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RESEARCH ARTICLE

# The S-shaped relationship between R&D investment and green innovation after cross-border merge and acquisition: evidence from China

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**Abstract**
In the economic transition process, emerging markets are recognizing the importance of accessing sophisticated technologies to green innovation. After cross-border merge and acquisition (M&A), research and development (R&D) investment has become the basic condition for acquiring mature market technologies. Many studies suggest that R&D can promote green innovation. However, in the context of cross-border M&A, the relationship between R&D and green innovation is more complicated. Based on the knowledge-based view and stakeholder theory, this paper takes 230 cross-border M&A events at Chinese enterprises as samples. The conclusions show that instead of a linear relation, the influence of R&D input on green innovation performance after cross-border M&A is in an "S-shape"; the political connection and institutional distance of enterprises play a negative role in promoting the relationship between R&D input and green innovation performance after cross-border M&A.

**Keywords** Green innovation · R&D investment · Cross-border m&a · Political connection · Institutional distance

## Introduction

The green innovative development of emerging markets has entered a new stage. Taking China as an example, at the Fifth Plenary Session of the 14th CPC Central Committee, the Chinese government proposed that "'Innovation and green' is the main theme of China's new stage of economic development. China needs to promote a comprehensive green transformation of its economic and social development, and build modernization in which man and nature coexist in harmony." Green innovation is an important breakthrough for emerging markets to achieve sustainable economic and environmental development, production transformation, and even economic transformation. Although the government has taken a series of measures in terms of green innovation resource input, green science and technology reward, and energy conservation and emission reduction for enterprises, since green innovation is complicated and diverse (Hojnik and Ruzzier 2016; Ardito et al. 2019), emerging markets still need to leverage mature partners in order to gain access to key technologies. Cross-border M&A has become an important springboard for the rise of emerging markets (Mathews 2006; Luo and Tung 2007; Buckley et al. 2007), an important measure to solve the key problem of green innovation, and a means of harmonious economic and social development. Thus, it is very important to study the mechanism of green innovation technology transfer in emerging markets under the condition of cross-border M&A.

It is difficult for emerging markets to automatically transfer the advanced technologies acquired through cross-border M&A, because emerging markets do not have the firm-specific advantages (FSA) and country-specific advantages (CSA) that mature markets have, and so, they have great difficulties in absorbing advanced technologies from mature markets (Miller and Parkhe 2002; Hitt et al. 2004). As an important embodiment of the absorptive capacity of enterprises, R&D investment is key to the acquisition and integration of core green innovation technologies in emerging markets. Therefore, it is of theoretical and practical significance to study the relationship between the R&D

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investment and green innovation performance of enterprises after cross-border M&A, because it is key to realizing the transformation of the green production mode and to achieving green innovation breakthroughs in emerging markets. Additionally, studying the mechanism of this relationship helps enterprises to solve environmental development problems by scientific means. Ignoring this topic may lead to a biased understanding of green technology acquisition mechanisms in emerging markets, which is not conducive to managers' attempts to formulate a R&D development strategy after cross-border M&A.

However, the existing literature on green innovation in emerging markets mostly focuses on the passive acquisition of green technology from developed countries. Most importantly, these studies ignore the important role of R&D in the process of cross-border M&A, which is a gap in the existing literature. For example, Eskeland and Harrison (2003) believed that when the host country introduces foreign investment, foreign enterprises gain more environmentally friendly production technology and pollution treatment technology than the host country enterprises, which provides incentives and opportunities for the host country enterprises to use green technology and to carry out clean production. Thus, the level of green innovation in the enterprises in the host country is improved; Hao et al. (2020), based on panel data from 30 provincial-level units in China from 1998 to 2016, suggested that increasing FDI could promote technological innovation and thus reduce the emission of environmental pollutants; Luo et al. (2021) used the sys-GMM method to show that foreign direct investment (IFDI) played a positive role in China's green innovation, which verifies the "pollution halo" hypothesis.

Nevertheless, these studies have ignored the fact that emerging markets are at a dynamic stage of development—these enterprises are not satisfied with the use of marginal technologies, and they have an urgent desire to transform their production methods and achieve harmony between business and the environment (Wu and Qu 2021). This has encouraged the enterprises in emerging markets to take a more radical approach—cross-border M&A—to acquire cutting-edge green innovation technologies. More importantly, R&D plays a crucial role in this process, as a means for enterprises in emerging markets to absorb advanced technologies for green innovation. These are problems that have not been sufficiently considered in previous studies. Our study attempts to fill this gap.

Moreover, most of the existing literature has concluded that R&D intensity plays a positive role in promoting the innovation or green innovation of enterprises. Rosell-Martínez and Sánchez-Sellero (2011) argued that R&D is crucial to creating knowledge and improving enterprise productivity. R&D-intensive departments were the most effective in terms of technological progress and innovation. Sánchez-Sellero et al. (2015) suggested that both internal and external collaborative R&D can promote innovation, and innovation in the production process can improve the application and production of the required knowledge. Taking China as their research sample, Fujii and Managi (2019) found that green innovation is strongly linked to spending on R&D, as well as a country's economic growth.

However, the question remains: under the special conditions of cross-border M&A, does R&D intensity still play a positive role in promoting the green innovation of enterprises? After cross-border M&A, enterprises may face a completely different political and economic environment from the domestic system (Peng et al. 2008; Wang et al. 2012). Additionally, the existing literature often fails to consider the effects of R&D on the green innovation performance of enterprises after cross-border M&A. For example, China's social system, economic growth path, and cultural customs are very different from those of mature markets, resulting in great institutional distance. Does institutional distance affect access to cutting-edge green technology in emerging markets? At the same time, when Chinese enterprises enter mature markets, can the original institutional advantages—institutional connections—still play the positive role they do in China? The existing literature does not provide the answer. Our study tries to fill these gaps.

In this study, we selected 230 cross-border M&A events in Chinese enterprises. The research objectives are as follows: (1) Is the effect of R&D on green innovation linear after cross-border M&A? What is its mechanism? (2) How does institutional distance affect the relationship between R&D and green innovation? (3) Does the domestic political connection of enterprises promote the relationship between R&D and green innovation, and what is its mechanism?

This paper mainly makes the following contributions: First, this paper studies the promotional effect (and its mechanism) of R&D on the green innovation of enterprises in the process of cross-border M&A, which is a special situation because previous literature has ignored the impact of Chinese enterprises' cross-border M&A on green innovation and mostly viewed emerging markets' utilization of mature market technologies from the perspective of technology spillover. We analyzed the important role of R&D in acquiring mature market green technologies from the perspective of technology acquisition. Second, this paper discusses the special role of political connection and institutional distance in R&D on the green innovation performance of cross-border M&A, which has not been discussed in the existing literature. Institutional distance and political connection are important factors influencing firms' access to green innovation resources and are also important conditions of R&D's effect on enterprises' green innovation after cross-border M&A. Our study reveals the mechanisms of this effect. Third, from a new theoretical perspective, this paper combines a knowledge-based view with stakeholder theory to analyze the mechanism of R&D's effect on the green innovation of cross-border M&A, which includes R&D investment, institutional distance, and a firm's political connection in a unified framework, which is a beneficial extension of the knowledge-based view and international investment theory.

## Theoretical background and hypothesis

### Knowledge-based view, stakeholder theory, and green innovation of cross-border M&A

According to the knowledge-based view, knowledge is a unique asset that an organization relies on for its survival. How an organization stores and uses its internal knowledge is related to its survival and development (Hakanson 2010). Organizations need not only to manage the accumulation of internal knowledge, but also to search for, absorb, and use external new knowledge, to improve their own performance (Martin-de-Castro et al. 2011).

Green innovation is related to an organization's ability to achieve sustainable development. It requires the organization to not only use internal knowledge, but also to combine internal knowledge with external knowledge and to eliminate or reduce environmental damage through the improvement of production technology, manufacturing processes, intermediate products, final products, and other links or the whole manufacturing process (Beise-Zee and Rennings, 2005; Chen and Lai 2006 Li 2022). The essence of green innovation is the integration of knowledge, organization, and the market. From the perspective of the knowledge-based view, enterprises need to constantly integrate internal and external knowledge in the process of green innovation and master new concepts and cutting-edge technologies through the efficient utilization and management of internal and external knowledge while reducing the cost of the green knowledge flow and improving the efficiency of green technology innovation. Therefore, knowledge management is an important mechanism for manufacturing enterprises to achieve green innovation.

The combination of the knowledge-based view and stakeholder theory can help us to better understand the special situation of green innovation faced by enterprises after cross-border M&A. According to stakeholder theory, organizations should balance the requirements of stakeholders, understand and respect the individuals closely related to organizational behavior and results, and try to meet their needs (Freeman 1984). According to stakeholder theory, this is not only an ethical requirement, but also a strategic means to bring stakeholders into organizational decision-making. Both are helpful to improving the organization's competitive advantage in a specific institutional environment (Cennamo et al. 2009; Plaza-Ubeda et al. 2010).

