*Original Research*

# Sustainable Development: R&D Internationalization and Innovation

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## Abstract

R&D internationalization is an important way for enterprises in emerging economies to achieve technology catch-up and maintain sustainable development. The direct relationship between R&D internationalization and innovation performance has been widely explored, but the research on the influence of the mechanism between these two elements above is relatively less. This paper takes China's knowledge-intensive listed enterprises from 2009 to 2015 as the research object and uses Poisson fixed effect regression, hierarchical regression, and bootstrap methods to study the mechanism of knowledge base between enterprise R&D internationalization and innovation performance and the moderating effects of institutional distance on the mechanism effect. The results show that: (1) Enterprises' innovation performance can be promoted with the increase of R&D internationalization degree and diversity. (2) Knowledge Base (scope and entropy) plays a  mechanism function between R&D internationalization and innovation performance. (3) By negatively moderating the relationship between the knowledge base and innovation performance, the institutional distance between home and host country negatively moderates the knowledge base's mechanism function.

## Introduction

Sustainable development requires coordinated development of the economy, society, resources, and environmental protection [1-2]. R&D internationalization is an important channel for the sustainable development of enterprises. In 2022, the report of the 20th National Congress of the Communist Party of China stressed that "we adhere to sustainable development, unswervingly follow the path of civilized development featuring development in production, prosperity and good ecology, and realize the sustainable development of the Chinese nation." And the report also stressed that need to "deeply participate in the global industrial division and cooperation, and maintain a diversified and stable international economic pattern and economic and trade relations." China is constantly increasing its foreign direct investment as an essential driving force of economic globalization. According to the Statistical Bulletin of China's Foreign Direct Investment 2021, the total amount of China's foreign direct investment in 2021 will be 178.82 billion US

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dollars, with a growth of 16.3%, ranking third in the world. The continuous rise of foreign direct investment has made the connection between Chinese multinational enterprises and the international market. It improved the availability of foreign knowledge and technology and promoted more and more Chinese multinational enterprises to carry out international R&D activities to win the technological competition and obtain new market competitive advantages. According to the Directory of Overseas Investment Enterprises (Institutions), Chinese multinational enterprises implemented 2745 R&D internationalization projects in 2015, an increase of 1806% compared with 152 projects in 2006. Therefore, how to successfully carry out R&D internationalization activities to improve the innovation performance of enterprises has become the focus of government and enterprises.

Does R&D internationalization improve the innovation performance of Chinese enterprises? There are different views in existing studies. The mainstream view mostly supports that R&D internationalization has a positive impact on innovation, believing that R&D internationalization can improve innovation performance by using heterogeneous knowledge sources and location advantages [3]. Some studies believe that R&D internationalization has a negative impact on innovation as the disadvantages of outsiders and newcomers in the internationalization process will cause additional costs [4]. The latest research puts forward the possible nonlinear relationship between R&D internationalization and innovation performance and draws some nonlinear conclusions such as U-shaped, inverted U-shaped, and S-shaped [5]. In view of the different conclusions on the relationship between R&D internationalization and innovation performance, scholars further explored the moderating effect of relevant situational factors on the relationship between them. Li, et al. (2021) [6] found that market competition will have a moderating effect on the relationship between R&D internationalization and innovation. Sommer and Bhandari (2022) [7] found that experience in conducting R&D internationally will adjust the relationship between their R&D internationalization and innovation performance. Hsu, et al. (2015) [8] research found that a firm's foreign expansion experience positively moderates the relationship between R&D internationalization and innovation performance [9]. Ferraris, et al. (2021) [3] research found that knowledge management can positively moderate the relationship between R&D internationalization and innovation performance [10]. However, the specific mechanism of R&D internationalization on enterprise innovation performance has not been paid much attention to in the past. These studies demonstrate that R&D internationalization promotes the acquisition and absorption of external knowledge by multinational enterprises and then directly equates knowledge with innovation performance without explaining how knowledge is further transformed into enterprise

innovation performance [9]. Or directly analyze the impact of R&D internationalization on innovation performance without any discussion and exploration of the "black box" between internationalization and innovation capability performance in the R&D process.

How does R&D internationalization affect enterprise innovation performance? From the perspective of knowledge, enterprises can obtain advanced foreign knowledge through R&D internationalization. On the one hand, this expands the scale of enterprise knowledge. On the other hand, enterprise knowledge diversification has also been improved [10]. Some scholars have found that R&D internationalization helps enterprises identify, absorb and integrate external knowledge of enterprises, improves the efficiency of knowledge flow between parent companies and subsidiaries, and has a positive impact on the scale and diversity of enterprise knowledge base [9]. The expansion of enterprise knowledge base scale and the improvement of diversity are also sources of enterprise innovation. Therefore, this paper intends to introduce the knowledge base as a mechanism variable to explore the deeper mechanism of R&D internationalization to innovation and reveal the internal structure of the "black box."

R&D internationalization may affect the innovation performance of enterprises by improving their knowledge base, and this process may be affected by institutional factors. More and more studies have found that institutional scenarios will affect the efficiency of knowledge sharing and the innovation willingness of knowledge owners and then affect the efficiency of innovation performance of knowledge-based production [11]. In the process of R&D internationalization, when enterprises use knowledge base absorption and integration to produce innovation performance, the strangeness brought by the huge institutional distance will make multinational enterprises face greater disadvantages and uncertainty risks of outsiders, increase the interaction barriers between R&D units, thus increasing the cost of knowledge absorption and integration and reducing innovation performance. Therefore, the institutional distance may affect the mechanism role of the knowledge base of R&D internationalization to innovation. That is, it plays a moderating role in the intermediary role of the knowledge base.

Based on the above analysis, this paper combines institutional theory, knowledge base view, and organizational learning theory and takes China's listed companies in knowledge-intensive industries that carried out overseas R&D activities from 2009 to 2015 as a sample to study the intermediary mechanism of the enterprise knowledge base of R&D internationalization (depth and breadth) to innovation performance. And the moderating effect of the institutional distance between the home country and the host country on the intermediary role of the knowledge base. This paper aims to fill the theoretical gap in the existing

internationalization research, enrich the relevant theoretical research on internationalization, and provide more accurate and effective suggestions for Chinese enterprises' overseas R&D investment activities.

