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The Influence of Internationalization on Open Innovation--Research based on Resource Orchestration Theory

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Abstract: Open innovation depends on the full integration of internal and external knowledge, and internationalization, as an important way for enterprises to obtain external resources, plays a crucial role in promoting open innovation. The existing research holds a positive attitude towards whether enterprises with higher internationalization can obtain more external resources as resource supplement to promote the development of open innovation, but neglects the initiative of enterprises in the process of resource orchestration. Based on the theory of resource orchestration, this paper empirically tests the relationship between internationalization and open innovation using the data of 2911 A-share listed manufacturing enterprises from 2009 to 2021. The findings are as follows: (1) There is an inverted U-shaped relationship between internationalization and open innovation. (2) Organizational inertia significantly enhances the inverse U-shaped relationship between internationalization and open innovation, while the heterogeneity of professional background of senior management team significantly weakens the inverse U-shaped relationship between internationalization and open innovation. (3) The inverse U-shaped relationship between internationalization and open innovation is more prominent in non-state-owned enterprises, large enterprises and growth-stage enterprises. This study explains the nonlinear relationship between internationalization and open innovation based on resource orchestration theory, which helps enterprises to deeply understand the complex resource orchestration in the process from internationalization to open innovation, enricfies the application of resource orchestration theory in the field of internationalization and innovation, and provides reference value for manufacturing enterprises to make strategic and innovation decisions.

1. