Does the Technological Diversification and R&D Internationalization of eMNCs Promote Enterprise Innovation?

An Empirical Study on China's Publicly Listed Companies

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ABSTRACT

Under the background of digital economy, technological diversification and R&D internationalization are important strategic choices for eMNCs, represented by China, to seek advanced technological resources and create competitive advantages. This paper takes China's listed MNCs from 2009 to 2019 as the research object and applies a non-equilibrium panel negative binomial fixed effect regression to investigate the impact mechanism of technological diversification of China's MNCs on enterprise innovation performance and the moderating effect of overseas R&D networks. Results show that the related technological diversification of MNCs has a significant positive impact, and the unrelated technological diversification and their innovation performance are in inverted U-shaped relationship; overseas R&D networks have significant moderating effect while the breadth and depth of the moderating effect are not the same; significant differences exist in the moderating effect of overseas R&D networks due to the heterogeneity of institutional development levels among regions in China.

KEYWORDS

Emerging Economy, Innovation Performance, MNC, Overseas R&D Networks, Technological Diversification

INTRODUCTION

Digital technologies represented by artificial intelligence, block chains, cloud computing, and big data are promoting the development of the digital economy. Human society is entering a brand-new historical stage marked by digital productivity. Digitalization promotes efficient circulation of real economic elements as well as efficiency changes (Banalieva & Dhanaraj, 2019; Ting & Gray, 2019). The technological innovation of enterprises under the background of the digital economy presents three main trends: first, the highly standardized commodities and services are transformed into complex commodities and personalized services; second, pure offline innovation is transformed into online and offline integration innovation; third, the transformation into the interactive innovation across

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the whole industrial chain from consumer-side innovation. It requires that MNCs can no longer rely simply on the development mode of traditional single technology, but should broaden the original technology foundation and carry out technology R&D and knowledge exploration in many fields (Kim et al., 2016). Technological diversification strategy has become the key for MNCs to cope with the changes in digital economy market, to break through technology constraints and realize innovative development.

In recent years, scholars have conducted studies on the relationship between technological diversification and innovation performance, but the research conclusions on the relationship between the two have always been divergent. Most study results indicate that technological diversification is beneficial for enterprises to expand their technological capability foundation, promote the use of knowledge across technological boundaries (Hsien et al., 2010; Suzuki & Kodama, 2004), enhance collaboration between R&D activities, and reduce the core rigidities of enterprises' capability development and path dependence (Garcia, 2006). Therefore, technological diversification is conducive to the improvement of enterprises' innovation abilities, especially the exploratory innovation abilities (Quintana & Benavides, 2008). However, some scholars hold the opposite view, that technological diversification can easily lead to high costs of integration, coordination, and communication between technologies in different fields, which are not conducive to innovation (Chen, et al., 2013). Some other scholars pointed out that there was a non-linear relationship (Leten & Belderbos, 2007; Huang & Chen, 2010) between technological diversification and innovation performance. Two possible reasons may account for the discrepancies in research conclusions: firstly, most scholars only studied technological diversification as a whole concept, without distinguishing the characteristics of diversified technologies in detail, which covered up the effects of different types of technology resources; secondly, when analyzing the relationship between technological diversification and innovation, existing researches seldom conduct in-depth exploration of the impact mechanism, such as considering the impact of the construction of overseas R&D networks. Although technological diversification can broaden the knowledge base of MNCs and improve the possibility of technological innovation, it only prepares a variety of technological basic resources for innovation activities of MNCs. If MNCs want to realize the synergy of various technologies in the process of market globalization, they also need the coordination and guarantee from overseas R&D networks. Information and communication technologies accelerate the process of economic globalization and enterprise internationalization, promote the construction of global data networks such as industrial globalization layout, cross-border trade and talent flow, and realize the integration and convergence of logistics, capital flow and data flow (Ting & Gray, 2019).

More and more enterprises begin to enter the international market to seek knowledge and capabilities that can bring them competitive advantages. Overseas R&D, as an important strategy and competitive means (Penner-Hahn & Shaver, 2005), has attracted the attention of MNCs (Dunning & Lundan, 2009). They participate in international competition by setting up R&D centers abroad or cooperating with global R&D alliances, etc. And they make full use of global technological resources to enhance their competitive advantages and technological innovation capabilities. MNCs in emerging economies, represented by China and India, have taken the construction of overseas R&D networks as their "springboard strategy". They acquire advanced technological knowledge from overseas that can enhance their innovation ability, in order to achieve the strategic goal of catching up with MNCs in developed countries (Luo & Tung, 2007). However, limited research has been conducted, from international R&D perspective, to explore the effect of technological diversification on innovation performance.

At present, studies on technological diversification and R&D internationalization of enterprises mainly focus on MNCs in developed countries, while little attention has been paid to MNCs in emerging economies to look into their technological diversification and R&D internationalization (Awate et al., 2015; Luo & Tung, 2007). In fact, the rapid rise of eMNCs is becoming one of the most important changes in today's global competition pattern (Ramamurt & Singh, 2009). It is the R&D internationalization that gives an opportunity to eMNCs which are originally "technology followers" and

“market latecomers”. However, eMNCs tend to be incapable of technology and knowledge integration possessed by MNCs in developed countries. What’s more, their experience in internationalization is relatively scarce. Will the technological diversification and R&D internationalization of eMNCs be profoundly affected by the specific socio-political and economic environment of their home countries and show performance different from those of developed countries? Therefore, taking multinational companies from emerging markets as a sample, exploring the impact of technological diversification on parent company innovation and comparing it with the research conclusions of a sample of developed countries will be a useful supplement to the theoretical research of multinational companies.

Based on the discussion above, this paper takes the MNCs listed in Shanghai and Shenzhen of China from 2009 to 2019 as samples in order to study the following two questions: firstly, the effect mechanism of related and unrelated technology diversification on the innovation performance of eMNCs; secondly, how do eMNCs’ overseas R&D networks adjust and affect the relationship between technological diversification and innovation performance? The findings of this study could enrich the theoretical research on the technological innovation strategy and internationalization strategy of MNCs and present valuable implications for eMNCs to direct their strategies so as to increase innovation performance.