## Theory and Research Hypothesis

### Sustainable Development

Sustainable Development is a new concept proposed in the 1980s. In 1987, the World Commission on Environment and Development elaborated the concept of sustainable development for the first time in its report "Our Common Future," which was widely recognized by the international community.

Sustainable development refers to meeting the needs of modern people without compromising the ability of future generations to meet their needs. In other words, it refers to the coordinated development of the economy, society, resources, and environmental protection [1]. They are an inseparable system. We should not only achieve the goal of economic development but also protect the natural resources and environments such as the atmosphere, freshwater, ocean, land, and forest that human beings rely on for survival, so that future generations can develop and live in peace and contentment. The core of sustainable development is development, but it requires economic and social development on the premise of strictly controlling the population, improving population quality, protecting the environment, and sustainable utilization of resources.

### Internationalization of R&D and Innovation Performance

Internationalization of R&D refers to the home country enterprises establishing R&D subsidiaries or establishing R&D strategic alliances to carry out R&D activities overseas through joint ventures, mergers, and acquisitions, or sole proprietorship with foreign enterprises [12]. This paper divides R&D internationalization into two dimensions of degree and geographic diversification and analyzes its impact mechanism on enterprise innovation performance.

#### *R&D Internationalization Degree and Innovation Performance*

Sustainable development requires coordinated development of the economy, society, resources, and environmental protection. Enterprises from emerging economies entering developed countries to carry out R&D internationalization will help them learn their advanced technologies and environmental protection concepts.

First of all, according to the knowledge base's view, the enterprise is a knowledge-processing system that can achieve innovation breakthroughs by effectively integrating and utilizing the organization's internal and external knowledge resources [13]. Therefore, by increasing the degree of R&D internationalization, establishing overseas R&D institutions can build mutual trust with the host country and create channels for receiving knowledge and technology spillovers from the host country. Absorb and learn all kinds of tacit knowledge in the exchange and cooperation with various local R&D institutions, enrich the knowledge base of enterprises, and provide effective support for enterprise innovation. Secondly, knowledge is generally implicit and sticky, and knowledge resources of host countries are often deeply embedded in their R&D networks. Overseas R&D activities help enterprises acquire and absorb more diversified external knowledge and reverse transfer it to the parent company so as to enhance the technological innovation capability of transnational enterprises. The improvement of the R&D internationalization degree can enhance the intensity and frequency of interaction between transnational enterprises and various nodes of overseas R&D networks and improve the network embeddedness. It also realized the reverse transfer of knowledge and technology by sending managers, engineers, and other R&D talents abroad and improving product development ability and innovation abilities. Finally, for enterprises aiming to enter overseas markets, R&D internationalization is conducive to enterprises' deeper integration into the supply chain and product market of the host country [6]. The interaction with local suppliers will help multinational enterprises learn from foreign advanced technology concepts and models, and then promote enterprise learning and applied innovation. Based on this, this paper proposes the following assumptions:

**H1a:** Under sustainable development, the increase of the R&D internationalization degree of enterprises will improve enterprise innovation performance.

#### *R&D Internationalization Geographic Diversification and Innovation Performance*

Sustainable development is an economic growth model that focuses on long-term development. Innovation brought by R&D internationalization can help enterprises to achieve sustainable development [14]. First, according to the resource-based view, the implicit and explicit resources owned by enterprises are the key elements to achieving sustainable development. Improving the geographic diversification of R&D internationalization and building a geographically decentralized overseas R&D network will help enterprises integrate and utilize diversified and diversified innovation resources from different countries and regions and build a diversified and complementary innovation resource database [15]. This improves the efficiency of innovation search and provides strong support for absorbing, utilizing, and innovative application of foreign advanced

technologies. Secondly, different countries have huge differences in culture, system, technology, and organizational management, which is conducive to enterprises' deeper understanding and learning. Setting up R&D institutions in different countries can bring more opportunities for enterprises to cooperate, exchange, and learn, which is conducive to enterprises' access to and acquisition of diversified advanced technologies in the host country. It also accumulates knowledge in the exchange and learning with various innovation subjects, and improves the enterprise's knowledge stock and the efficiency of internal knowledge sharing and interaction, thus promoting enterprise innovation. Finally, the geographical decentralization of R&D activities of multinational enterprises means that enterprises will face more complex and changing market environments and diversified customer needs, which will help enterprises accumulate rich international operation experience and knowledge, broaden the knowledge structure of managers, and promote them to grasp the opportunities and challenges of new technological changes more keenly, thus improving enterprise innovation performance. Based on the above analysis, the following assumptions are made.

**H1b:** Under sustainable development, the increase of R&D internationalization geographic diversification will improve enterprise innovation performance.

### The Mechanism Role of the Knowledge Base

The knowledge base is a collection of all internal knowledge resources owned by an enterprise, including technology, talents, and patents [16, 17]. Staudt and Jarke (2000) [18] expanded the knowledge base definition and included enterprise cognitive behavior and past knowledge experience into the category of the enterprise knowledge base. Since then, scholars have further classified the measurement dimensions of the knowledge base, including the width, depth, or scale and diversity of the knowledge base in two-dimensional classification, and the width, depth, heterogeneity, and quality of the knowledge base in four-dimensional classification. This paper divides the knowledge base into scope and diversity [17, 19], and analyzes its intermediary role in the relationship between R&D internationalization and innovation performance.

### R&D Internationalization, Knowledge Base Scope, and Innovation Performance

Multinational enterprises' R&D internationalization activities can increase the reverse knowledge spillovers obtained by enterprises from the host country and help enterprises identify, absorb and integrate external knowledge of enterprises [6]. With the increasing R&D internationalization degree, enterprises can have more

