**	**$Patent_{t+1}$**
$TechUniversity211$	0.031*** (2.97)	0.030*** (2.94)				
$University_t$			0.002** (2.05)	0.002** (2.10)		
$University211_t$					0.007** (2.41)	0.007** (2.52)
$Size_t$	0.408*** (5.81)	0.408*** (5.73)	0.379*** (4.93)	0.388*** (5.02)	0.210*** (2.88)	0.213*** (3.02)
$Leverage_t$	0.785*** (6.68)	0.781*** (6.63)	0.764*** (5.23)	0.734*** (5.16)	0.331** (2.43)	0.366** (2.45)
$Cash_t$	0.611*** (5.02)	0.695*** (5.73)	0.562*** (4.87)	0.591*** (5.00)	0.487*** (3.55)	0.479*** (3.64)
GDP_t					0.288*** (3.05)	0.291*** (3.11)
$Population_t$					0.000 (0.16)	0.000 (0.25)
$Education_t$					0.110* (1.78)	0.102* (1.74)
Intercept	-6.054*** (-4.75)	-6.156*** (-5.04)	-5.994*** (-4.16)	-5.712*** (-4.11)	-6.222*** (-4.58)	-6.103*** (-4.21)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	4131	4025	4131	4025	4131	4025
Adj. R^2	0.216	0.210	0.209	0.205	0.235	0.230

Notes: This table presents the relationship somewhere in the range of TechUniversity211 and Patent by multivariate relapse examination. The de-swinging variable is Patent. See Supplement A for variable definitions. The fakers for year-fixed impacts are incorporated (as well as consistent) in every one of the sections however not announced. Standard mistakes are grouped by firm, and t-values are introduced in enclosures. Factual importance at the 10%, 5%, and 1% levels are shown by *, **, and ***, individually.

7. Conclusions

This study examined whether firms demonstrate differing levels of innovation-based performance based on the degree of exposure to knowledge-sharing practices. The findings imply that physical closeness to research institutions may lower coordination costs and increase the effectiveness of information exchange and that geographic proximity to research institutions benefits a firm's capacity for innovation. This paper contributes to the existing literature as follows. First, this study introduces a new aspect, geographic proximity, and thus increased knowledge-sharing accessibility, positively affecting a firm's innovation capacity. In recent years, studies on this subject have attracted more attention from academics and professionals in the relevant industries. These novel insights can potentially guide stakeholders to understand the aspects of these factors better and thereby may be able to suggest how to effectively improve innovation by more closely paying attention to the direct effects of firm location choices and collaboration with external research institutions. Furthermore, this study shows that, by keeping all other conditions equal, it is more important for firms that spend fewer R&D expenses and non-SOEs to locate close research institutions.

The study used a Chinese 211 Project universities sample and found that industrial clustering frequently causes positive innovation effects. This finding is specifically evident for firms near universities with predominantly STEM-oriented faculties, which is a determining factor for firm innovation and performance. Lastly, this study provides evidence, as it has additionally shown, that the clustering of universities and research centers is helpful for information making and sharing. There remains a need for future research on this sub-field. After all, the location can serve as a facilitator or leverage point for knowledge spillovers that yield external economies. The findings in this instance may depend on ongoing bilateral communication between the research institutions and the innovation-focused companies. Lastly, there are still some limitations of this study, for instance, because of the data availability. This study's limited reach prohibits investigating the geographic proximity at the intra-city level.

Appendix A: Variable definitions

Variables	Definitions
Patent	The natural logarithm of the number of patents granted for a firm in a year.
University211	The natural logarithm of one plus the number of universities belonging to Project 211 in a city.
Size	Firm size, measured by the natural logarithm of the book value of total assets.
Leverage	Firm financial leverage, calculated as total liabilities divided by total assets.
Cash	The ratio of firm cash to firm total assets.
Distance20	An indicator variable, which equals one if the linear distance between a firm and its closest research institutes is within 20km, and zero otherwise.
Distacne20_40	An indicator variable, which equals one if the linear distance between a firm and its closest research institutes is between 20km to 40km, and zero otherwise.

SOE	An indicator variable, which equals one if a firm is a state-owned enterprise, and zero otherwise.
RD	R&D expenditures to sales.
TechUniversity211	The natural logarithm of one plus the number of technology universities belonging to Project 211 in a city.
University	The natural logarithm of one plus the number of universities in a city.
GDP	The annual GDP per capita in a city.
Population	The natural logarithm of the total number of local residents in a city.
Education	The ratio of the number of local residents who possess a college degree or above to the total number of local residents in a city.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, Zhao Ruan and Yuanxi Gao.; methodology, Yu Pang; software, Yuanxi Gao.; validation, Zhao Ruan., Yuanxi Gao and Yu Pang; formal analysis, Pang Yu; investigation, Yuanxi Gao; resources, Yu Pang; data curation, Yuanxi Gao; writing—original draft preparation, Zhao Ruan; writing—review and editing, Zhao Ruan; visualization, Yu Pang.; supervision, Yuanxi Gao.; project administration, Yuanxi Gao; funding acquisition, Zhao Ruan. All authors have read and agreed to the published version of the manuscript." Please turn to the CRediT taxonomy for the term explanation. Authorship must be limited to those who have contributed substantially to the work reported.

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