The layout of this paper is as follows: the second part theoretically analyzes the relationship between technological diversification and innovation performance and the moderating effect of overseas R&D networks on the relationship, and puts forward research hypothesis. The third part is research design. The fourth part uses the negative binomial fixed effect model to empirically test and analyze the relationship between technological diversification and the innovation performance of MNCs and the moderating effect of overseas R&D networks on the relationship, and further tests the difference of the moderating effect of overseas R&D networks on the relationship under different institutional environments. The fifth part is the research conclusion, contribution and implication.

THEORETICAL ANALYSIS AND RESEARCH HYPOTHESIS

Technological Diversification and Innovation Performance of MNCs

Technological diversification means that the technological activities and technological knowledge stock of an enterprise span across multiple technological fields, essentially to strengthen current technological capabilities or to develop new technological capabilities (Castaldi et al., 2013; Ceipek et al., 2019). From the perspective of Knowledge-Based Theory and drawing lessons from Krafft’s conclusion when studying the evolution track of industrial technology knowledge base, this paper divides the diversity of technological knowledge base into two dimensions, related and un-related diversification, according to the degree of relation between knowledge elements. Related technological diversification refers to technological knowledge that belongs to the same scientific category and has similar basic principles of science and technology. It means that although the technology of enterprises is distributed in different fields, the difference between the elements involved in the technological knowledge base is relatively small and the degree of connection between technologies is relatively high. Enterprises invest R&D equipment, human resources and capital in similar scientific and technological fields, contributing to the production of higher learning effect and cumulative effect (Castaldi et al., 2013). On the one hand, based on the path effect, MNCs can realize knowledge transfer between products and businesses with lower R&D and communication costs when conducting R&D development on the basis of original theory (Chen & Chang, 2012). On the other hand, the relevance inspiration between technologies can effectively reorganize diversified knowledge and reduce the integration cost between different technologies (Suzuki & Kodama, 2004). The degree of relation between technologies is high and the difference between technologies is small. So the reorganization and integration of technologies take place easily, which can effectively drive the rapid aggregation of related technology resources. From the perspective of economic benefits, due to the same or similar principles in the internal laws of knowledge elements among related technologies, MNCs can

obtain scope economy benefits by copying previous experience (Metcalfe & Miles, 1994). Related technologies can accelerate the accumulation of resources, thus promoting the formation of economies of scale. These two economic effects can reversely accelerate the degree of related technological diversification of MNCs and improve the R&D rate. A virtuous circle is thus formed for technological innovation and ultimately the innovation performance is improved. In addition, when MNCs enter technology fields in high degree of relation with their original technologies, they can better balance between the depth and breadth of technological diversification, effectively reorganize technologies in different fields, promote the mutual transfer of technologies in different fields, and reduce the risk of failure in new product R&D (Jones & Hudson, 1996). Therefore, MNCs can focus on exploring the depth of their knowledge base (Breschi et al., 2003) when implementing related technological diversification, and highlight the technological resource advantages to expand their technological activities together with their technological fields, thus improving innovation performance.

Technological knowledge of unrelated technological diversification belongs to different scientific categories, with significant differences in basic principles of science and technology (Chen & Chang, 2012) and in technological knowledge elements distributed in different fields. When MNCs diversify unrelated technologies through cross-domain technology investment, they can not only avoid technology lock-in and share R&D risks, but also enhance their potential to create new technologies and new products. Therefore, when unrelated technological diversification increases various R&D portfolios can reduce the locking effect in a specific technological field, enhance MNCs' strategic flexibility, improve the innovation performance and then reach an optimal value. There is a positive correlation between low-level unrelated technological diversification and innovation performance. However, when the level of unrelated technological diversification of MNCs exceeds a certain critical value, excessive diversification of heterogeneous knowledge will increase the uncertainty of R&D investment. Large technological differences and low degree of technological correlation have exacerbated the decentralization of enterprise resources, leading to the restriction in allocation of enterprise resources in different technological fields. Based on the Resource-Constraint Theory, due to limited resources, it is difficult for unrelated diversified enterprises to effectively allocate resources like technology and human resource to improve performance. Enterprises may lose the ability to control the leverage of its own technological resources, making it more difficult for enterprises to gain competitive advantages in any technological field (Shin & Jalajas, 2010). At the same time, owing to the high heterogeneity of technological knowledge base, it is difficult to transfer and merge diversified technologies across domains (Chen & Chang, 2012). As a result, MNCs cannot fully understand and absorb their own knowledge, which will not only reduce the efficiency of their own knowledge integration, but also lead to an increase in the cost to select, evaluate and convert external new technological knowledge. It can be seen that excessive unrelated technological diversification will make MNCs' internal capital market ineffective, resulting in diversification discount (Castaldi et al., 2013), which may eventually affect the innovation performance negatively.

Based on the analyses above, this paper puts forward the following hypotheses:

H1a: There is a positive correlation between related technological diversification and innovation performance of MNCs.

H1b: There is an inverse U-shaped relationship between unrelated technological diversification and innovation performance of MNCs.

The Effect of Overseas R&D Networks on the Relationship Between Technological Diversification and Innovation of MNCs

As to the research on overseas R&D networks of eMNCs, Peng & Luo (2000) pointed out that eMNCs tend to set up certain cooperation or innovation networks in their own countries, are difficult to maintain under different institutional backgrounds. Ernst (2009) pointed out that eMNCs may

become global technological leaders by increasing their own R&D investment and connecting with different global innovation and manufacturing networks in pursuit of technological diversification. R&D internationalization has become an important springboard for eMNCs to overcome the disadvantage of latecomers and transform from “backward followers” to “fast followers” and even to “industry challengers” (Luo & Tung, 2007; Child & Rodrigues, 2005). Based on the strategic intention of technological catch-up, the overseas R&D sub-institutions of eMNCs no longer undertake the function of extending the competitive advantages of their parent companies and applying the production technological knowledge they acquire from their parent companies to meet the needs of overseas markets. Instead, they transfer advanced technological knowledge acquired from overseas to their parent companies which are in a backward position in technology. The knowledge flow in their R&D internationalization networks is also opposite to that of MNCs in developed countries: it flows from overseas R&D sub-institutions to MNCs in their mother countries and plays a role in improving parent companies’ innovation performance (Awate et al., 2015).