overseas R&D subsidiaries, and the links between overseas R&D subunits will be closer. Multinational companies can also be more easily embedded in the R&D network of the host country. Furthermore, multinational enterprises can obtain more heterogeneous knowledge resources and expand their knowledge base. With the improvement of the R&D internationalization geographic diversification, multinational enterprises will cover R&D activities in more host countries and will be able to access more abundant and diversified technical knowledge and more easily expand their knowledge base through learning. Therefore, increasing the R&D internationalization degree and geographic diversification can effectively expand the scale of the enterprise knowledge base. Furthermore, expanding the knowledge base scale may affect the innovation performance of enterprises through the following three intermediaries. First, a more extensive knowledge base scale is conducive to improving the efficiency of enterprises in searching, absorbing, and applying knowledge, and improving innovation capability [20]. In terms of knowledge search, enterprises with large knowledge bases often have more relevant background knowledge and capabilities so that they can identify and discover new technologies more quickly. In terms of knowledge absorption, the absorption effect of enterprises on external knowledge mainly depends on their own knowledge accumulation [21]. The larger the scale of the enterprise's knowledge base, the richer the accumulated knowledge stock and the more conducive to the enterprise's full absorption of external knowledge. In terms of knowledge application, only when the scale of the knowledge base reaches a certain level can enterprises effectively integrate and utilize the knowledge acquired by R&D internationalization. Second, a large-scale knowledge base is conducive to achieving economies of scale and scope effects of enterprise knowledge, thereby further improving R&D efficiency and reducing R&D costs [22]. Third, the scale of the knowledge base can reduce the potential uncertainty risk of R&D projects. Due to the extremely long R&D time and expensive R&D investment, the risk of R&D projects is huge [23]. The larger scale of the knowledge base can support enterprises to carry out multiple different R&D projects at the same time and share R&D risks. So, this paper proposes the following assumptions:

**H2a:** The increase of R&D internationalization degree promotes enterprise innovation by improving the knowledge base scope.

**H2b:** The increase of R&D internationalization geographic diversification promotes enterprise innovation by improving the knowledge base scope.

### R&D Internationalization, Knowledge Base Diversity, and Innovation Performance

The distribution of knowledge resources in different geographical regions is not balanced, and the number

and type of knowledge resources in different regions differ. Enterprises can obtain different knowledge and technologies by distributing R&D activities in different host countries [24]. With the improvement of the R&D internationalization degree, the establishment of numerous overseas R&D subsidiaries is conducive to enterprises' easier access to diversified and differentiated advanced technical knowledge. It also absorbs, transfers, and integrates into the enterprise knowledge base through the internal knowledge transfer channel to enrich the enterprise knowledge base [25]. Under the higher level of R&D internationalization, enterprises' R&D activities are more geographically dispersed, which is conducive to enterprises' interaction, contact, and learning with more host countries to obtain more diversified knowledge [26]. Therefore, the R&D internationalization degree and geographic diversification can improve the diversity of the enterprise knowledge base.

Furthermore, the expansion of enterprise knowledge base diversity may affect enterprise innovation performance through three intermediaries. First, diversified knowledge accumulation can effectively promote the integration of internal knowledge of enterprises. The greater the diversity of an enterprise's knowledge base, the easier it is to integrate knowledge among different knowledge fields, generate new knowledge technologies, and thus improve the enterprise's innovation performance [17]. Moreover, because the integration of diversified and heterogeneous knowledge will produce breakthrough innovation achievements, the higher the diversity of the knowledge base, the more knowledge fields it has, the stronger the ability to integrate heterogeneous knowledge, and the higher the breakthrough innovation performance [27]. Second, diversified knowledge accumulation can promote the R&D efficiency of enterprises. The low diversity of the knowledge base indicates that the knowledge and technology mastered by enterprises are highly relevant and concentrated in a few knowledge fields. At this time, enterprises' knowledge search scope will become smaller, the degree of correlation between knowledge combinations will be higher, and repeated search and repeated integration will be more likely to occur, leading to lower R&D performance. Third, the more diversified the knowledge base, the more effectively the enterprise can avoid innovation risks. There are greater risks and costs in knowledge coupling across technology fields. Higher diversity of knowledge base indicates that enterprises have more knowledge in different fields, and enterprises have more opportunities to couple familiar knowledge fields to reduce risks. Therefore, this paper believes that the diversity of the knowledge base is positively related to enterprise innovation performance. That is, the higher the diversity of the enterprise knowledge base, the better the enterprise innovation performance. Therefore, it is assumed that:

**H2c:** The increase of R&D internationalization degrees promotes enterprise innovation by improving the knowledge base diversity.

**H2d:** The increase of R&D internationalization geographic diversification promotes enterprise innovation by improving the knowledge base diversity.

## The Moderating Effect of Institutional Distance

The increase in the R&D internationalization degree and geographic diversification can effectively expand the scale and diversity of the enterprise knowledge base. And further improve their innovation performance through knowledge search, absorption, and integration activities in the host country. However, R&D cooperation and competition in the knowledge economy will be affected by the institutional [28]. So, the promotion effect of knowledge base size and diversity on enterprise innovation performance may be affected by the institutional distance between the home country and the host country. According to the institutional theory, the institutional is the criterion of social activities, providing necessary support and guarantee for the business activities of enterprises [29]. However, when enterprises choose a host country with a large distance from the home country system to conduct knowledge innovation activities, institutional strangeness will hurt innovation.

Enterprises with a larger knowledge base will search and absorb knowledge more efficiently because they have more prior knowledge. The institutional strangeness will greatly increase the disadvantage and uncertainty risk of outsiders [30], affect the efficiency of knowledge search and absorption, and cause additional costs [4]. So it harms innovation performance. In addition, higher institutional distance means that multinational enterprises may face more differences and contradictions when cooperating with other R&D institutions in the host country. This increases the cost of external coordination and communication of enterprises, increases the difficulty of embedding in the host country's R&D network, and makes knowledge search and absorption more difficult and inefficient. It increases the cost of external knowledge acquisition of enterprises, which is not conducive to the improvement of innovation performance.

Enterprises with higher knowledge base diversity tend to improve their innovation performance through internal knowledge integration. The circulation, transfer, and integration of knowledge between parent companies and subsidiaries are of great significance. However, the institutional differences between the home country and the host countries will cause differences between the parent company and overseas subsidiaries in terms of knowledge asset evaluation, knowledge circulation transfer, and integration [31]. Especially in the host countries with large gaps in international property rights and intellectual property rights, these

differences will become more obvious. The parent company needs to pay higher communication and coordination costs for knowledge integration within the organization, thus affecting the efficiency of knowledge integration [31], which harms innovation performance. Therefore, based on the above analysis, this paper proposes assumptions:

**H3a:** When the institutional distance between the home country and the host country increases, the positive effect of knowledge base scope on enterprise innovation performance decreases.

**H3b:** When the institutional distance between the home country and the host country increases, the positive effect of knowledge base diversity on enterprise innovation performance decreases.