Green innovation after cross-border M&A relies not only on local stakeholders, but also on the host country's stakeholders. On the one hand, enterprises' green innovation relies on the support of the domestic government. For example, some politically connected enterprises can learn the government's policy orientation and derive information related to the overseas investment environment and thus target enterprise information more quickly (Wang et al. 2012). In addition, due to the close relationship between the government, state-owned banks, and the Securities and Insurance Regulatory Commission, it is easier for politically connected enterprises to obtain financing facilities and benefit from the government's tax incentives and financial subsidies (Peng and Luo 2000). These enterprises are deeply dependent on local institutional systems and stakeholders, forming a certain degree of path dependence. On the other hand, enterprises hope to rapidly acquire cutting-edge green innovative technologies through cross-border M&A (Wu and Qu 2021) and thus gain growth opportunities. This requires them to overcome the inertia of growth caused by political connection and become familiar with the institutional system of mature markets as new entrants. However, due to institutional conflicts between emerging and mature markets, the process is often fraught with twists and turns. Emerging market enterprises need to be embedded in the host country's innovation network. They need not only to cooperate with host country suppliers, customers, and shareholders, but also to establish good relations with host country governments, financial institutions, and consulting intermediaries, so as to reduce the liability of outsiders and obtain the space required for the growth of green innovation.

### R&D invest after cross-border M&A

Because green innovation involves comprehensive knowledge of different technical fields, such as green product design, manufacturing processes, circular production, sewage treatment, and energy saving, its realization requires more innovation resources than general innovation (Strambach 2017). Therefore, emerging markets rely on their R&D not only to create innovative resources, but also to be able to absorb and integrate the knowledge resources acquired from mature markets. However, the unique nature of emerging markets means enterprises have limited R&D resources to invest in the process of cross-border M&A. On the one hand, due to the disadvantages of outsiders, cross-border M&A in emerging markets always produces more information search costs, cognitive costs, transaction costs, and organizational costs compared with M&A in mature markets; on the other hand, due to the huge technological gap between emerging markets and mature markets, the managers of target enterprises may worry about the enterprise's development prospects (Knoerich 2010), and this may result in a large number of managerial and technical staff being dismissed (Ernst and Vitt 2000). As a result, emerging markets are faced with a shortage of innovative resources. Therefore, in the early stage of cross-border M&A, due to the consumption of integration resources and the reduction of innovation resources, some parts of enterprises receive relatively little R&D investment. However, the M&A of mature market enterprises in emerging markets has a strong focus of technology acquisition (Luo and Tung 2007; Child and Rodrigues 2005; Mathews 2006; Rui and Yip 2008). Therefore, some companies gradually increase R&D investment to a relatively high level in order to ensure their mastery of mature market technologies. In addition, some enterprises, with the effective combination of various resources after M&A, gradually stabilize their business status and performance and become increasingly able to keep R&D investment at a very high level to ensure innovation returns.

## The relationship between R&D investment and green innovation after cross-border M&A

After cross-border M&A, although enterprises are exposed to a large amount of heterogeneous knowledge, small R&D investments limit the development of green innovation in enterprises. First of all, less R&D investment leads to a lower knowledge pool capacity and absorptive capacity in enterprises (Cohen and Levinthal 1990), which limits the acquisition of green innovative technologies. In the process of cross-border M&A, enterprises in emerging markets have the disadvantages of being outsiders and latecomers (Zaheer and Mosakowski 1997). Due to large differences in the development of the economy, politics, science, and technology, compared with mature market, the M&A between emerging markets and mature markets will produce more cognitive cost (costs due to technical information overload), transaction costs (such as search costs and technology limitation costs), and organizational integration cost (such as the cost of establishing special procedures and regulations). However, the resources of enterprises are limited, and these costs often demand a large section of innovation resources. Therefore, R&D investment in the early stage of cross-border M&A is limited, which affects the accumulation of knowledge resources and improvements in the absorptive capacity of enterprises (Cohen and Levinthal 1990). Green innovative technology has its uniqueness and complexity, which requires enterprises to have a solid knowledge base and good absorptive capacity (Strambach 2017). For example, compared with ordinary innovation, green technology innovation capability includes not only green product innovation capability and green process innovation capability, but also terminal governance technology capability (Chang 2011). Therefore, lower R&D investment limits the development of enterprises' green innovation capability. Second, the introduction of green innovation technology may change the original product design process and production process, and given that enterprises need to coordinate knowledge transfer between stakeholders, including engineers, technicians, and R&D personnel with different technical backgrounds, this may lead to an increase in integration, communication, and coordination costs, crowding out R&D resources. Low R&D investment hinders the coordination of resources and is not conducive to the formation of innovation synergy. Finally, as important stakeholders, employees are important to realizing the green innovation of enterprises. High R&D investment is conducive to training and learning related to green innovation for employees, such that the concept of green innovation can be deeply rooted in the conceptual consciousness of employees (Cai and Zhou 2014). On the contrary, less R&D investment is not conducive to the cultivation of a green innovation consciousness in employees.

More R&D investment plays a positive role in promoting the green innovation performance of the enterprise. First, cross-border M&A can expose enterprises to diversified and heterogeneous complementary knowledge, and increasing R&D investment is conducive to broadening the knowledge pool, thus producing a good connection with heterogeneous knowledge (Cohen and Levinthal 1989, 1990). Moreover, increasing R&D investment is conducive to enhancing the absorptive capacity of enterprises, so as to better integrate and digest green innovation knowledge (Jayaram and Pathak, 2013). Second, cross-border M&A enables enterprises to broaden their green innovation network, and increased R&D investment helps enterprises to maintain and strengthen interactions with network members. Through cross-border M&A, enterprises have access to stakeholders, including suppliers, research institutes, and environmental protection agencies, in the host country. More R&D investment is conducive to expanding the cooperation and communication between enterprises and these stakeholders, thus improving the complexity and flexibility of enterprise innovation, enhancing internal innovation capacity, and promoting green innovation (Zhang and Xu 2019). Finally, more R&D investment is conducive to better learning and training for M&A enterprises and target enterprises. In this way, the R&D personnel in the enterprise can gain a deeper understanding of the existing knowledge system and thus clearly understand the mechanisms necessary to creating green inventions, thus promoting green innovation.

However, excessive R&D investment after cross-border M&A tends to produce R&D redundancy, which is detrimental to the green innovation performance of enterprises. Child (1972) believed that in a complex technical environment, the existence of redundant resources would cause enterprises to make reckless decisions, resulting in resource waste and increased risks. Too much R&D spending may cause the enterprise to commit a lot of time and energy to familiar and limited technology; enterprises may depend on the original technology and fall into a trap, and redundant resources could also encourage enterprises to choose an unsuitable technical route (such as one with high costs, causing a low success rate in the development of green technology), thus increasing the failure rate of green innovation. In addition, human resource is an important aspect of R&D investment, as overly intensive human resource investment may lead to the leakage of enterprise innovation information and low efficiency in innovation management. For example, when an enterprise sends too much human resource from its home country to the host country, due to differences in values, cultures, and preferences, frictions in green innovation decision-making may occur. In addition, differences in information channels, perspectives, and cognitive conflicts constrain the behaviors of managers, leading to a reduced decision-making efficiency and cohesion in enterprises, thus increasing communication and coordination costs (Alesina et al. 2003, 2016), which is detrimental to green innovation after cross-border M&A. Based on the above analysis, we conclude that:

Hypothesis 1: There is an S-shaped relationship between R&D investment and green innovation after cross-border M&A.

## Political connection, R&D investment, and green innovation

Political connection represents the special connection between enterprises and the government. Politically connected enterprises are often able to obtain more preferential treatment in terms of land use, bank loans, market access, and import quotas and can also expand their innovation cooperation network by virtue of political connection (Siegel 2007), reducing the risk and uncertainty involved in the process of cross-border M&A. After cross-border M&A, enterprises lack integration resources and face a series of risks and uncertainties brought about by cross-border M&A. A politically connected entity can mitigate the negative impacts of insufficient R&D investment on green innovation. Firstly, enterprises with political connections can obtain more green innovation resources from the government stakeholder, including rewards for R&D personnel, tax incentives, and direct financial subsidies for enterprises (Guo et al. 2018), which lay a good foundation for green innovation after cross-border M&A. In addition, enterprises with political connections are more likely to obtain information resources from the government, such as generous green innovation policies in host countries. Thus, enterprises can influence the regulatory measures of production in advance, so as to reduce sunk costs. Second, political connection can help enterprises establish green innovation cooperation networks in host countries. As an advocate and facilitator of cross-border M&A, the government can help enterprises build relationships with stakeholders in host countries, and relationships are the foundation of knowledge sharing. Enterprises can establish a series of connections with suppliers, customers, peer companies, universities, technology laboratories, and intermediaries (De Marchi 2012; Arranz et al. 2019) and thus gain more knowledge spillover. Finally, politically connected enterprises are more confident in cross-border M&A and dare to try cutting-edge green innovative technologies. At the early stage of cross-border M&A, enterprises often undergo a series of changes in strategic orientation, organizational structure, and external relations. Therefore, R&D investment is relatively limited at this stage, and enterprises dare not attempt green technologies, preventing major breakthroughs. Depending on the identity of their political connection, cross-border M&A enterprises tend to be more confident in dealing with the risks involved in the complex environment of the host country's market (Heidenreich et al. 2015) and may invest more energy and time in green innovation projects that can bring long-term benefits, which is conducive to green innovation.