With the deepening of knowledge and economic globalization, overseas R&D networks play a key guiding and bridging role in the process of technological innovation path reform and technological diversification development. Enterprises constructing overseas R&D networks can obtain more abundant and heterogeneous innovative resources in the international market (Kafourous et al., 2008). The breadth of overseas R&D network is the number of countries in which enterprises have set up R&D centers. Increasing the breadth enables MNCs to increase their innovation capability or reduce innovation costs by searching for and utilizing these differentiated innovation resources in a wider range, thus improving the innovation performance. When examining the relationship between technology correlation and technological innovation, Shin et al. (2010), pointed out that enterprises formed a specific path of technological knowledge accumulation through technology correlation in familiar core technology fields. The open innovation theory holds that the knowledge of an enterprise derives not only from the enterprise itself, but also from its external related networks. eMNCs tend to adopt imitation and catch-up strategies. Overseas R&D networks make it possible for enterprises to acquire differentiated and diversified knowledge. The establishment of R&D institutions in different countries is conducive to enterprises’ obtaining of diversified R&D investment; the discovery of novel scientific and technological combinations is conducive to the acquisition and integration of cross-domain heterogeneous knowledge resources. In this way, enterprises can rapidly upgrade the advanced technology and knowledge for innovation, skip the initial stage of knowledge creation and diffusion in developed countries, and quickly shape their own competitive advantages in order to compete with global industry leaders and seize market share.

Laursen & Salter (2006) defined the depth of an enterprise’s overseas exploration as the extent to which the enterprise utilizes foreign resources. In this study, it is defined as the extent to which the resource originates from the same country, i.e. the density of R&D centers in a certain country. It is often difficult to obtain cutting-edge knowledge and technology resources in the host country effectively. MNCs own more information and knowledge sources by establishing R&D alliance cooperation networks with local suppliers, R&D centers, customers, etc. By means of formal and informal organizational contacts, they transfer knowledge, share information and integrate technological knowledge within the global R&D network (Balsvik & Haller, 2011). As the “latecomer” of the host country, China’s enterprises are likely to face high environmental uncertainty and increase of transaction costs when building overseas R&D networks. In addition, related technological diversification requires higher asset specificity for foreign technology investment and continuous investment. Therefore, enterprises may adopt a highly controlled entry mode, increasing their coordination and communication costs as well as investment and conversion costs, which is against the improvement of innovation performance.

Based on the analyses above, this paper puts forward the following hypotheses:

H2a: The overseas R&D network breadth (ORNB) moderates positively the relationship between related technological diversification and innovation performance.

H2b: The overseas R&D network depth (ORND) moderates negatively the relationship between related technological diversification and innovation performance.

When the new technological fields involved in MNCs' technological knowledge gradually expand, (i.e. the degree of unrelated technological diversification increases) due to the highly heterogeneous technological knowledge base, it is hard for diversified technologies across fields to transfer and merge with each other. In order to cope with the uncertainty of the external environment and seek for enterprise development, enterprises still need to develop new technologies and new products that adapt to environmental changes. Therefore, ORNB increases and MNCs with unrelated technological diversification need to carry out cross-country and cross-domain integration. Geographical dispersion brings about different business environments in different countries. When enterprises enter unfamiliar business environments and explore different technological fields, the cost of technology integration, coordination and exchange of MNCs will increase. They even need to spend more human, material and financial resources to learn new technological principles. Even if enterprises have successfully developed new technologies and diversified unrelated technologies, these cross-domain technologies need to be successfully applied to realize the successful transition from new technologies to new products. In addition, the original technological knowledge and experience cannot provide corresponding guidance for managers, and the application of unrelated technologies will increase the difficulty of enterprise organization and management, adding the management cost.

ORND can strengthen the correlation between knowledge bases, improve MNCs' understanding and absorption ability to heterogeneous knowledge, reduce learning cost and transformation cost, and realize the integration of originally separated technologies(Wang et al.,2019). It can be inferred that when MNCs invest in unrelated technology fields, a strong ORND can, on the one hand, strengthen the understanding of technological knowledge and avoid the inefficiency of innovation brought about by incompatibility; on the other hand, it may effectively coordinate and restrict the arbitrariness and disorder of technological development and prevent out-of-control and deviation in the innovation process(Wang et al.,2018), promoting the further improvement of enterprise innovation performance. Besides, the advanced technology and knowledge needed for technological innovation are often tacit, with certain heterogeneity and path dependence. Through overseas R&D networks, enterprises can effectively transfer the tacit knowledge that is uneasy to transfer through market and improve learning efficiency through communication and cooperation with customers, suppliers and R&D partners. The long-term organizational learning is helpful for MNCs to accumulate technological knowledge. Their abilities to absorb the knowledge and technology and to integrate scattered R&D resource are hence continuously improved, with leaps and bounds in technological innovation capability.

Based on the analyses above, this paper puts forward the following hypotheses:

H3a: ORNB moderates negatively the relationship between unrelated technological diversification and innovation performance.

H3b: ORND moderates positively the relationship between unrelated technological diversification and innovation performance.

Figure 1 shows all the constructs and the hypothesized relationships among them.

Figure 1. Conceptual model

EMPIRICAL MODEL AND VARIABLES

Selection of Data Interval and Sample

Since 1995, China's enterprises have set up technology monitoring stations or R&D laboratories overseas. With the development of China's foreign direct investment, this trend has become more obvious in recent years (Tung, 2005). Moreover, China's enterprises "are establishing a clear technological advantage, which is beneficial to the R&D networks in both the host country and the home country" (Zedtwitz, 2004). The rapid development of China's enterprises' foreign direct investment began after the "going global" officially became the national strategy in 1999 and China joined the World Trade Organization in 2001. However, at this stage, the "going global" enterprises are mainly state-owned enterprises based on resources and infrastructure construction, whereas relatively few enterprises carry out foreign direct investment. Until 2008, with the outbreak of financial crisis in the United States and its spread to other countries, the global production network system has undergone major changes, and China's MNCs began to develop rapidly in their foreign direct investment. According to this, this paper selects the data interval of enterprise samples for a total of 11 years from 2009 to 2019. Such a data interval can not only form a large-scale stable research sample, but also examine the construction level of R&D institutions of China's MNCs and their "time effect" on enterprise innovation performance.