Due to the increase in the degree and geographic diversification of R&D internationalization, the scope and diversity of the knowledge base are improved to promote enterprise innovation. However, institutional distance will reduce the positive impact of knowledge base scope and diversity on innovation performance. Based on this, this paper believes that when the institutional distance is high, the institutional strangeness will greatly increase the disadvantage and uncertainty risk of the outsider. The lack of external legitimacy makes it difficult for multinational enterprises to integrate into the host country's R&D network. Multinational enterprises will face more complex business conditions and higher external coordination and communication costs in exchange and cooperation with host enterprises, and the search and absorption of knowledge will become more difficult and inefficient. Therefore, it will hinder innovation. At the same time, when the institutional distance is relatively high, the increased institutional differences will cause differences between the parent company and overseas subsidiaries in terms of the value evaluation of intellectual assets, the transfer of knowledge circulation, and the process and method of integration. It reduces the efficiency of enterprises' integration and utilization of diversified knowledge, thereby affecting innovation performance. Therefore, this paper proposes the following assumptions:

**H4a:** Institutional distance negatively moderates the mechanism role of knowledge base scope between R&D internationalization degree and innovation performance.

**H4b:** Institutional distance negatively moderates the mechanism role of knowledge base scope between R&D internationalization geographic diversification and innovation performance.

**H4c:** Institutional distance negatively moderates the mechanism role of knowledge base diversity between R&D internationalization degree and innovation performance.

**H4d:** Institutional distance negatively moderates the mechanism role of knowledge base diversity between R&D internationalization geographic diversification and innovation performance.

## Methodology

### Sample Collection

The sample of this paper is China's knowledge-intensive listed enterprises. In view of the high R&D demand and investment of knowledge-intensive enterprises, they hold a large number of R&D internationalization projects, so they meet the sample standards of research related to R&D internationalization. In order to avoid the possible negative impact of the 2008 financial crisis on enterprises' overseas R&D behavior, this paper selects 2009 as the starting time of the sample. Since the Department of Foreign Investment and Economic Cooperation of the Ministry of Commerce of the People's Republic of China was unable to obtain the details of foreign investment enterprises and investment projects after upgrading the database interface in 2016, this paper selects 2015 as the deadline for the sample. The year range of this sample is 2009-2015. First, according to the Directory of Overseas Investment Enterprises published by the Department of Foreign Investment and Economic Cooperation of the Ministry of Commerce of China, this paper searches the overseas R&D subsidiaries owned by multinational enterprises from 2009 to 2015. That is enterprises whose business scope includes R&D-related keywords such as technology import and export, technology research and development, and technology development. Second, match the data of listed companies and get the original sample. Third, based on the availability of data, delete ST enterprise samples, delete enterprise samples with serious data information loss, and delete some enterprise samples with obvious tax avoidance tendencies. Finally, an unbalanced panel enterprise sample consisting of 249 enterprises and 804 observations was obtained.

### Measures

#### *Dependent Variables*

Innovation performance. According to the previous literature, the measurement of innovation performance is mainly divided into three types [32]. One is total factor productivity, which measures the contribution rate of R&D internationalization investment as a factor of production to the value-added of transnational enterprises' total factors of production. The second is patent data, including patent output, that is, the number of patents applied by the enterprises each year [33-34]. And the number of patent citations, that is, the frequency of patent citations several years after the successful application [4]. Third, the output of new products, that is, the market sales of new products [32]. Because most of the variables involved in total factor productivity are seriously missing, and transnational patent references are difficult to query,

the annual reports of existing enterprises often lack reports on new product data. Therefore, this paper selects the number of patent applications of enterprises in the observation year as the measurement method of enterprise innovation performance.

*Independent Variables*

R&D internationalization degree. In view of the availability of data, this paper refers to Hsu, et al. (2015) [8] and uses the number of overseas R&D subsidiaries owned by enterprises in the observed year as a measure of the R&D internationalization degree. The judgment standard of overseas R&D subsidiaries is that the business scope of enterprises in the List of Overseas Investment Enterprises includes 59 R&D-related keywords such as technology import and export, technology research and development, and technology development.

R&D internationalization geographic diversification. According to previous literature, the R&D internationalization geographic diversification is mostly measured based on the geographical diversity of overseas R&D subsidiaries. Including the Blau diversity index, the average geographical distance between any group of patents of the enterprise [35]. Based on the availability of data, this paper uses the measurement method of Wu, et al. (2016) [36] for reference and uses 1 to subtract the Herfindahl Hirschmann index (HHI) of the geographical distance of the enterprise's overseas R&D subsidiaries in the observed year [40].

$$Diversity = 1 - \sum_k \left(\frac{n_k}{n}\right)^2 \tag{1}$$

Where, $n_k$ is the distance between the host country of subsidiary $k$ and China, and $n$ is the sum of the distance between the host country of all subsidiaries and China.

*Mechanism Variables*

Knowledge base scope. There are many methods to measure the types of stored knowledge in the enterprise knowledge base. The more types of knowledge, the larger the scale of the knowledge base. With reference to Ye (2021) [19], this paper selects a 5-year observation window to reduce the impact of technological strategy changes. Measure the number of patent classifications of all patents applied by enterprises in the past five years since the year of observation that is, the total number of classifications.

Knowledge base diversity. It is used to measure the relevance of the stored knowledge in the enterprise knowledge base. The lower the relevance, the higher the diversity. With reference to Ye (2021) [19], this paper also selects a 5-year observation window to measure the dispersion of all patents applied by

enterprises in the past five years under the IPC secondary classification since the year of observation. Based on operability considerations, this paper uses the entropy method to measure.

$$Entropy = 1 - \sum_k F_k \ln\left(\frac{1}{F_k}\right) \tag{2}$$

$$F_k = \frac{S_k}{s} \tag{3}$$

In the model, $F_k$ is the proportion of patents under the $k$ classification in all patents. $\ln(1/F_k)$ is the weight of the $k$ classification, $S_k$ is the number of all patents under the $k$ classification and $s$ is the total patents of enterprises.

*Moderating Variable*

Institutional distance. According to relevant research literature [30], this paper first calculates the institutional mean value of each country according to the average score of six sub-indicators of property rights, intellectual property protection, judicial independence, government regulation, judicial efficiency, and transparency of government decision-making in the formula indicators of the Global Competitiveness Report. Then, the institutional distance is measured by the difference between the institutional mean of each host country and that of China. If the number of enterprise host countries is greater than 1, the difference between the average value of all host country institutions and the average value of China's institutions is used to measure. In addition, according to the existing literature, this paper selects enterprise age and R&D internationalization motivation as control variables.