When enterprises invest more in R&D, first of all, the funding effect of political association on enterprises' R&D resources is marginally diminishing, and the promotional effect is gradually weakened. In addition, enterprises with sufficient R&D resources usually have sufficient corporate capital in the stage of cross-border M&A, so they will return the income obtained from political connections, thus drowning out the integration resources and innovation resources available for the green development of enterprises in the process of M&A. In the process of green innovation, the obtaining of government support may bring about the "political curse"; this means enterprises have to pay the return cost to the associated party when obtaining capital support (Wang et al. 2012). For example, in the process of cross-border M&A, enterprises may violate their own economic interests, and the selection of external directors and managers may be influenced by government policies. They may choose managers who are more in line with the interests of the government, rather than those with professional strategic thinking capacity and management ability. While green innovation involves the coordination of stakeholders and the integration of professional technology, a lack of professional managers and technical personnel may lead to friction in the process of innovation and knowledge transfer.

When corporate R&D investment is at a very high level, political connections can mitigate the waste of resources caused by R&D redundancy. On the one hand, enterprises may continue to pay "return costs" to stakeholders in host countries in order to maintain their politically connected identity. On the other hand, politically connected enterprises' decisions are usually influenced by government policies (Wang et al. 2012). For example, the report of the 19th National Congress of the Communist Party of China pointed out that to accelerate the reform of the ecological civilization system, enterprises must move towards respecting and protecting nature and diversified development. In the context of overseas investment, politically connected enterprises must align themselves with the policy direction of the government (Roumeliotis 2016). Therefore, they will pay more attention to the collection of green innovation resources, expand innovation channels, and actively explore issues related to green innovation, thus reducing the problem of repeated innovation caused by redundant innovation resources. Based on the above analysis, we conclude that:

Hypothesis 2: Political connection can help mitigate the "S-shaped" relationship between R&D investment and green innovation.

## Institutional distance, R&D investment, and green innovation

When enterprises invest less in R&D, the primary problem they face is whether the institutions of the host country can protect their survival, rather than their innovation and development. Chinese enterprises' overseas investment is largely based on the prospect of "escape" from the original institution. Cross-border M&A enterprises are faced with a non-market competitive environment in China, and relationships are crucial in the development and survival of enterprises. Some enterprises even bribe local government officials through relationship ties to escape environmental laws, regulations, and penalties (Luo 2000). When enterprises enter a host country with a better institutional environment, they are faced with better legislation and law enforcement systems and stricter judicial procedures related to green innovation. Therefore, enterprises can invest more green innovation resources in their own development rather than maintaining relationships. As a result, for enterprises with less R&D investment, institutional distance is conducive to allocating more resources to the coordination between departments after M&A, so as to mitigate the negative effects of lower R&D investment on green innovation.

With increases in R&D investment, enterprises in emerging markets focus on innovation and development, rather than on coordination between various departments after M&A. Compared with low R&D investment, high R&D investment helps to enhance the absorptive capacity and innovation capacity of enterprises (Cohen and Levinthal 1989); however, institutional distance may increase the difficulty of knowledge integration, which is inhibitory to the green innovation of enterprises. At the macro level, enterprises face different approval and legal procedures and codes of conduct in the process of cross-border M&A, coming from their home countries. Enterprises need not only to abide by explicit provisions, but also to follow the implicit value-related norms of the host country. A large institutional distance may increase the difficulty in enterprises implementing the host country's M&A procedures and economic rules, leading to resistance from stakeholders in the host country, which hinders the formation of post-M&A innovation synergy and further increases the risk to green innovation. From the micro level, green innovation is highly dependent on the knowledge transfer between the acquisition enterprise and the target enterprise, among which tacit knowledge is the key resource of enterprise green innovation (Zhang and Xu 2019), but such knowledge is often hidden and implied, and it is difficult generate it through training and teaching. Its transmission requires the formation of a relationship of mutual trust and collaboration between the stakeholders, such as the managers and technical personnel, of the M&A enterprise and the target enterprise (Kogut and Zander 1992), which occurs naturally when the relationship between the two parties is harmonious. Due to the great differences between the value norms, practices, and standards adhered to by the M&A enterprise and the target enterprise, there is a general resistance to communication and exchange between employees. Therefore, when the enterprise commits to high R&D investment, institutional distance is not conducive to promoting the relationship between R&D and green innovation.

When R&D investment is very high, institutional distance can alleviate the disadvantages of R&D investment redundancy. First, with increases in R&D investment, the absorptive capacity of enterprises will gradually improve, so that cross-border M&A enterprises can better identify, integrate, and digest heterogeneous knowledge (Elango and Pattnaik 2007). Institutional distance can help enterprises gain access to more heterogeneous knowledge resources, including the latest green technology in mature markets, market development information, and marketing network information. At this time, enterprises can quickly capture, digest, and integrate these resources and adjust their green technology development mode and talent training mode according to said technologies and market knowledge, so as to improvement the enterprise's innovation ability, thus promoting green innovation. Second, institutional distance can encourage cross-border M&A enterprises to establish a broader innovation network, with the better transfer of green innovation knowledge and technology and access to green innovation information. When the R&D investment of an enterprise is very high, the enterprise has more resources available to help establish links with mature market stakeholders, such as enterprises, suppliers, research institutes, and government agencies, and embed itself in local supply chains. In this context, institutional distance encourages emerging market enterprises to get in touch with different local conditions, customs, values, and innovation systems. Different values and innovation systems can stimulate the inspiration of employees (Vermeulen and Barkema 2001), thus promoting green innovation.

Hypothesis 3: Institutional distance can help mitigate the "S-shaped" relationship between R&D investment and green innovation.

# Methods

## Data and samples

Our samples come from the CSMAR database, which is the most authoritative database related to the statistical information of listed companies in China. Following the practice of Du et al. (2016), Chen et al. (2017), Zhang et al. (2018), and Li (2022), we set a series of criteria to screen out samples of cross-border M&A from 2006 to 2019.

There are 828 cross-border events in CSMAR database between 2006 to 2019 initially. First, we deleted the M&A events where the target companies are located in tax havens, such as the British Virgin Islands, Cayman Islands, and Bermuda, which are probably only for the purposes of tax avoidance and thus have no research value (90 samples). Second, we deleted the target enterprises in the Hong Kong, Macao, and Taiwan administrative regions, and those located overseas but whose production and operation activities are still concentrated in China, because these target enterprises are not overseas enterprises (178 samples. Thirdly, as the related party transaction may cause the price and method of transaction to face abnormal competition, we also excluded this part of the samples (117 samples). Fourth, if the event occurred within 1 month before overseas mergers and acquisitions in the listed companies, such as changes in assets organization, the board of directors, and lawsuits, in order to eliminate the noise produced by this, we deleted this portion of the sample, and if there are two of the same enterprise within six calendar months of cross-border M&A, we used the first cross-border M&A for the sample (41 samples). Fifth, we excluded samples with an M&A value of under one million yuan, because these samples may only involve a short-term investment motivation (108 samples). Sixth, we deleted samples showing unsuccessful M&A and missing serious financial data, so as to ensure the authenticity and reliability of the samples (64 samples). After the above layers of screening, we finally got 230 cross-border M&As as our research samples.

To further test the validity of sample size, we used power analysis to determine whether we had collected enough samples; the power was set at 80%, and the sample size required by each model was tested successively. The results show that the sample size of 230 was sufficient.

## Measurement method

### The dependent variable

Enterprise green innovation performance (*lngip*). There are two ways to measure innovation performance: One is to measure the added value of new products; this reflects the commercial value of innovation activities, but there is no unified new product classification standard, so there are shortcomings in this approach. The other is to measure the number of patents, including the number of patents authorized, the number of patent applications, the number of patent citations, and the number of cumulative patent citations (Hall et al. 2005). Considering that the number of patent applications is a direct reflection of an enterprise's innovation achievements, it also reflects the efficiency of its R&D activities (Ahuja and Katila 2001; Fang et al. 2014). Therefore, similar to enterprise innovation, we believe that the number of green patent applications of enterprises can better reflect the status of their green production technology and green products, and so we took the annual number of green patent applications as the dependent variable. Since this variable involves a large amount of 0 values, we added 1 to it to take the logarithm, as introduced by Wooldridge (2002). We derived the relevant data from the Chinese Research Data Services database (CNRDS).

### The independent variable

Enterprise R&D investment (*RD*). Since enterprise R&D investment is a relative quantity, in order to eliminate its dimensional influence, this paper adopts the ratio of company R&D investment to sales revenue to measure enterprise R&D investment. Relevant data were obtained from the Guotaian (CSMAR), CNRDS, and Ruisi (RESSET) databases.