A MNC is an organization that engages in foreign direct investment and owns or controls value-added enterprises in more than one country (Dunning, 1993). According to this standard, as long as a domestic enterprise establishes one or more subsidiaries abroad through foreign direct investment to engage in value-added activities such as R&D, production or marketing services, it can be identified as a MNC. Considering the authority, stability and continuity of the data, MNCs listed in Shanghai and Shenzhen stock markets are selected as samples. As listed companies, it's easier to collect their basic information and overseas R&D data, which are more objective and comprehensive, making the research results more real and effective. In this paper, the list of listed companies provided in CSMAR is matched with the list of overseas investment enterprises recorded by the Ministry of Commerce to obtain relevant information of all MNCs listed in China's A shares. The business scope of these overseas subsidiaries includes market information collection, import and export trade, market seeking and R&D activities. Further examining and screening are then carried out: firstly, MNCs with overseas R&D activities are screened out, sample enterprises that only invest in tax havens like the Virgin Islands and Cayman Islands or that only set up investment holding companies overseas are excluded (Luo & Tung, 2007), and enterprises that have been warned of delisting risks or whose owner's equity is negative during the testing year are deleted; then, the annual reports of listed companies from 2009 to 2019 are collected in the WIND database, and the screened "name sets of MNCs that have developed overseas R&D and are listed" are matched to obtain relevant information of all enterprises with overseas R&D institutions listed in China's A shares. In the end, China's listed companies with 2 or more R&D subsidiaries abroad are retained, with altogether 236 sample enterprises distributed in various industries, including machinery, electronics, internet technology, chemical medicine and energy, etc. Judging from the distribution of host countries of overseas R&D subsidiaries, the United

States is still in a leading position in the siting of overseas R&D investment for Chinese enterprises. Traditional developed economies such as Germany and Japanese also the focus of overseas investment. Meanwhile, emerging economies such as Russia and India have gradually become the hot siting for overseas R&D. The patent numbers, patent citations and patent application data of the 236 sample enterprises from 2009 to 2019 are retrieved from the Derwent Innovation Index database. Overseas R&D network data are obtained by manually sorting out relevant information about overseas R&D institutions on enterprise official website, news reports and annual reports. Other financial data come from WIND database. The market environment data at the provincial level are measured by the market index system of China's sub-provinces compiled by Wang et al. (2019).

Variable Measurement

Innovation Performance

Patents are the most direct results of technological innovation. More and more enterprises apply for patents to protect their intellectual property rights. This paper, referring to the research by Hagedoorn & Cloudt(2003), Branstetter(2006), Lahiri(2010) and other scholars, uses the number of technological innovation patent counts (TIC) of sample enterprises in Year T as an approximate measurement index of enterprise innovation performance.

Technological Diversification

Technological Diversification (TD) reflects the distribution of patents in various fields. Based on the existing research results, the distribution degree of patented technology is a common indicator to measure the technological diversification of enterprises. The overall technological diversification includes related diversification and unrelated diversification. The former measures the degree of related technological fields involved in technological knowledge, while the latter is the degree of brand-new technological fields involved in technological knowledge. This paper adopts Chen & Chang's (2012) method to calculate the information entropy index, which is based on the four international patent classification numbers (IPC-4) involved in organization's patents to measure the technological fields involved by the organization. The formula for calculating the overall technological diversification of the enterprise in Year T is as follows:

$$TD = \sum_{i=1}^n P_{it} \ln\left(\frac{1}{P_{it}}\right)$$

Among them, P_{it} refers to stands for the number of patents belonging to the technological classification number i in the small patent category accounts for the proportion of all patents, and n represents the quantity of small patent category number of the enterprise in Year t . The higher the entropy value, the higher the degree of enterprise technological diversification. Information entropy index mainly measures the degree of dispersion of a certain index and is composed of intra-group and inter-group. The decomposability of entropy can well distinguish related and unrelated types. The calculation formula for unrelated technological diversification is:

$$UTD = \sum_{j=1}^m P_{jt} \ln\left(\frac{1}{P_{jt}}\right)$$

In the formula, P_{jt} stands for the number of patents belonging to the technological classification number j in the large patent category accounts for the proportion of all patents, and m represents the

quantity of large patent category number of the enterprise in Year t . Related diversification is the difference between overall technological diversification and unrelated technological diversification, i.e. $RTD = TD - UTD$.

Breadth and Depth of Overseas R&D Networks

The breadth of overseas R&D refers to the number of countries where MNCs set up R&D centers. Learning from Castellani et al. (2016), this paper uses the number of countries or regions in which the enterprises invest R&D subsidiaries to measure the breadth of overseas R&D. The depth of overseas R&D refers to the density of R&D centers set up by MNCs in a certain country overseas. Based on Hsu et al.'s method(2015), this paper measures the depth of R&D with the number of R&D subsidiaries set up in the same country. This value indicates the intensity of MNCs' R&D activities in their overseas expansion.

Control Variable

Referring to Yasuda(2005), Chen et al. (2012) and Hsu et al. (2015), this paper controls the following variables: Enterprise size, expressed as the natural logarithm of the total assets of the enterprise; Enterprise age (Age) is expressed by the natural logarithm of the time from the establishment of the enterprise to the investigation year; Return on assets(ROA), profitability of enterprises, is expressed as net profit divided by the average balance of total assets. The average balance of total assets = (total assets ending balance + total assets beginning balance)/2. Organizational slack(Slack) is expressed as the average of inhalation slack and non-inhalation slack. Inhalation slack=(sales expenses + financial expenses + management expenses)/sales revenue. Non-inhalation slack is the enterprise flow ratio; Experience of enterprise internationalization, experience of parent company internationalization (Experience) is expressed by the total number of overseas subsidiaries before the investigation year. The institution of the home country (Institution) is expressed by the market index of the province where the parent company is located.

Metrological Model

In order to analyze the impact of technological diversification and overseas R&D network construction on China's MNCs' innovation performance, the following econometric analysis model is established:

$$TIC_{it} = \alpha_0 + \alpha_1 TD_{it} + \alpha_2 ORNB_{it} + \alpha_3 ORND_{it} + \alpha_4 TD_{it} * ORNB_{it} + \alpha_5 TD_{it} * ORND_{it} + \theta_i X_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (1)$$

In this model, TIC_{it} represents the innovation performance of $MNCi$ during period t ; TD_{it} represent respectively the total patent application volume and invention patent application volume of $MNCi$ during period t ; X_{it} represents technological diversification, $ORNB_{it}$ and $ORND_{it}$ represent respectively ORNB and ORND of $MNCi$ during period t ; X_{it} represents control variables; μ_i represents individual effect; ν_t represents time effect; ε_{it} represents random error term.

In order to better control the causal effect and endogeneity, the dependent variable lags the independent variable by two years in the study. And since it's difficult to obtain some sample enterprises' data for eleven consecutive years, resulting in some missing values, this paper adopts non-equilibrium panel data regression model. In statistical analysis, considering the dependent variable "innovation performance" is a non-negative counting variable, it's better to adopt the counting model. In the counting model, the common non-linear panel counting model is panel Poisson regression model and negative binomial regression model (Funk, 2014), both of which regress the mean value of counting variables through maximum likelihood estimation. In this study, the standard deviation of "innovation performance" is far greater than its mean (standard deviation = 526.3, mean = 134.9) (see Table 1). There is excessive dispersion. If Poisson regression is used, there will be false high-

Table 1. Descriptive statistics and correlation coefficient of variables

Variable	Mean	Std. Dev.	VIF	1	2	3	4	5	6	7	8	9	10	11
<i>TTC</i>	134.9	526.3		1										
<i>ORNB</i>	3.16	1.89	2.62	0.46***	1									
<i>ORND</i>	1.30	0.68	1.89	0.34***	-0.19***	1								
<i>UTD</i>	0.84	1.12	1.81	0.45***	0.26***	0.08	1							
<i>RTD</i>	0.38	1.31	1.59	0.39***	0.12**	0.09**	-0.03	1						
<i>Size</i>	16.63	3.27	2.12	0.31***	0.16***	0.25***	0.21***	0.19***	1					
<i>Age</i>	3.32	1.20	1.17	0.03	0.12***	0.03	0.18***	0.24***	0.27***	1				
<i>ROA</i>	0.08	0.07	1.24	-0.07***	-0.02	-0.01	0.28***	0.29***	-0.23***	-0.21***	1			
<i>Slack</i>	1.73	1.96	1.56	-0.05	0.08**	0.05	-0.14***	-0.11***	-0.28***	-0.26***	0.34***	1		
<i>Expe</i>	2.36	3.07	1.36	0.31***	0.14***	0.03	0.04	0.03	0.41***	0.06**	-0.17***	-0.09**	1	
<i>Insti</i>	9.31	1.91	1.12	0.04	-0.02	0.07**	0.06**	0.03	0.03	-0.03	0.07**	-0.03	0.07**	1

Note: ** and *** mean significance at 5% level and 1% level respectively. Results are given by stata15.0, the same below.

level significance. In order to avoid this problem, when dealing with the over-dispersed explained variables, the sample is assumed to obey the negative binomial distribution. And then the maximum likelihood estimation (MLE) method, that is, the negative binomial regression model is used. This paper uses panel data, including 236 samples (N=236), 11 periods (t=11), a short panel with smaller t, larger N and the characteristics of unbalanced panel. Therefore, this paper adopts a negative binomial regression model based on panel data. Due to the unobservable heterogeneity of each enterprise, there may be missing variables that do not change with time. And fixed effect or random effect model is used to control its individual effect. This paper employs Hausma test (Chi=210.41, P =0.0000) selects fixed effect model according to the test results. Therefore, this paper uses negative binomial fixed effect model to examine the relationship between technological diversification and innovation performance, as well as the moderating effect of overseas R&D networks. At the same time, the unconditional negative binomial model proposed by Allison & Waterman (2002) is compared with the traditional negative binomial fixed effect model to test the robustness of the model. The new model can effectively control the heteroscedasticity of data with robust standard deviation.

ANALYSIS OF EMPIRICAL RESULTS

Descriptive Statistics of Variables

The correlation system among all variables is less than 0.6, and the variance inflation factor (VIF) of all variables is less than 10, indicating that there is no multicollinearity interference among variables.

Regression Analysis

Regression Results of Main Effect and Moderating Effect

In this study, innovation performance is taken as the dependent variable, and non-equilibrium panel negative binomial fixed effect regression is carried out on the relationship between technological diversification and innovation performance as well as the moderating effect of ORNB and ORND. In regression analysis, in order to avoid the multicollinearity problem caused by interaction terms, all variables with interaction are first centralized and then multiplied. The negative binomial regression results are shown in Table 2.

According to the research hypothesis, seven regression models are listed. Model 1 mainly demonstrates the effect of control variables on enterprise innovation performance. Results show

that this group of variables has significant effect on innovation performance, and all have significant positive effect at 1% level. Model 2 and Model 3 examine the impact of related and unrelated technological diversification on MNCs' innovation performance. Model 2 shows that the regression coefficient of related technological diversification is 2.412, which is significant at 1% level, indicating that related technological diversification has a significant positive effect on innovation performance. Regression results of Model 3 show that there is an inverse U-shaped relationship between unrelated technological diversification and innovation performance. There is an optimal value for unrelated technological diversification. Before reaching the optimal value, the increase of unrelated technological diversification is conducive to the improvement of innovation performance. After exceeding the optimal value, excessive investment in unrelated technology will have a negative effect on MNCs' innovation performance, which verifies hypothesis 1b.

Model 4 and Model 5 discuss the moderating effect of ORNB of MNCs. Model 4 is based on model 2 with the addition of adjustment variables ORNB and interaction terms between ORNB and related technological diversification. Results show that the interaction coefficient between related technological diversification and ORNB is 0.172($p < 0.1$), which indicates that ORNB significantly and positively moderates the relationship between related technological diversification and innovation performance. Thus hypothesis 2a is supported. Model 5 adds moderating variables ORNB and interaction terms between ORNB and unrelated technological diversification on the basis of Model 3. The interaction term coefficient is -1.112($p < 0.01$), which indicates that ORNB significantly and negatively moderates the relationship between unrelated technological diversification and innovation performance, supporting hypothesis 3a.

Model 6 and Model 7 analyze the moderating effect of ORND of MNCs. Model 6 is based on model 2 with the addition of the moderating variable ORND and the interaction term between ORND and related technological diversification. Results show that the interaction term coefficient between related technology diversification and ORND is -1.218($p < 0.01$), which indicates that ORND significantly and negatively moderates the relationship between related technological diversification and innovation performance. Hypothesis 2b is therefore supported. Model 7 is based on Model 3 with the addition of moderating variables ORND and interaction terms between ORND and unrelated technological diversification. The interaction term coefficient is 1.352($p < 0.01$), which indicates that ORND significantly and positively moderates the relationship between unrelated technological diversification and innovation performance. Such results support hypothesis 3b. Model 5a and Model 7a are from regression analyses using the unconditional negative binomial model proposed by Allison & Waterman (2002). Comparing Model 5 and Model 7, we find Model 5 and Model 5a, Model 7 and Model 7a are quite similar in coefficient and significance level, indicating that the model has high stability.

Impact of Different Institutional Environments

In different institutional environments, overseas R&D networks may have different impacts on the relationship between technological diversification and innovation performance (Pan et al., 2018). Based on the index system of marketization level of various regions in China compiled by Wang et al. (2019), this paper measures the development level of institutional environment of various provinces in China. If the index of the province where the MNC is located is higher than the median of the market index of all provinces, this region will be classified as a region with developed institutional environment; if not, it is classified as a region with backward institutional environment. According to this, the MNC samples in regions with developed institutional environment and with backward institutional environment are regressed respectively. Results are shown in Table 3.

Comparing the estimation results of regions with developed and backward institutional environment, MNCs' technological diversification in the former regions has far greater impact on innovation performance than in the latter regions. The coefficients of related technological diversification and unrelated technological diversification in Model 1b are 2.156 and 1.861

Table 2. Regression Results

Var	Model-1	Model-2	Model-3	Model-4	Model-5	Model-5a	Model-6	Model-7	Model-7a
<i>Size</i>	0.956*** (31.94)	0.985*** (32.45)	0.943*** (30.79)	0.982*** (31.81)	0.952*** (29.91)	0.922*** (28.92)	0.959*** (30.74)	0.941*** (29.65)	0.879*** (28.69)
<i>Age</i>	0.550*** (7.02)	0.418*** (6.87)	0.563*** (6.94)	0.131* (7.12)	0.121 (6.62)	0.109 (6.49)	0.131 (7.45)	0.175** (7.40)	0.169** (7.06)
<i>ROA</i>	0.792*** (3.91)	0.601*** (1.89)	0.857*** (1.85)	0.763*** (2.42)	0.574*** (2.31)	0.556*** (2.25)	0.962*** (2.50)	0.718*** (2.18)	0.702*** (2.28)
<i>Slack</i>	1.246 *** (7.41)	1.225 *** (7.52)	1.205 *** (7.36)	1.402 *** (7.51)	1.293 *** (7.48)	1.282 *** (7.40)	1.426 *** (7.64)	1.259 *** (7.32)	1.327 *** (7.38)
<i>Experience</i>	0.243 *** (19.84)	0.237 *** (16.52)	0.216 *** (19.64)	0.191 *** (20.42)	0.212 *** (15.42)	0.211 *** (15.47)	0.186 *** (13.41)	0.179*** (15.84)	0.163 *** (15.94)
<i>Institution</i>	0.531 *** (19.61)	0.534 *** (20.64)	0.561*** (20.43)	0.671 *** (19.16)	0.592 *** (18.06)	0.557 *** (18.02)	0.532 *** (19.36)	0.496 *** (18.92)	0.485*** (19.36)
<i>RTD</i>		2.412 *** (32.75)		1.994 *** (29.82)			2.493*** (32.61)		
<i>UTD</i>			4.543*** (17.82)		3.864 *** (14.82)	3.698 *** (14.48)		3.772*** (14.56)	3.639*** (14.38)
<i>UTD²</i>			-2.532*** (-8.31)		-1.516 *** (-5.78)	-1.489 *** (-5.76)			
<i>ORNB</i>				1.362 *** (7.85)	1.328 *** (7.85)	1.362 *** (8.02)			
<i>RTD*ORNB</i>				0.172* (7.03)					
<i>UTD*ORNB</i>					-1.112 *** (-4.21)	-1.108 *** (-4.34)			
<i>ORND</i>							1.352 *** (7.69)	1.286 *** (7.15)	1.267*** (6.79)
<i>RTD*ORND</i>							-1.218 ** (-6.74)		
<i>UTD*ORND</i>								1.352 *** (6.91)	1.185 *** (6.47)
<i>Constant</i>	-2.879*** (-3.35)	-2.754*** (-3.28)	-2.654*** (-3.17)	-2.652*** (-3.12)	-2.768*** (-3.32)	-2.256*** (-2.97)	-2.869*** (-3.25)	-2.682*** (-3.24)	-2.635*** (-3.26)
<i>Log likelihood</i>	-1989.54	-1792.63	-1632.26	-1631.52	-1779.31	-1469.81	-1879.32	-1628.25	-1647.36
<i>Wald Chi²</i>	66.75 ***	1210.24 ***	1012.92 ***	1322.16 ***	1121.72 ***	967.74 ***	987.86 ***	1658.63 ***	1548.31 ***
<i>N</i>	236	236	236	236	236	236	236	236	236

Note: Z value in brackets; *,** and ***mean significance at 10% level, 5% level and 1% level respectively.

respectively, significant at the 1% level. The coefficients in Model 4b are positive whereas significantly lower than those in Model 1b and are insignificant. This means that the technological diversification of China's MNCs in regions with backward institutions has not been well transformed into the patent output. One possible reason is the restriction of local institutional environment, lacking in effective intellectual property protection and fair and transparent market operation mechanism. The moderating role of overseas R&D networks also shows significant differences in the two different institutional environments. From Model 2b and Model 3b, in regions with developed institutional environment, ORNB and ORND have a relatively significant moderating effect on the impact of technological diversification on innovation performance. Such result is basically consistent with the previous ones. On the contrary, it can be seen from Model 5b and Model 6b that the coefficient of interaction items is significantly lower or even insignificant in regions with backward institutional environment.

There are also significant institutional environment differences in the impact of enterprise heterogeneity resources on innovation performance. These enterprise heterogeneity resources are controlling variables, including return on assets (ROA), organizational slack (Slack), and international experience (Experience), etc. In regions with developed institutional environment, the positive effect of enterprise profitability is not significant; the relationship between organizational slack and innovation performance is significantly negative; and international experience has a significant positive effect on innovation performance. It shows that the excessive resources of China's MNCs in regions with developed institutional environment may cause resource slack and strategic inertia, leading to a lack of motivation for technological innovation. While international experience has significantly promoted enterprise innovation. On the contrary, in regions with backward institutional environment, the size, age and profitability of enterprises help MNCs avoid and overcome the adverse effects of backward institutional environment, thus improving the innovation performance.

Table 3. Regression Analysis Results in Different Institutional Environments

Variable	Developed Institutional Environment			Backward Institutional Environment		
	Model-1b	Model-2b	Model-3b	Model-4b	Model-5b	Model-6b
<i>Size</i>	0.338*** (18.76)	0.365*** (19.80)	0.372*** (20.25)	0.946*** (31.34)	0.932*** (29.47)	0.926*** (28.83)
<i>Age</i>	0.103 (5.46)	-0.096 (-4.81)	-0.098 (-4.82)	0.342** (14.59)	0.345** (14.66)	0.348*** (14.69)
<i>ROA</i>	0.687 (-17.32)	-0.130 (-6.41)	-0.071 (-3.48)	0.869*** (19.75)	0.839*** (18.89)	0.841*** (19.85)
<i>Slack</i>	-0.329*** (19.18)	-0.523*** (-17.84)	-0.496*** (-16.87)	0.051 (2.67)	-0.046 (-2.97)	0.041 (2.62)
<i>Experience</i>	0.365*** (15.68)	0.158** (7.27)	0.232*** (14.91)	-0.028 (1.73)	-0.062 (-4.65)	-0.038 (-3.27)
<i>RTD</i>	2.156*** (30.23)	2.102*** (29.32)	1.963*** (25.43)	0.065 (3.73)	0.229** (14.32)	0.045 (3.62)
<i>UTD</i>	1.861*** (19.52)	2.150*** (30.22)	1.981*** (24.29)	0.049 (2.68)	0.147* (12.57)	0.083 (5.36)
<i>ORNB</i>		2.145*** (30.22)			0.112 (14.23)	
<i>ORND</i>			1.785*** (22.46)			0.078 (5.59)
<i>RTD*ORNB</i>		1.928*** (27.34)			-0.552** (16.43)	
<i>UTD*ORNB</i>		-0.643** (-18.60)			0.068 (12.59)	
<i>RTD*ORND</i>			-2.021*** (-25.26)			-0.628* (-9.37)
<i>UTD*ORND</i>			0.849** (18.54)			0.079 (5.82)
<i>Constant</i>	-3.754*** (-7.18)	-3.357*** (-7.31)	-3.273*** (-7.28)	-3.119*** (-6.59)	-3.329*** (-6.89)	-3.343*** (-7.28)
<i>Log likelihood</i>	-1569.84	-1595.63	-1570.14	-1812.08	-1836.57	-1812.83
<i>Wald Chi²</i>	2367.32	2290.42	2358.35	1686.57	1636.26	1681.49
<i>N</i>	139	139	139	97	97	97

Note: Z value in brackets; *, ** and *** mean significance at 10% level, 5% level and 1% level respectively.

CONCLUSION AND POLICY IMPLICATION

Main Conclusions and Discussions

Based on the background of digital economy and the sample of listed MNCs in Shanghai and Shenzhen stock markets from 2009 to 2019, this paper examines the impact of technological diversification on the innovation performance of MNCs and the moderating effect of overseas R&D networks on the relationship between technological diversification and innovation performance. Conclusions are as follows.

First, the related technological diversification of MNCs has a significant positive impact on their technological innovation performance. This shows that the stronger the ability of MNCs to accumulate relevant technological knowledge within the same scientific scope, the more intangible assets such as intellectual property rights will be acquired by enterprises and the wider the range of technologies that can be used and transformed. And then through the “knowledge accumulation” mechanism, the sustainability of enterprise innovation will be promoted (Moaniba, et al.,2019).

There is an inverse U-shaped relationship between the unrelated technological diversification and the innovation performance of MNCs. This indicates that when enterprises explore diversified knowledge across scientific and technological fields, their innovation performance will be improved at the initial stage. Diversification of unrelated technologies can bring differentiated and sustainable competitive advantages for eMNCs, ease the dependence of enterprises on a specific technology, and improve the efficiency of enterprise innovation(Christina & Carlos,2008). Diversification of unrelated technologies will bring economies of scope, enabling eMNCs to gain differentiated advantages, attract new customers and face the complex market environment.

However, the diversification of unrelated technologies will bring a high degree of uncertainty to the enterprise. Although unrelated diversification increases the scope of technology, it makes companies ignore the in-depth exploration of technology. What's more, subject to the constraints of limited resources, eMNCs will have to face coordination costs. When the level of unrelated technological diversification exceeds a certain critical point, where coordination cost outweighs the advantage of economies of scope, the continuous increase of diversified heterogeneous knowledge will have a negative impact on innovation performance.

Second, overseas R&D networks have a significant moderating effect on the relationship between technological diversification and innovation performance. ORNB and ORND have different moderating effects. ORNB has a significant positive moderating effect on the relationship between related technological diversification and innovation performance, but ORND has a significant negative moderating effect. The greater the ORNB, the greater the promotion effect of related technological diversification on innovation performance. Nevertheless, ORND inhibits the promotion effect. This result is consistent with China's current level of overseas R&D. China is a “latecomer” in the global innovation network. Chinese companies' overseas R&D activities are mainly aimed at seeking technology currently. Decentralized overseas R&D is more suitable for Chinese MNCs, which is an easier access to obtain heterogeneous resources and knowledge. The more related technical acceptance points of MNCs, the easier it is for the parent company to absorb advanced technical knowledge, which strengthens the parent company's own technical knowledge in related fields, thereby promoting its innovation performance. However, most of the knowledge resources obtained by setting up R&D institutions in the same country are duplicates, with other heterogeneous resources not obtained, which is not conducive to the improvement of the innovation capability of eMNCs.

ORNB has a significant negative moderating effect on the relationship between unrelated technological diversification and innovation performance, while ORND has a significant positive moderating effect. When eMNCs explore diversified knowledge through unrelated technology fields, the increase in ORNB will cause additional R&D costs, internal coordination costs or organizational management costs to eMNCs, which are not conducive to the improvement of innovation performance. However, deeper overseas R&D networks in a specific country can effectively coordinate and prevent

the arbitrariness and disorder in unrelated technological diversification development, thus promoting the relationship between unrelated technological diversification and innovation performance.

Third, the moderating role of overseas R&D networks is significantly different due to the heterogeneity of institutional development levels among regions in China. Compared with the regions with backward institutions, the technological diversification of MNCs in the regions with developed institutions has a more significant impact on innovation performance, and the moderating effect of overseas R&D networks is also more significant. Restricted by the level of regional economic development, China's MNCs in regions with backward institutional environment are weak in overall strength, lacking experience and ability in international operation. And they do not have the absorption and integration ability to effectively utilize reverse knowledge spillover in R&D internationalization. It is difficult to fully absorb and apply the advanced technological knowledge from R&D internationalization. Furthermore, under such unfavorable conditions, the construction of overseas R&D network may disperse the innovative resources that enterprises could otherwise use for domestic independent R&D, and may also lead to the unbalanced allocation of innovative resources and backward innovation capability.

Main Contribution and Implication

The main contributions of this paper are as follows: (1) From the perspective of R&D internationalization, this paper explains the moderating and influence mechanism of contextual factors of the relationship between technological diversification and innovation performance of eMNCs. Meanwhile, it confirms the different effects of related and unrelated technological diversification on innovation performance, and reveals the boundary conditions of technological diversification on enterprise innovation. In turn, it responds to the controversial issue of whether technological diversification and overseas R&D can be conducive to MNCs' innovation, and provides a new way for the research on contextual factors of technological innovation strategy, R&D internationalization strategy and enterprise innovation of eMNCs. (2) Enriching the theoretical research on the technological innovation strategy and internationalization strategy of MNCs. A majority of the mainstream theories of international business management focus on developed international MNCs. However, with the development of information technology and the intensification of global technology competition, more and more enterprises in developing countries and emerging economies that are at a technological disadvantage regard technological diversification and R&D internationalization as an important way to quickly realize technological catch-up and enhance their innovation capability. One more and more obvious motivation for the technological innovation of MNCs in developing countries is to make full use of the international market for technological learning and access to innovative resources (Luo & Tung, 2007), thus improving the innovation performance. This is significantly different from the international motivation of technological utilization of traditional MNCs in developed countries. Therefore, the relationship between technological diversification, R&D internationalization and innovation performance in developing countries may present completely different characteristics from those in developed countries. Taking listed MNCs in China, a typical emerging economy, as the object, this paper explores the relationship between technological diversification, overseas R&D network and innovation performance in the context of developing countries. This paper also conducts normative empirical tests to further enrich and perfect the theoretical research on MNCs' technological innovation and R&D internationalization. (3) It supports the research conclusion that the existing external institutional environment affects the non-market behavior of enterprises (Julian & Dankwa, 2013), and extends it to the contextual research of technological innovation and R&D internationalization. Additionally, it identifies the external institutional conditions that the overseas R&D network affects the relationship between technological diversification and innovation performance, further enriching relevant research on technological innovation and overseas R&D in emerging economies.

According to the conclusions, the following implications are drawn: (1) Enterprises are the main body of the national innovation system and an important factor driving the national economic

development. Therefore improving the innovation ability of enterprises is the key to building an innovative country. With the further deepening of knowledge and economic globalization, MNCs should broaden the original technological base, carry out technological R&D and knowledge exploration in many fields, and capture strategic opportunities for cross-market development. In the process of rational allocation of technological resources, it is necessary to grasp the direction and focus of technological development, and pay attention to the dynamic balance between technological relevance and non-relevance.(2) eMNCs should expand their internationalization vision and gradually extend from the internationalization of production and sales links to the high-end link of the value chain, that is, the process of internationalization of R&D. Enterprises should attach importance to the rational distribution of their R&D resources in global scope, and gradually improve their technological level and innovation ability by making use of the rich innovation resources, diversified learning opportunities and good institutional environment of the international market, so as to establish their own competitive advantages in the global competition.(3) The government can strengthen the construction of institutional environment and take relevant measures to provide necessary support for MNCs' technological diversification and R&D internationalization. First of all, the government can issue relevant policies to encourage MNCs to carry out technological innovation and overseas R&D investment. For example, externally, relevant policy consultation mechanisms can be established to encourage international capital flows and technological exchanges; internally, the approval procedures can be simplified and the approval efficiency be improved. Secondly, financial and tax support can be increased for MNCs' technological innovation activities, and financing channels for overseas R&D investment be actively expanded. Finally, relevant intermediary service agencies can be cultivated and developed, a comprehensive and interactive information service platform be built, and the docking of domestic and international research supply and demand be promoted.

Limitations and Prospects

Although this paper enrich the existing research results theoretically and practically, this paper still has certain limitations. Firstly, the research conclusion reveals that there is an inverse U-shaped relationship between unrelated technological diversification and innovation performance, which indicates an optimal value for the promotion of technological innovation by unrelated technological diversification. However, the optimal value level is not given in this paper. Subsequent research can further explore it. Secondly, overseas R&D network is a relatively complex concept. This paper only analyzes it from ORNB and ORND. At present, the degree of R&D internationalization of Chinese MNCs is relatively low, and the overseas R&D network system is still imperfect. Many MNCs have only two overseas R&D subsidiaries, and fewer companies have established two or more companies in the same country, so that the measurement of depth is relatively weak. Future research can further expand data sources and measure overseas R&D network from multiple levels and angles. Thirdly, this paper only uses the sample of China's listed MNCs for research, which can be compared with other emerging economy countries or regions in the future to provide more universal suggestions for eMNCs to construct reasonable technological development paths.

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