## Results

### Descriptive Statistics and Correlation Analysis

The descriptive statistical results are shown in Table 1. The variance expansion factor (VIF) of each variable is less than 5, indicating that there is no serious multicollinearity. From the perspective of the correlation coefficient, the R&D internationalization degree and geographic diversification are significantly positively correlated with innovation performance. H1a and H1b are preliminarily confirmed. The knowledge base scope and diversity are positively correlated with innovation performance. The R&D internationalization degree and geographic diversification are significantly positively correlated with the knowledge base scope and diversity. The above correlation analysis is a preliminary conclusion, which still needs further empirical testing.

Table 1. Descriptive Statistics and Correlation Coefficients.

| Variable | Mean | SD | VIF | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Innovation | 377.3 | 1063 | | | | | | | | |
| 2. Scope | 21.72 | 23.77 | 2.980 | 0.490*** | | | | | | |
| 3. Entropy | 1.587 | 0.792 | 2.820 | 0.222*** | 0.797*** | | | | | |
| 4. Degree | 1.940 | 1.578 | 2.690 | 0.223*** | 0.255*** | 0.154*** | | | | |
| 5. Diversity | 0.172 | 0.250 | 2.800 | 0.216*** | 0.258*** | 0.197*** | 0.785*** | | | |
| 6. INS | 0.871 | 0.680 | 1.100 | 0.193*** | 0.215*** | 0.170*** | 0.131*** | 0.237*** | | |
| 7. Age | 15.54 | 6.298 | 1.010 | 0.019 | 0.025 | 0.085** | 0.04 | 0.039 | 0.018 | |
| 8. Motive | 0.486 | 0.500 | 1.040 | -0.073** | -0.114*** | -0.075** | 0.073** | 0.126*** | 0.028 | 0.001 |

Note: *p<0.05, **p<0.01, ***p<0.001.

## Regression Analysis

The dependent variable in this paper is the number of patent applications of sample enterprises in each year from 2009 to 2015, which is a non-negative integer discrete variable. Therefore, this paper uses the Poisson model for regression. Hausman test results show that the fixed effect is more suitable for testing. This paper uses stata 15 software. This paper uses Poisson fixed effect model to test the main effect of R&D internationalization and innovation performance. The regression results are shown in Table 2. It can be seen that the R&D internationalization degree has a significant positive impact on enterprise innovation performance. (Panel A of Table 2, M1: b = 0.267, p<0.01). H1a is verified. The R&D internationalization geographic diversification has a significant positive impact on enterprise innovation performance (Panel A of Table 2, M2: b = 2.332, p<0.01). H1b is verified.

## Mechanism Test

In the existing literature, Baron's stepwise method and Sobel's test are often used to test mechanisms. The above two methods are widely used, but they are questioned by some scholars due to their statistical measurement errors. Therefore, this paper adopts a more scientific Bootstrap method to test the mechanism effect. In this study, we conducted the Bootstrap mediation test to analyze the mechanism [37]. The sample size is set to 5000, and the confidence level of the confidence interval is set to 95%. The bootstrap sampling method selects a nonparametric percentile method for deviation correction.

This paper first examines the relationship between R&D internationalization, knowledge base, and innovation performance. The regression results are shown in Table 2. The results show that the R&D internationalization degree is positively related to the scale of the knowledge base after controlling the age of enterprises and the motivation

of R&D internationalization (Panel A of Table 2, M7: b = 0.147, p<0.01). The R&D internationalization geographic diversification is also positively related to the knowledge base scope (Panel A of Table 2, M8: b = 1.131, p<0.01). The R&D internationalization degree is positively related to the knowledge base diversity (Panel B of Table 2, M7: b = 0.084, p<0.01). The R&D internationalization geographic diversification is also positively related to the knowledge base diversity (Panel B of Table 2, M8: b = 0.665, p<0.01). Moreover, the knowledge base scope positively affects the innovation performance of enterprises (Panel A of Table 2, M3: b = 0.035, p<0.01; M4: b = 0.034, p<0.01). The diversity of the knowledge base positively affects the innovation performance of enterprises (Panel B of Table 2, M3: b = 0.729, p<0.01; M4: b = 0.651, p<0.01). The results of the regression test preliminarily support the hypothesis of mediation of H2a, H2b, H2c, and H2d.

In order to further verify the mechanism role of knowledge base scope and knowledge base diversity for R&D internationalization to innovation. This paper uses SPSS PROCESS to test. Panel A of Table 3 shows the test results of the mechanistic role of knowledge base scope in the relationship between R&D internationalization and innovation performance. Panel A of Table 3 shows that for the path of "R&D internationalization degree to innovation performance," the indirect effect value r=0.077, 95% confidence interval is [0.053, 0.106]. It does not contain 0, indicating that the mechanical effect of the knowledge base scope is significant, so H2a is verified. For the path of "R&D internationalization geographic diversification to innovation performance," the indirect effect value r = 0.508, 95% confidence interval is [0.364, 0.675], excluding 0, indicating that the mechanical effect of knowledge base scope is significant, and H2b is verified. Therefore, the knowledge base scope plays a mechanism role in the impact of R&D internationalization on innovation performance.

Panel B of Table 3 shows the test results of the mechanistic role of knowledge base diversity for

Table 2. Hierarchical Regression Results of Knowledge Base.

| Variable | Innovation | | | | | | Knowledge base scope | |
|---|---|---|---|---|---|---|---|---|
| | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 |
| Panel A: Hierarchical Regression Results of Knowledge Base Scope | | | | | | | | |
| Age | 0.014*** (0.0003) | 0.012*** (0.0003) | 0.019*** (0.0003) | 0.019*** (0.0003) | 0.021*** (0.0003) | 0.021*** (0.0003) | 0.006*** (0.0012) | 0.006*** (0.0012) |
| Motive | -0.497*** (0.0038) | -0.604*** (0.0038) | -0.105*** (0.0039) | -0.242*** (0.0040) | -0.129*** (0.0039) | -0.252*** (0.0040) | -0.287*** (0.0154) | -0.331*** (0.0156) |
| Degree | 0.267*** (0.0007) | | 0.194*** (0.0009) | | 0.196*** (0.0010) | | 0.147*** (0.0037) | |
| Diversity | | 2.332*** (0.0066) | | 1.432*** (0.0073) | | 1.245*** (0.0072) | | 1.131*** (0.0281) |
| Scope | | | 0.035*** (0.0001) | 0.034*** (0.0001) | 0.031*** (0.0001) | 0.030*** (0.0001) | | |
| INS | | | | | 0.783*** (0.0049) | 0.791*** (0.0050) | | |
| Scope◊INS | | | | | -0.005*** (0.0001) | -0.006*** (0.0001) | | |
| N | 804 | 804 | 804 | 804 | 804 | 804 | 804 | 804 |
| Log likelihood | -378723 | -368271 | -216248 | -214756 | -195604 | -198290 | -9570 | -9452 |
| Wald chi2 | 144280 | 135751 | 422920 | 422834 | 397234 | 393828 | 1811 | 1876 |
| Prob>chi2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Panel B: Hierarchical Regression Results of Knowledge Base Diversity | | | | | | | Knowledge base diversity | |
| Age | 0.014*** (0.0003) | 0.012*** (0.0003) | 0.011*** (0.0003) | 0.010*** (0.0003) | 0.009*** (0.0004) | 0.008*** (0.0003) | 0.013*** (0.0045) | 0.012*** (0.0045) |
| Motive | -0.497*** (0.0038) | -0.604*** (0.0038) | -0.447*** (0.0038) | -0.606*** (0.0039) | -0.455*** (0.0038) | -0.591*** (0.0040) | -0.133** (0.0552) | -0.156*** (0.0550) |
| Degree | 0.267*** (0.0007) | | 0.266*** (0.0008) | | 0.256*** (0.0008) | | 0.084*** (0.0175) | |
| Diversity | | 2.332*** (0.0066) | | 2.095*** (0.0070) | | 1.845*** (0.0070) | | 0.665*** (0.1106) |
| Entropy | | | 0.729*** (0.0024) | 0.651*** (0.0024) | 0.503*** (0.0026) | 0.414*** (0.0027) | | |
| INS | | | | | 1.163*** (0.0062) | 1.210*** (0.0064) | | |
| Entropy◊INS | | | | | -0.299*** (0.0029) | -0.358*** (0.0031) | | |
| N | 804 | 804 | 804 | 804 | 804 | 804 | 804 | 804 |
| Log Likelihood | -378723 | -368271 | -331807 | -329677 | -304923 | -307912 | | |
| Wald chi2/F | 144280 | 135751 | 200250 | 193677 | 226634 | 212899 | 11.89 | 16.49 |
| Prob>chi2/F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Note: standard error in parentheses, *p<0.05, **p<0.01, ***p<0.001. In panel B's M7 and M8, because knowledge diversity is a continuous variable, OLS regression is used.

R&D internationalization to innovation. It can be seen from Panel B of Table 3 that for the path of "R&D internationalization degree to innovation performance," the indirect effect value r = 0.019, 95% confidence interval is [0.008, 0.033], excluding 0, indicating that

the mechanical effect of the knowledge base diversity is significant, and H2c has been verified. For the path of "R&D internationalization geographic diversification to innovation performance," the indirect effect value r = 0.148, 95% confidence interval is [0.006, 0.248],

Table 3. Mechanism test of the knowledge base.

| Path | Effect | Effect value r | Standard error | 95% confidence interval | |
|---|---|---|---|---|---|
| | | | | Lower limit | Upper limit |
| Panel A: Mechanism test of knowledge base scope | | | | | |
| R&D internationalization degree to innovation performance | Direc effect | 0.068 | 0.020 | 0.029 | 0.108 |
| | Indirect | 0.077 | 0.014 | 0.053 | 0.106 |
| R&D internationalization geographic diversification to innovation performance | Direct effect | 0.406 | 0.129 | 0.153 | 0.659 |
| | Indirect | 0.508 | 0.008 | 0.364 | 0.675 |
| Panel B: Mechanism test of knowledge base diversity | | | | | |
| R&D internationalization degree to innovation performance | Direct | 0.126 | 0.022 | 0.084 | 0.169 |
| | Indirect | 0.019 | 0.007 | 0.008 | 0.033 |
| R&D internationalization geographic diversification to innovation performance | Direct | 0.767 | 0.140 | 0.493 | 1.040 |
| | Indirect | 0.148 | 0.049 | 0.006 | 0.248 |

excluding 0, indicating that the mechanical effect of knowledge base diversity is significant, and H2d is verified. Therefore, knowledge base diversity plays a partial mechanism role in the impact of R&D internationalization on innovation performance.

## Moderating Effect Test

This paper uses Poisson fixed effect regression model to test the moderating effect. The regression results are shown in Table 2, M5 and M6. The results show that the interaction coefficient between knowledge base size and institutional distance is negative (Panel A of Table 2, M5: $b = -0.005$, $p<0.01$; M6: $b = -0.006$, $p<0.01$). This shows that institutional distance negatively moderates the knowledge base scope to innovation, which is verified by H3a. The interaction coefficient between knowledge base diversity and institutional distance is negative (Panel B of Table 2,

M5: $b = -0.299$, $p<0.01$; M6: $b = -0.358$, $p<0.01$). This shows that institutional distance negatively moderates the knowledge base diversity to innovation, which is verified by H3b. Moreover, referring to Dawson (2014) [38], this paper draws a moderating effect figure to verify the moderating effect of institutional distance. The results are shown in Fig. 1. According to Fig. 1a), under the low institutional distance (-1SD), the scope of the knowledge base has a stronger impact on innovation performance. Therefore, institutional distance negatively moderates the positive correlation between knowledge base scope and innovation performance. According to Fig. 1b), under the low institutional distance (-1SD), knowledge base diversity has a stronger impact on innovation performance. Therefore, institutional distance negatively moderates the knowledge base diversity to innovation. The test results of the moderating effect figure are consistent with the regression results in Table 2.
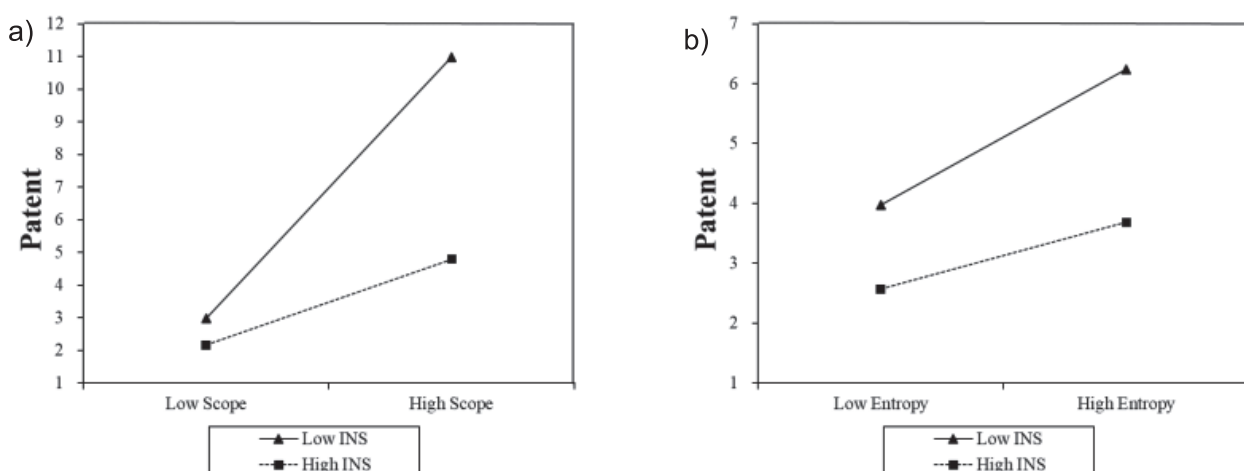


Fig. 1  Moderating effect.

## Mechanism Test with Moderating

This paper uses a moderated mechanism model to test that, under different conditions of high and low institutional distance, R&D internationalization affects the innovation performance of enterprises through the knowledge base. According to the research of Alfons, et al. (2022) [37], and with reference to the moderating mechanism analysis model proposed by Hayes (2017) [39], this paper uses the Bootstrap method to test. The results are shown in Table 4.

Panel A of Table 4 reports the test of the moderating effect of institutional distance on the mechanistic role of knowledge base scope. The results show that institutional distance will moderate the mechanism role of the knowledge base scale for R&D internationalization to innovation. The indirect impact of R&D internationalization on enterprise innovation performance through the mechanism variable of knowledge base scope is significantly different under different institutional distances. Specifically, for the path of "R&D internationalization degree to knowledge base scope, then to innovation performance," under the low institutional distance, knowledge base scope plays a significant mechanism role of R&D internationalization degree to innovation (Effect value r = 0.083, 95% confidence interval is [0.056, 0.119], excluding 0). Under the high institutional distance, the mechanical effect of knowledge base scope for R&D internationalization degree to innovation is significant (effect value r = 0.062, 95% confidence interval is [0.041, 0.087], excluding 0). It can be seen from the comparison that the mechanism effect decreases with the increase of institutional distance, indicating that institutional distance negatively moderates the mechanism effect of knowledge base scope for R&D internationalization degree to innovation. H4a has been verified. For the path of "R&D internationalization geographic diversification to knowledge base scope, and then to innovation performance" at a low institutional distance, the effect value r = 0.551, the 95% confidence interval is [0.390, 0.752], excluding 0, indicating that knowledge base scope has a significant mechanism effect of R&D internationalization geographic diversification to innovation. Under the high institutional distance, the knowledge base scope has a significant mechanism effect of R&D internationalization geographic diversification to innovation (the estimated effect r = 0.423, 95% confidence interval is [0.296, 0.553], excluding 0). It can be seen from the comparison that the mechanism effect decreases with the increase of institutional distance, indicating that institutional distance negatively moderates the mechanism effect of knowledge base scope for R&D internationalization geographic diversification to innovation. H4b has been verified.

Panel B of Table 4 shows the moderating effect of institutional distance on knowledge-based diversity. The results show that institutional distance moderates the mechanism role of knowledge base diversity for R&D internationalization to innovation. The indirect impact of R&D internationalization on enterprise innovation performance through the mechanism variable of knowledge base diversity is significantly different under different institutional distances. Specifically, for the path of "R&D internationalization degree to knowledge base diversity, then to innovation performance" at a low institutional distance, the mechanical effect of knowledge base diversity for R&D internationalization degree to innovation is significant (effect value r = 0.018, 95% confidence interval [0.004, 0.035], excluding 0). Under the high institutional distance, the mechanical effect of knowledge base diversity for R&D internationalization degree to innovation is significant (the estimated value of effect r = 0.015, 95% confidence interval is [0.005, 0.027], excluding 0). It can be seen from the comparison that the mechanism role decreases with the increase of institutional distance, which indicates that institutional distance negatively moderates the mechanism role of knowledge base diversity for R&D internationalization degree to innovation. H4c has been verified. For the path of "R&D internationalization geographic diversification to knowledge base diversity, then to innovation performance," at a low institutional distance, knowledge base diversity has a significant mechanism effect for R&D internationalization geographic diversification to innovation (effect value r = 0.136, 95% confidence interval [0.014, 0.263], excluding 0). Under the high institutional distance, knowledge base diversity has a significant mechanism effect for R&D internationalization geographic diversification to innovation (effect value r = 0.131, 95% confidence interval [0.060, 0.215], excluding 0). It can be seen from the comparison that the mechanism effect decreases with the increase of institutional distance, indicating that institutional distance negatively moderates the mechanism effect of knowledge base diversity for R&D internationalization geographic diversification to innovation. H4d has been verified.

## Conclusions and Discussion

### Research Conclusion

In developed countries, environmental protection is more strict. R&D internationalization can promote state-owned enterprises in emerging economies to learn their advanced technologies and environmental protection concepts to achieve sustainable development. This paper uses Poisson fixed effect regression, hierarchical regression, and Bootstrap method to test the mechanical effect of the knowledge base scope and diversity based on the R&D internationalization degree and geographic diversification on enterprise innovation performance through the sample of Chinese knowledge-intensive listed enterprises that made overseas R&D investments from 2009 to 2015. It also analyzes the moderating effect of the institutional distance

Table 4. Institutional distance moderates the knowledge base mechanism.