### Moderator variables

(1) Political connection (*pc*). Wang et al. (2012) suggested that to measure the degree of political connection of an enterprise, one uses the proportion of senior executives with politically related backgrounds out of the total number of personnel in the senior management team. Here, political connection background means having served as representatives of the people's congresses and CPPCC at any level or

having served in relevant government departments or the military. The relevant data were taken from the CSMAR database and the enterprise's annual report. (2) Institutional distance (*institu*). This paper uses the Worldwide Governance Indicators (WGI) database to measure institutional quality and institutional gap. The index employs six institutional factors, including public discourse power and accountability system, political stability and elimination of violence and terrorism, government efficiency, supervision quality, rule of law level, and corruption control. We adopted the standardized Euclidean distance measurement method, the specific formula for which is as follows:

$$IDij = \sum_{n=1}^{6} \frac{(Inj - Dnj)^2}{vn} \quad (1)$$

$ID_{ij}$ represents the institutional difference between China and country *j*. $I_{ni}$ refers to China's score in category *N* institutional factors; $D_{nj}$ refers to the score of country *j* in the $n_{th}$ institutional factors; $V_n$ refers to the variance in each country's score in category *n* of institutional factors within the sample.

## Control variables

(1) Enterprise size (*scale*). Larger companies have more resources available to benefit from acquired R&D and carry out actual innovative business (Ahuja and Katila 2001). We used the logarithm of the company's annual sales revenue to measure the size of the enterprise, and the relevant data came from the CSMAR database. (2) Age of enterprise (*age*). Compared with older companies, young companies have less innovation inertia and are more prone to innovation commitment (Balasubramanian and Lee 2008). In line with Chen et al. (2012), we used the difference between the observation year and the company's registration year to measure the company's age. Relevant data were derived from the CSMAR database. (3) M&A experience (*MAexper*). Overseas experience can help enterprises reduce the uncertainty related to foreign investment (Johanson and Vahlne 1977), establish the learning curve effect, and thus facilitate green innovation. We defined the portion of cross-border M&A events that have occurred since the establishment of the enterprise as 1, and others as 0, to measure whether the enterprise has cross-border M&A experience. Relevant data were derived from the CSMAR database. (4) *TobinQ*. TobinQ is the ratio of the stock market's valuation of a company's assets to the cost of producing them. It determines whether an enterprise will invest in the market (Tobin 1969). A high *Q* value means that the enterprise will tend to expand the scale of its market investment, which may crowd out green innovation resources. We obtained the relevant data from the CSMAR database. (5) Price-to-sales ratio (*PSR*). The price-to-sales ratio reflects a company's business prospects and investment value. A low price-to-sales ratio reflects the stability and reliability of a company's income base and means that enterprises are more likely to carry out green innovation. The relevant data came from the RESSET database. (6) Economic freedom of the host country (*ecofr*). Economic freedom represents the development degree of a country's market economy. Countries with higher economic freedom are often better places for cross-border M&A to acquire knowledge resources, such as advanced technology and R&D (Tsang and Yip 2007). The data were derived from the Fraser Institute's report (2020). (7) Host country natural resources (*resouc*). Previous studies have shown that the abundance of natural resources in a host country is an important motivation for cross-border M&A (Ye 1992; Zhan 1995). When enterprises focus on investing in countries rich in natural resources, it means their production mode mainly depends on the input of large amounts of resources, instead of representing green production, which is thus not conducive to green innovation. We measure the abundance of natural resources in a country by the proportion of its oil, gas, and mineral exports to its total exports of goods. The relevant data were taken from the World Development Indicator (WDI) database.

## Model construction

We used the individual time dual fixed effects model. Because the characteristics of enterprises in different years are different, this paper, referring to Jaffe and Trajtenberg (2002), takes the year as a control variable to reduce the cross-year difference caused by such "truncation bias." At the same time, when the fact that there may be a time lag in the R&D investment was considered, the effectiveness may not have appeared in the current period but may gradually occur after a period of time, eventually affecting the innovation. Furthermore, since the dependent variable is green innovation and the independent variable is R&D investment, there may have been a two-way causal relationship between R&D investment and green innovation. In order to alleviate the time delay and endogeneity, in reference to Mohr et al. (2018) and Scalera et al. (2018), we delayed the core explanatory, moderator, and all control variables by one period.

Meanwhile, from the theoretical analysis, there may be an S-shaped relationship between R&D investment and green innovation after cross-border M&A. We further empirically tested whether the relationship between R&D investment and green innovation is nonlinear. The empirical results show that the significance and goodness of fit of the model increase when we successively added the quadratic and cubic independent variables. Therefore, the research model was developed as following:

**Table 1** Variable description table

| Variable | Obs | Mean | Std | Min | Max | Source |
|---|---|---|---|---|---|---|
| *lngip* | 230 | 0.745 | 1.117 | 0 | 6.449 | CNRDS |
| *RD* | 230 | 0.050 | 0.075 | 0 | 0.585 | CSMAR, CNRDS |
| *scale* | 230 | 217.164 | 14.655 | 180.954 | 264.162 | CSMAR |
| *age* | 230 | 14.739 | 5.607 | 3 | 34 | CSMAR |
| *MAexper* | 230 | 0.461 | 0.500 | 0 | 1 | CSMAR |
| *TobinQ* | 230 | 2.126 | 1.348 | 0.830 | 13.313 | CSMAR |
| *PSR* | 230 | 5.392 | 4.937 | 0.102 | 27.991 | RESSET |
| *ecofr* | 230 | 7.894 | 0.481 | 6.340 | 8.700 | Fraser Institute |
| *resouc* | 230 | 5.053 | 7.727 | 0.125 | 42.527 | WDI (World Development Indicator) |
| *pc* | 230 | 0.079 | 0.092 | 0 | 0.417 | CSMAR, corporate annual reports |
| *institu* | 230 | 130.613 | 51.988 | 3.905 | 250.251 | WGI (World Government Indicator) |

**Table 2** Variable correlation matrix

| | lngip | RD | scale | age | MAexper | TobinQ | PSR | ecofr | resouc | pc | institu | VIF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lngip | 1 | | | | | | | | | | | |
| RD | -0.012 | 1 | | | | | | | | | | 1 |
| scale | 0.398*** | -0.368*** | 1 | | | | | | | | | 1.16 |
| age | 0.077 | -0.151** | 0.294*** | 1 | | | | | | | | 1.17 |
| MAexper | -0.078 | 0.054 | -0.047 | -0.079 | 1 | | | | | | | 1.13 |
| TobinQ | -0.207*** | 0.323*** | -0.298*** | -0.100 | 0.193*** | 1 | | | | | | 1.17 |
| PSR | -0.271*** | 0.368*** | -0.602*** | -0.199*** | 0.122* | 0.555*** | 1 | | | | | 1.45 |
| ecofr | -0.048 | 0.109* | -0.094 | -0.200*** | 0.010 | 0.075 | 0.106 | 1 | | | | 1.40 |
| resouc | 0.147** | -0.089 | 0.079 | 0.036 | -0.020 | -0.110* | -0.113* | -0.070 | 1 | | | 1.36 |
| pc | 0.013 | 0.054 | -0.082 | -0.297*** | 0.031 | 0.014 | 0.037 | 0.061 | 0.074 | 1 | | 1.34 |
| institu | 0.034 | 0.159** | -0.085 | -0.359*** | 0.058 | -0.030 | 0.091 | 0.625*** | 0.075 | 0.261*** | 1 | 1.50 |

$$lngip_{i,t} = \alpha 0 + \alpha 1RD_{i,t-1} + \alpha 2RD^2{}_{i,t-1} + \alpha 3RD^3{}_{i,t-1} + \sum_k \alpha kcontrols_{i,t-1,k} + Year_{i,t} + Ind_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$\ln gipi,t = \alpha 0 + \beta 1RDi,t-1 + \beta 2RD^2 i,t-1 + \beta 3RD^3 i,t - 1 + \beta 4pci,t-1 + \beta 5RDi,t-1 \times pci,t-1 + \sum_k \beta kcontrolsi,t-1,k + Yeari,t + Indi,t + \varepsilon i,t \quad (3)$$

$$\ln gipi,t = \alpha 0 + \varphi 1RDi,t-1 + \varphi 2RD^2 i,t-1 + \varphi 3RD^3 i,t-1 + \varphi 4pci,t-1 + \varphi 5RDi,t-1 \times pci,t-1 + \varphi 6institui,t-1 + \varphi 7RDi,t-1 \times institui,t-1 + \sum_k \varphi kcontrolsi,t-1,k + Yeari,t + Indi,t + \varepsilon i,t \quad (4)$$

*i* refers to individual, *t* refers to time, and *controls* refers to control variables. Model 2 tests the relationship between R&D investment and green innovation. Model 3 is based on model 2 with the interaction term of R&D investment and political connection. Model 4 is based on model 3 with the interaction term of R&D investment and institutional distance.

## Results

### The process of the test

Table 1 describes the variables, Table 2 shows the variables' correlation, Table 3 shows the test results of the benchmark model, and Tables 4–6 show the robustness test results. It can be seen from Table 2 that the correlation coefficient between variables does not exceed 0.63. Meanwhile, we performed a variance inflation factor analysis, and the VIF value

**Table 3** Benchmark model test table

| Variables | m1 | m2 | m3 | m4 | m5 | m6 | m7 | m8 |
|---|---|---|---|---|---|---|---|---|
| | *lngip* | *lngip* | *lngip* | *lngip* | *lngip* | *lngip* | *lngip* | *lngip* |
| *RD* | | 0.057* | −0.075* | −0.110*** | −0.109*** | −0.099** | −0.098** | −0.126*** |
| | | (0.029) | (0.041) | (0.039) | (0.041) | (0.047) | (0.048) | (0.038) |
| $RD^2$ | | | 0.002*** | 0.018*** | 0.019*** | 0.018*** | 0.018*** | 0.009 |
| | | | (0.000) | (0.005) | (0.006) | (0.006) | (0.006) | (0.006) |
| $RD^3$ | | | | −0.0002*** | −0.0003*** | −0.0002*** | −0.0003*** | −0.0001 |
| | | | | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *pc* | | | | | −0.020 | −0.024 | −0.034** | −0.056*** |
| | | | | | (0.019) | (0.019) | (0.016) | (0.017) |
| *institu* | | | | | | 0.002 | 0.001 | −0.003 |
| | | | | | | (0.004) | (0.003) | (0.004) |
| $RD \times pc$ | | | | | | | −0.006* | −0.012*** |
| | | | | | | | (0.003) | (0.003) |
| $RD \times institu$ | | | | | | | | −0.003** |
| | | | | | | | | (0.001) |
| *scale* | 0.077*** | 0.095*** | 0.078*** | 0.078*** | 0.085*** | 0.089*** | 0.072*** | 0.078*** |
| | (0.020) | (0.020) | (0.019) | (0.020) | (0.018) | (0.019) | (0.023) | (0.020) |
| *age* | −0.610 | −0.374 | −0.708 | −0.657 | −0.679* | −0.738 | −0.458 | −0.501 |
| | (0.530) | (0.501) | (0.472) | (0.408) | (0.407) | (0.450) | (0.500) | (0.485) |
| *MAexper* | 0.705*** | 0.547*** | 0.589*** | 0.546*** | 0.566*** | 0.610*** | 0.610*** | 0.638*** |
| | (0.195) | (0.202) | (0.178) | (0.155) | (0.156) | (0.198) | (0.201) | (0.173) |
| *TobinQ* | −0.317*** | −0.296*** | −0.369*** | −0.368*** | −0.375*** | −0.376*** | −0.360*** | −0.448*** |
| | (0.101) | (0.102) | (0.099) | (0.082) | (0.074) | (0.075) | (0.084) | (0.081) |
| *PSR* | 0.122*** | 0.134*** | 0.178*** | 0.178*** | 0.161*** | 0.146*** | 0.158*** | 0.231*** |
| | (0.043) | (0.045) | (0.045) | (0.039) | (0.032) | (0.039) | (0.035) | (0.059) |
| *ecofr* | 0.008* | 0.006 | 0.007** | 0.009*** | 0.010*** | 0.010*** | 0.007** | 0.006** |
| | (0.004) | (0.004) | (0.003) | (0.003) | (0.002) | (0.002) | (0.003) | (0.003) |
| *resouc* | −0.050*** | −0.048*** | −0.058*** | −0.064*** | −0.077*** | −0.085*** | −0.067*** | −0.073*** |
| | (0.015) | (0.017) | (0.016) | (0.012) | (0.011) | (0.021) | (0.019) | (0.020) |
| Constant | −11.055 | −18.705** | −9.254 | −11.895* | −13.757** | −13.546** | −13.140* | −12.037* |
| | (8.202) | (7.267) | (6.725) | (6.585) | (6.580) | (6.648) | (7.133) | (6.144) |
| Observations | 230 | 229 | 229 | 229 | 229 | 229 | 229 | 229 |
| *R*-squared | 0.778 | 0.797 | 0.845 | 0.867 | 0.873 | 0.875 | 0.886 | 0.908 |
| Adj *R*-squared | 0.762 | 0.781 | 0.831 | 0.854 | 0.861 | 0.862 | 0.873 | 0.898 |
| *F* | 29.02 | 26.52 | 147.6 | 2010 | 3739 | 1871 | 1206 | 33,185 |
| Id FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *F* test | 3.28 | 3.21 | 3.89 | 4.05 | 3.53 | 3.88 | 3.40 | 3.72 |
| *LM* test | 6.47 | 4.42 | 4.27 | 3.55 | 3.50 | 3.50 | 3.34 | 3.33 |
| Hausman test | 29.98 | 30.03 | 35.17 | 37.32 | 36.55 | 35.86 | 36.31 | 37.64 |

Robust standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

was found to be between 1.13 and 1.50, which is far below the defined minimum critical value of 5 (O'Brien 2007). Therefore, we speculated that there is no serious multicollinearity problem between variables. Since panel data can more effectively solve the problem of omission variable bias, which does not change over time, they help to reduce endogeneity (Wooldridge 2002). We used panel data to test the model. First, we conducted an *F* test on the data model, whose null hypothesis is $u_i = 0$. The test results of each model strongly reject the null hypothesis and allow individuals to have their own intercept term. Therefore, fixed effect should be used over mixed effect. The LM test rejects the null hypothesis that "there is no individual random effect," so we chose the random effect model over mixed regression.

The Hausman test strongly rejects the null hypothesis that $u_i$ is not correlated with $x_{it}$ and $z_i$, and the fixed effect model should be selected over random effects. The relevant results are shown in Table 3.

In addition, the variables involved in the interaction term are mean-centered to further reduce possible multicollinearity. We also performed a 1% tail reduction for continuous variables to reduce the estimation variable deviation caused by extreme values.

## The main results

As shown in Table 3, model 1 tests all control variables, and models 2–4 are the test models of the relationship between the core independent variable and the parent company's green innovation performance, after adding the core independent variable R&D input, the square term of R&D input, and the cubic term of R&D input, respectively. On the basis of model 4's results, political connection and institutional distance are gradually added into model 5 and model 6 as control variables. Model 7 examines the interaction between political connection and R&D investment. Model 8 tests the interaction between institutional distance and R&D investment.

According to model 1, enterprise size, cross-border M&A experience, and the economic freedom of the host country have positive effects on the enterprise's green innovation performance[1] ($\beta = 0.077$, $p < 0.01$; $\beta = 0.705$, $p < 0.01$; $\beta = 0.008$, $p < 0.1$). Meanwhile, TobinQ and the resources of the host country have a negative and significant impact on green innovation ($\beta = -0.317$, $p < 0.01$; $\beta = -0.050$, $p < 0.01$). It is noteworthy that the influence of enterprise age on the green innovation performance of enterprises after M&A is negative but not significant ($\beta = -0.610$, $p > 0.1$), indicating that although young enterprises are more flexible and have less innovation inertia and greater exploratory spirit (Balasubramanian and Lee 2008), older enterprises may have more complete rules and regulations and richer management experience (Chen et al. 2012; Huergo and Jaumandreu 2004). Price-to-sales ratio has a positive and significant promotional effect on enterprises' green innovation, indicating that in our sample, those companies with unstable returns tend towards green innovation, which may be because cross-border M&A causes volatility in enterprises' returns (Lee and Caves 1998) but promotes their green innovation.

It can be seen from models 2–4 that the impact of R&D investment on an enterprise's green innovation adopts the shape of an "S." In model 3, the impact of a single item of R&D investment on enterprise green innovation is negative and significant ($\beta = -0.075$, $p < 0.1$), and the square item has a positive significant impact ($\beta = 0.002$, $p < 0.01$). This proves that the relationship between R&D investment and green innovation is nonlinear. Furthermore, after the cubic term of R&D input is added into model 4, the square term and cubic term have negative, positive, and significant negative promotional effects on green innovation, respectively. This indicates that lower R&D investment is not conducive to the green innovation of enterprises (Rosell-Martínez and Sánchez-Sellero, 2011). With the gradual increase in R&D investment, the green innovation performance of enterprises increases and then gradually declines. Hypothesis 1 has thus been confirmed.

When we added political connection and institutional distance as control variables into model 5 and model 6, the goodness of fit of the model increased ($R^2$ increased from 0.873 to 0.875). In model 7, political connection has a negative and significant impact on the relationship between R&D investment and green innovation ($\beta = -0.006$, $p < 0.1$), which means that when R&D investment is low, political affiliation can bring more policy, capital, and information support to enterprises (Boddewyn 1988; Bonardi et al. 2005; Rodriguez et al. 2005). Political connection moderates the negative effect of R&D investment on green innovation in the initial stage of cross-border M&A; when the R&D investment of enterprises is high, they pay a large amount in return costs for the government funding of R&D resources, crowding out green innovation resources. Political association is not conducive to the relationship between the R&D investment and green innovation of enterprises. Finally, when enterprises face R&D redundancy, political connection can help them pursue new innovative directions and projects (Li et al. 2014; Sun et al. 2016); therefore, the adverse impact of R&D redundancy on enterprise green innovation might be alleviated. Thus, hypothesis 2 is confirmed. In model 8, institutional distance has a negative and significant impact on the relationship between R&D investment and green innovation in enterprises ($\beta = -0.003$, $p < 0.05$), indicating that although institutions in mature markets help to protect the green R&D of M&A enterprises, large institutional distances restrict the absorption of green and cutting-edge technologies by emerging market enterprises, which is alleviated with the continuous increase in R&D investment and the improvement in absorptive capacity. Hypothesis 3 is thus confirmed.

Figure 1 shows the effects of R&D invest on the green innovation of enterprises. As hypothesized in our study, the *RD-lngip* curve is S-shaped, which in the beginning decreases at a lower rate but then increases at a faster rate as R&D invest increases. However, *lngip* stops and the *RD-lngip* curve decrease gradually at a higher level of R&D invest; this further proves hypothesis 1. Figure 2 shows the

[1] Corresponding to the significance level in the tables, we set three significance levels of 10%, 5%, and 1%.

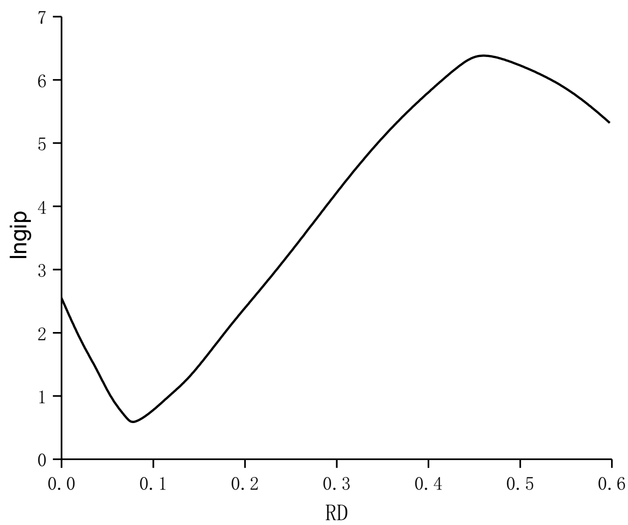


**Fig. 1** Main effects

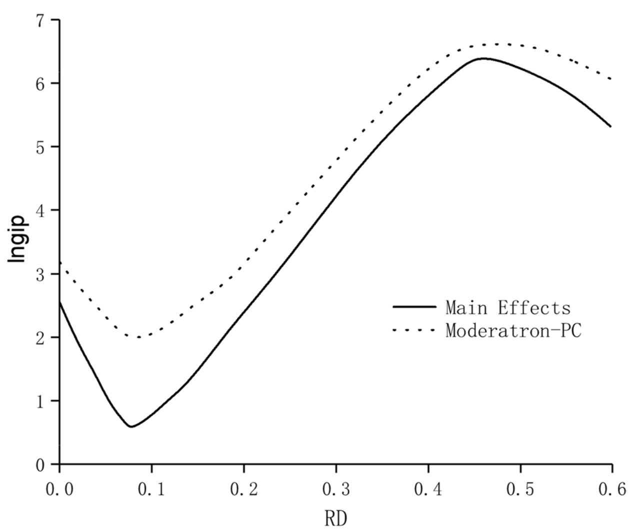


**Fig. 2** Moderating effects of *pc*

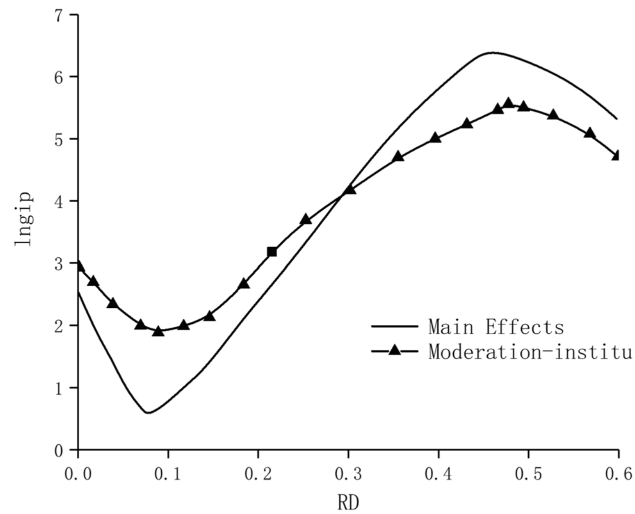


**Fig. 3** Moderating effects of *institu*

interaction term of R&D investment and political connection of enterprises; compared with the main effects, enterprises with low R&D invest would have higher green innovation before the first inflection point, and enterprises with high R&D invest would have decreasing green innovation growth after this inflection point; similarly, when the R&D invest increases to the second inflection point, the decline in green innovation growth has been more gradual compared with the main effect, which confirms hypothesis 2. As shown in Fig. 3, the relationship between R&D invest and green innovation is complicated because there is an intersection point between the two lines, but we can still see that, in the effect of institutional distance, the *RD-institu* curve of moderation becomes more gentle compared with Fig. 2, which is consistent with hypothesis 2.

## Robust tests

Tables 4–6 are robustness test tables, which we put in the Appendix, and the test sequence of each is consistent with the benchmark model. Green patent application includes green invention patents, green practical patents, and green design patents. Among these, green invention patents contain more green cutting-edge technologies and are the most innovative. Therefore, the number of green invention patent applications (*lngipa*) was used as a substitute variable for the number of green patent applications when testing each model again. Since this variable involves a large amount of 0 values, we added 1 to it to take the logarithm, as introduced by Wooldridge (2002). As shown in Table 4, the coefficient for R&D investment of linear terms on green innovation remains negatively significant ($\beta = -0.077$, $p < 0.01$), the coefficient of quadratic term remains positively significant ($\beta = 0.012$, $p < 0.01$), and the coefficient of cubic term remains negatively significant ($\beta = -0.0002$, $p < 0.01$), thus supporting the hypotheses. When the interaction between political connection and green innovation was added to the model, the direction and the statistical significance remains unchanged ($\beta = -0.004$, $p < 0.1$). Moreover, when the interaction between institution distance and green innovation was added to the model, the direction and the statistical significance remains unchanged ($\beta = -0.002$, $p < 0.05$).

Since previous literature has used 10% ownership as the requirement for equity investment in a foreign enterprise (Cho 1999; Thomas et al. 2007; Xu et al. 2020), the rationale for this threshold is in for acquiring enterprises with less than 10% ownership, they are less likely to exert significant influence. As a result, we retested the models by excluding the samples with less than 10% ownership. As shown in Table 5, the result of a robust test with sampling criteria changes remains consistent with our hypothesis testing. Although the regression coefficients change slightly, they are not significantly different from our original sample. The results show that coefficient for R&D investment of linear term is negatively significant on green innovation ($\beta = -0.108$, $p < 0.01$), the coefficient of quadratic term is positively significant ($\beta = 0.014$, $p < 0.01$), the coefficient of cubic term is negatively significant ($\beta = -0.0002$, $p < 0.01$), the coefficient of the interaction term between R&D investment and political connection is negative and significant ($\beta = -0.006$, $p < 0.05$), and the coefficient of the interaction term between R&D investment and institutional distance is negative and significant ($\beta = -0.002$, $p < 0.1$), and thus, the test result of the benchmark test was still robust when the sample selection criteria were changed.

Meanwhile, the consistent covariance matrix estimation method is more robust for heteroskedasticity and autocorrelation problems. Its sample size is not limited, and it is more efficient than the fixed effect model and robust standard error (Beck and Katz 1995; Driscoll and Kraay 1998). Given that we used fixed effect models and clustering of robust standard errors in the benchmark model, in order to better solve the heteroscedasticity problems in the samples, we used the consistent covariance matrix estimation method to test the samples simultaneously and prove the robustness of the results. The results show that the coefficients remain the same with the benchmark test and the significance changes slightly in terms of the relationship between R&D investment and green innovation after cross-border M&A (from $p < 0.01$ in Table 3 to $p < 0.05$ in Table 6). However, it still remains significant at the level of 5%, and the coefficient of interaction between R&D investment and political connection becomes more significant (from $p < 0.1$ in Table 3 to $p < 0.01$ in Table 6). Similarly, the coefficient between R&D investment and institutional distance also becomes more significant (from $p < 0.05$ in Table 3 to $p < 0.01$ in Table 6), which further proves the robustness of the conclusion, the results of which are shown in Table 6. The test results in Tables 4, 5, and 6 are consistent with those of the benchmark model, proving its reliability.

## Conclusion and discussion

### Conclusions

R&D expenditure plays a crucial role in the manufacturing of environmental products, the application of green technology, and the promotion of green innovation in enterprises (Fujii and Managi 2019). The green innovation of enterprises in emerging markets requires not only their own R&D investment, but also the help of mature markets (Feng et al. 2018; Hao et al. 2020; Wu and Qu 2021).

The previous literature has mainly focused on the impact of enterprises' own R&D on green innovation (Fujii and Managi 2019), ignoring the strong motivation of enterprises in emerging markets to actively acquire green innovation technologies in mature markets. Based on previous studies, against the background of cross-border M&A, we have discussed the impact of R&D investment on the green innovation of enterprises. Our research finds that the impact of R&D investment on the green innovation of enterprises after cross-border M&A adopts an "S" shape. Compared with the M&A between mature markets, cross-border M&A in emerging markets may produce more cognitive costs, transaction costs, and organizational integration costs. These costs often crowd out innovation resources. Therefore, some enterprises invest less in R&D, which affects the accumulation of knowledge resources and the improvement of the absorptive capacity of enterprises (Cohen and Levinthal 1990). Either because the strategic goal of cross-border M&A is to acquire advanced technology in mature markets or because the integration of various resources during the M&A period often enters a relatively stable stage, enterprises invest more in R&D after cross-border M&A. This increased R&D investment helps enterprises absorb diversified and heterogeneous green innovation knowledge, so as to improve their green innovation performance. When the R&D investment of enterprises remains at a high level, due to the large quantity of R&D resources in a single technology field, R&D redundancy is generated, which is not conducive to green innovation.

Differently from the previous literature, which focuses on the spillover of green technology from foreign investment into emerging markets (Eskeland and Harrison, 2003; Hao et al. 2020), the green technologies acquired via cross-border M&A emerge in different institutional environments and with different stakeholders from their home countries, and it is thus difficult to make full use of their own institutional advantages (such as political connections). This paper finds that with differences in R&D investment, the effect of the relationship between political connection and institutional distance on R&D investment and green innovation varies greatly.

### Theoretical implications

First, based on the special background of cross-border M&A in emerging markets, this paper studies the effect of R&D on green innovation, which is a supplement to innovation literature. As emerging markets enter a new stage of economic development, the harmonious relationship between nature and productive forces depends on the progress of green technology. Cross-border M&A is not only an important means for enterprises to acquire technology, but is also an important means for enterprises to obtain green innovation resources. In this context, the promotional effect of R&D on green innovation is extremely complex. This paper analyzes the internal mechanism of this effect and fills the gap in the innovation literature and international business theory.

Second, this paper divides the R&D investment of cross-border M&A into three states. Most previous studies have stated that the impact of R&D on enterprise green innovation is linear (Horbach 2008; Rosell-Martínez and Sánchez-Sellero 2011), lacking systematic analysis. This paper studies the promotional effect of R&D on enterprises' green innovation with three levels of R&D investment, which supplements previous literature on the relationship between R&D and green innovation.

Third, this paper systematically studies the effect of political connection and institutional distance on the relationship between R&D and green innovation in the context of cross-border M&A. Most existing studies have paid attention to the promotional effect of foreign technology spillover on the green innovation of enterprises in host countries (Eskeland and Harrison, 2003; Luo et al. 2021). However, few systematic analyses have been performed on the mechanisms and conditions of enterprises' active acquisition of green technology under the condition of cross-border M&A. Political connection and institutional distance affect enterprises' acquisition of knowledge resources from home and host countries. This paper argues that enterprises' acquisition of external resources is influenced by a series of stakeholders. Political connection and institutional distance play a crucial role in the process of green innovation.

Fourth, this paper combines the knowledge-based view and stakeholder theory to analyze the acquisition process of green technology and places enterprise R&D and green innovation performance after cross-border M&A, political connection, and institutional distance into a unified analytical framework. This enables a more comprehensive understanding of the process of green technology acquisition and the realization of green innovation in emerging markets, which not only enriches the theory of international investment, but also expands the knowledge base. In the process of acquiring external knowledge, enterprises in emerging markets are inevitably affected by a series of stakeholders, which includes not only the host country's stakeholders, but also domestic stakeholders, resulting in the interaction between the two. This paper broadens the boundaries of the knowledge-based view.

## Managerial implications

The findings of this study have important implications for practitioners.

In the early stage of cross-border M&A, enterprises lack various resources. Politically connected enterprises can turn to their home country's government and financial institutions for direct subsidies and loan financing. Meanwhile, they must also seek help from stakeholders in the host country, such as the host country's government, suppliers, research institutes, and consulting institutions. It is necessary to understand not only the development trend of green innovation technology in the host country, but more importantly, its system norms and value culture. For example, given stricter intellectual property right protection systems, more detailed legal norms for green production, and customers' pursuit of green ideas, enterprises have to strive to reduce the initial resistance and costs of cross-border M&A.

When R&D investment is large, the enterprise must consider the threshold of the promotional effect of R&D investment on green innovation. Since the enterprise will have focused on R&D innovation rather than post-merger resource integration at this stage, it is more necessary to coordinate the relationship between stakeholders related to green innovation. For example, the enterprise can employ meetings, training, team building exercises, and other means to strengthen communication between R&D team members and between R&D personnel and managers and other staff, so as to reduce the obstacles to knowledge transfer caused by the institutional distance between home country and host country.

When enterprises continue to increase their R&D investment, they should try to avoid organizational redundancy, disperse green innovation goals, and prevent the waste of green innovation resources. Green technology is more complex than other technologies. For example, the green manufacturing process of enterprises may involve multiple technical fields, such as cyclic production, energy-saving technology, mechanical automation, and information systems. Enterprises can devote R&D resources to multiple technological areas while responding to the call of their home governments for new green innovation projects.

## Limits and future prospects

This paper has three main shortcomings: First, we collected 230 cross-border M&A events from 2006 to 2019, using the data of listed companies provided by CSMAR. In the future, as time goes by and sample databases are further improved, we expect to collect more samples for the further research. Second, this paper studies the mechanism of influence of R&D on green innovation under the condition of cross-border M&A and discusses the roles of political connection and institutional distance.

In the future, other conditions affecting R&D and green innovation in the process of cross-border M&A could be explored. Third, this paper is based on a sample of Chinese cross-border M&A enterprises; whether its conclusions can be extended to India, Brazil, and other emerging markets remains to be discussed.

# Appendix

**Table 4** Robustness test of the dependent variable replaced

| Variables | m1 | m2 | m3 | m4 | m5 | m6 | m7 | m8 |
|---|---|---|---|---|---|---|---|---|
| | *lngipa* | *lngipa* | *lngipa* | *lngipa* | *lngipa* | *lngipa* | *lngipa* | *lngipa* |
| *RD* | | 0.040* | −0.053* | −0.077*** | −0.076*** | −0.069** | −0.068** | −0.088*** |
| | | (0.021) | (0.029) | (0.028) | (0.029) | (0.033) | (0.033) | (0.027) |
| $RD^2$ | | | 0.001*** | 0.012*** | 0.013*** | 0.013*** | 0.013*** | 0.006 |
| | | | (0.000) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) |
| $RD^3$ | | | | −0.0002*** | −0.0002*** | −0.0002*** | −0.0002*** | −0.000 |
| | | | | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *pc* | | | | | −0.014 | −0.017 | −0.023** | −0.039*** |
| | | | | | (0.013) | (0.013) | (0.011) | (0.012) |
| *institu* | | | | | | 0.001 | 0.001 | −0.002 |
| | | | | | | (0.003) | (0.002) | (0.002) |
| *RD*×*pc* | | | | | | | −0.004* | −0.009*** |
| | | | | | | | (0.002) | (0.002) |
| *RD*×*institu* | | | | | | | | −0.002** |
| | | | | | | | | (0.001) |
| *scale* | 0.054*** | 0.066*** | 0.055*** | 0.054*** | 0.059*** | 0.062*** | 0.050*** | 0.054*** |
| | (0.014) | (0.014) | (0.013) | (0.014) | (0.013) | (0.013) | (0.016) | (0.014) |
| *age* | −0.425 | −0.261 | −0.494 | −0.458 | −0.474* | −0.515 | −0.320 | −0.349 |
| | (0.370) | (0.349) | (0.330) | (0.285) | (0.284) | (0.314) | (0.349) | (0.338) |
| *MAexper* | 0.492*** | 0.381*** | 0.411*** | 0.381*** | 0.395*** | 0.426*** | 0.426*** | 0.445*** |
| | (0.136) | (0.141) | (0.124) | (0.108) | (0.109) | (0.138) | (0.140) | (0.121) |
| *TobinQ* | −0.221*** | −0.206*** | −0.257*** | −0.257*** | −0.261*** | −0.262*** | −0.251*** | −0.312*** |
| | (0.070) | (0.071) | (0.069) | (0.057) | (0.052) | (0.052) | (0.058) | (0.056) |
| *PSR* | 0.085*** | 0.093*** | 0.124*** | 0.124*** | 0.112*** | 0.102*** | 0.110*** | 0.161*** |
| | (0.030) | (0.031) | (0.031) | (0.027) | (0.023) | (0.027) | (0.024) | (0.041) |
| *ecofr* | 0.005* | 0.004 | 0.005** | 0.006*** | 0.007*** | 0.007*** | 0.005** | 0.004** |
| | (0.003) | (0.003) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| *resouc* | −0.035*** | −0.033*** | −0.040*** | −0.045*** | −0.053*** | −0.059*** | −0.047*** | −0.051*** |
| | (0.011) | (0.012) | (0.011) | (0.009) | (0.008) | (0.014) | (0.013) | (0.014) |
| Constant | −7.723 | −13.051** | −6.457 | −8.300* | −9.599** | −9.452** | −9.168* | −8.398* |
| | (5.721) | (5.070) | (4.692) | (4.595) | (4.591) | (4.638) | (4.977) | (4.287) |
| Observations | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 |
| *R*-squared | 0.778 | 0.797 | 0.845 | 0.867 | 0.873 | 0.875 | 0.886 | 0.908 |
| Adj *R*-squared | 0.761 | 0.781 | 0.831 | 0.854 | 0.861 | 0.862 | 0.873 | 0.898 |
| *F* | 29.01 | 26.52 | 147.6 | 2010 | 3739 | 1871 | 1206 | 33,185 |
| Id FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

**Table 5** Sampling criteria of less than 10% equity deleted

| Variables | m1<br>*lngip* | m2<br>*lngip* | m3<br>*lngip* | m4<br>*lngip* | m5<br>*lngip* | m6<br>*lngip* | m7<br>*lngip* | m8<br>*lngip* |
|---|---|---|---|---|---|---|---|---|
| *RD* | | 0.053* | −0.081** | −0.108*** | −0.108*** | −0.094*** | −0.093*** | −0.113*** |
| | | (0.029) | (0.037) | (0.032) | (0.034) | (0.035) | (0.035) | (0.032) |
| $RD^2$ | | | 0.002*** | 0.014*** | 0.016*** | 0.015*** | 0.015*** | 0.010* |
| | | | (0.000) | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| $RD^3$ | | | | −0.0002*** | −0.0002*** | −0.0002** | −0.0002*** | −0.0001 |
| | | | | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| *pc* | | | | | −0.017 | −0.022 | −0.031*** | −0.046*** |
| | | | | | (0.016) | (0.015) | (0.011) | (0.011) |
| *institu* | | | | | | 0.003 | 0.002 | −0.001 |
| | | | | | | (0.003) | (0.003) | (0.004) |
| *RD×pc* | | | | | | | −0.006** | −0.010*** |
| | | | | | | | (0.003) | (0.003) |
| *RD×institu* | | | | | | | | −0.002* |
| | | | | | | | | (0.001) |
| *scale* | 0.068*** | 0.085*** | 0.068*** | 0.069*** | 0.075*** | 0.080*** | 0.063*** | 0.069*** |
| | (0.019) | (0.017) | (0.017) | (0.017) | (0.016) | (0.016) | (0.019) | (0.019) |
| *age* | −0.658 | −0.439 | −0.777 | −0.729* | −0.744* | −0.821* | −0.538 | −0.546 |
| | (0.535) | (0.500) | (0.476) | (0.427) | (0.427) | (0.474) | (0.524) | (0.502) |
| *MAexper* | 0.776*** | 0.627*** | 0.671*** | 0.628*** | 0.641*** | 0.699*** | 0.699*** | 0.695*** |
| | (0.180) | (0.181) | (0.159) | (0.150) | (0.154) | (0.202) | (0.205) | (0.188) |
| *TobinQ* | −0.294*** | −0.275*** | −0.348*** | −0.350*** | −0.356*** | −0.357*** | −0.341*** | −0.403*** |
| | (0.100) | (0.102) | (0.096) | (0.083) | (0.078) | (0.078) | (0.090) | (0.077) |
| *PSR* | 0.132*** | 0.142*** | 0.187*** | 0.186*** | 0.172*** | 0.153*** | 0.165*** | 0.211*** |
| | (0.040) | (0.041) | (0.041) | (0.036) | (0.031) | (0.036) | (0.032) | (0.052) |
| *ecofr* | 0.008** | 0.007* | 0.007*** | 0.009*** | 0.010*** | 0.009*** | 0.007** | 0.006** |
| | (0.004) | (0.004) | (0.003) | (0.003) | (0.002) | (0.002) | (0.003) | (0.003) |
| *resouc* | −0.055*** | −0.053*** | −0.063*** | −0.068*** | −0.078*** | −0.088*** | −0.070*** | −0.073*** |
| | (0.014) | (0.014) | (0.012) | (0.009) | (0.009) | (0.019) | (0.017) | (0.018) |
| Constant | −8.314 | −15.443** | −5.892 | −8.354 | −10.017 | −9.668 | −9.220 | −9.361 |
| | (8.300) | (7.308) | (6.550) | (6.165) | (6.213) | (6.192) | (6.578) | (5.998) |
| Observations | 215 | 215 | 215 | 215 | 215 | 215 | 215 | 215 |
| *R*-squared | 0.817 | 0.833 | 0.881 | 0.895 | 0.899 | 0.902 | 0.913 | 0.921 |
| Adj *R*-squared | 0.803 | 0.819 | 0.871 | 0.885 | 0.889 | 0.892 | 0.903 | 0.911 |
| *F* | 225.4 | 109.9 | 197.5 | 3146 | 2736 | 3923 | 6535 | 7878.26 |
| Id FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

**Table 6** Robustness test of test method replaced

| Variables | m1 | m2 | m3 | m4 | m5 | m6 | m7 | m8 |
|---|---|---|---|---|---|---|---|---|
| | *lngip* | *lngip* | *lngip* | *lngip* | *lngip* | *lngip* | *lngip* | *lngip* |
| *RD* | | 0.057** | −0.075 | −0.110** | −0.109** | −0.099* | −0.098* | −0.126** |
| | | (0.025) | (0.048) | (0.051) | (0.048) | (0.052) | (0.055) | (0.000) |
| $RD^2$ | | | 0.002*** | 0.018** | 0.019** | 0.018** | 0.018** | 0.009 |
| | | | (0.000) | (0.007) | (0.008) | (0.008) | (0.007) | (0.008) |
| $RD^3$ | | | | −0.0002** | −0.0003** | −0.0002* | −0.0003** | −0.0001 |
| | | | | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *pc* | | | | | −0.020 | −0.024 | −0.034** | −0.056*** |
| | | | | | (0.017) | (0.016) | (0.014) | (0.003) |
| *institu* | | | | | | 0.002 | 0.001 | −0.003 |
| | | | | | | (0.003) | (0.002) | (0.002) |
| *RD*×*pc* | | | | | | | −0.006*** | −0.012*** |
| | | | | | | | (0.002) | (0.002) |
| *RD*×*institu* | | | | | | | | −0.003*** |
| | | | | | | | | (0.001) |
| *scale* | 0.077*** | 0.095*** | 0.078*** | 0.078*** | 0.085*** | 0.089*** | 0.072*** | 0.078*** |
| | (0.021) | (0.014) | (0.011) | (0.014) | (0.010) | (0.010) | (0.010) | (0.009) |
| *age* | −1.210*** | −1.388*** | −1.210*** | −1.302*** | −1.425*** | −1.473*** | −1.171*** | −1.153*** |
| | (0.239) | (0.189) | (0.167) | (0.147) | (0.152) | (0.122) | (0.155) | (0.137) |
| *MAexper* | 0.705** | 0.547** | 0.589*** | 0.546*** | 0.566*** | 0.610*** | 0.610*** | 0.638*** |
| | (0.242) | (0.212) | (0.191) | (0.126) | (0.126) | (0.145) | (0.146) | (0.133) |
| *TobinQ* | −0.317*** | −0.296*** | −0.369*** | −0.368*** | −0.375*** | −0.376*** | −0.360*** | −0.448*** |
| | (0.045) | (0.048) | (0.058) | (0.048) | (0.042) | (0.041) | (0.042) | (0.022) |
| *PSR* | 0.122*** | 0.134*** | 0.178*** | 0.178*** | 0.161*** | 0.146*** | 0.158*** | 0.231*** |
| | (0.039) | (0.026) | (0.032) | (0.028) | (0.024) | (0.027) | (0.027) | (0.029) |
| *ecofr* | 0.008*** | 0.006*** | 0.007*** | 0.009*** | 0.010*** | 0.010*** | 0.007* | 0.006* |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.003) | (0.003) | (0.004) | (0.003) |
| *resouc* | −0.050*** | −0.048*** | −0.058*** | −0.064*** | −0.077*** | −0.085*** | −0.067*** | −0.073*** |
| | (0.010) | (0.011) | (0.010) | (0.008) | (0.013) | (0.015) | (0.011) | (0.010) |
| Observations | 229 | 229 | 229 | 229 | 229 | 229 | 229 | 229 |
| *R*-squared | 0.778 | 0.797 | 0.845 | 0.867 | 0.873 | 0.875 | 0.886 | 0.908 |
| *F* | 312.6 | 740.5 | 1716 | 318.0 | 358.6 | 1559 | 256.2 | 145.9 |
| Id FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses. ***$p<0.01$, **$p<0.05$, * $p<0.1$

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**Data availability** The datasets analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

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