| Path | Moderating variable | Effect value r | Standard error | 95% confidence interval | |
|---|---|---|---|---|---|
| | | | | Lower limit | Upper limit |
| Panel A: Institutional distance moderates the knowledge base scope's mechanism | | | | | |
| R&D internationalization degree to knowledge base scope, then to innovation performance | Low institutional distance (-1SD) | 0.083 | 0.016 | 0.056 | 0.119 |
| | High institutional distance (+1SD) | 0.062 | 0.0116 | 0.041 | 0.087 |
| | Difference | 0.021 | 0.011 | 0.015 | 0.032 |
| R&D internationalization geographic diversification to knowledge base scope, then to innovation performance | Low institutional distance (-1SD) | 0.551 | 0.093 | 0.390 | 0.752 |
| | High institutional distance (+1SD) | 0.423 | 0.067 | 0.296 | 0.553 |
| | Difference | 0.128 | 0.026 | 0.094 | 0.199 |
| Panel B: Institutional distance moderates the knowledge base diversity's mechanism | | | | | |
| R&D internationalization degree to knowledge base diversity, then to innovation performance | Low institutional distance (-1SD) | 0.018 | 0.008 | 0.004 | 0.035 |
| | High institutional distance (+1SD) | 0.015 | 0.006 | 0.005 | 0.027 |
| | Difference | 0.003 | 0.002 | -0.009 | 0.008 |
| R&D internationalization geographic diversification to knowledge base diversity, then to innovation performance | Low institutional distance (-1SD) | 0.136 | 0.064 | 0.014 | 0.263 |
| | High institutional distance (+1SD) | 0.131 | 0.039 | 0.060 | 0.215 |
| | Difference | 0.005 | 0.025 | 0.046 | 0.038 |

between the host country and the home country on the above mechanism. The research conclusions are as follows. (1) Both the R&D internationalization degree and geographic diversification positively promote innovation performance. The enhancement of R&D internationalization degree helps enterprises to be more embedded in the host country's R&D network. The promotion of R&D internationalization geographic diversification helps enterprises to learn more advanced technical knowledge in a more dispersed geographical range. These two aspects are conducive to the improvement of enterprise innovation performance. (2) The scope and diversity of the enterprise knowledge base play a part of mechanism role in the impact of R&D internationalization degree and geographic diversification on innovation performance. R&D internationalization degree and geographic diversification promote enterprise innovation performance by increasing the knowledge base scope and diversity. (3) The institutional distance between the home country and the host country has a negative moderating effect on the mechanistic role of the knowledge base scope and diversity. A greater institutional distance will expand the negative impact of the disadvantage of outsiders, increase the communication and coordination costs of internal and external cooperation, and reduce the efficiency of knowledge search, absorption, and integration.

## Research Contribution

First, this paper discusses the mechanism role of the knowledge base for R&D internationalization to

innovation. Most of the previous studies on R&D internationalization and innovation performance only demonstrated that R&D internationalization enables multinational enterprises to acquire external knowledge and then stop here, directly equating knowledge with innovation performance. But, it does not explain and tests the mechanism through which enterprises transform knowledge into innovation performance after acquiring external knowledge. This paper attempts to open the "black box" for R&D internationalization to innovation by building a mechanism model of knowledge-based characteristics, which opens up a new research direction for further research on the specific mechanism of R&D internationalization affecting enterprise innovation performance.

Second, this study confirms the moderating effect of institutional distance on the mechanical effect of knowledge-based and expands the context research boundary for R&D internationalization to innovation. Most of the previous studies based on the institutional perspective only focused on the direct moderating effect of institutional factors on the relationship between R&D internationalization and innovation and did not further clarify the specific function path of institutional factors to play the moderating effect. This paper studies the moderating effect of institutional distance on the knowledge base to innovation and explores whether institutional distance has a moderating effect on the mechanistic role of the knowledge base for R&D internationalization to innovation. This paper further improves the mechanism model of "R&D internationalization to the knowledge base, and then to innovation performance" and expands

the relevant research on innovation performance by institutions.

Thirdly, this paper explores the relationship and mechanism for R&D internationalization to the innovation of Chinese multinational enterprises, complementing the relevant research on R&D internationalization and innovation performance in the context of emerging economies. Most of the previous studies focused on the R&D internationalization of multinational enterprises in developed economies. These enterprises have a high level of technology. The purpose of R&D internationalization is to reduce R&D costs and seize the market of the host country by taking advantage of technology. However, multinational enterprises in emerging economies have a low level of technology, and the motivation for R&D internationalization is to seek new technologies from host countries. Therefore, the impact mode, mechanism, and even result of R&D internationalization on innovation performance in the context of emerging economies may be different from that in the context of developed economies. Therefore, taking Chinese multinational enterprises as the research object is an excellent supplement to the research on R&D internationalization and innovation performance.

## Practical Enlightenment

For multinational enterprises in emerging economies represented by China, the internationalization of R&D is an important channel for them to learn advanced foreign technical knowledge and achieve breakthrough innovation. This study shows that the increase in the R&D internationalization degree and geographic diversification contributes to the improvement of enterprise innovation performance. Therefore, while promoting the internationalization of R&D, multinational enterprises should also pay attention to the geographical decentralization of overseas R&D subsidiaries so as to obtain more diversified host country-specific knowledge, enrich and improve the knowledge base of enterprises, and improve innovation performance

This study confirms the knowledge base scope and diversity mechanism of the relationship between R&D nationalization and innovation performance. Therefore, multinational enterprises should pay more attention to the construction and development of enterprise knowledge bases when improving enterprise innovation performance through an R&D internationalization strategy. While accelerating the speed of knowledge and technology acquisition and improving the scope of the enterprise knowledge base, we should pay attention to the diversity of the enterprise knowledge base and maintain the diversity of knowledge base at a higher level by learning and absorbing knowledge from different fields so as to better play the innovation incentive effect of R&D internationalization. In addition, enterprises also need to improve their ability to develop and apply the knowledge base and

improve the efficiency of transforming the enterprise knowledge base into innovation performance through effective knowledge learning and integration.

The R&D internationalization of multinational enterprises should be carried out in the host country that is closer to the home country's institutional distance. The text research confirms that institutional distance negatively modifies the mechanistic role of enterprise knowledge base scope and diversity for R&D internationalization to innovation. Choosing a host country that is closer to the home country's institutional distance for R&D internationalization can reduce the impact of the disadvantage of outsiders. Furthermore, reduce the cost of cooperation between enterprises and R&D institutions in the host country and the cost of coordination and management of overseas R&D subsidiaries to improve enterprises' innovation performance.

## Conflict of Interest

The authors declare no conflict of interest.

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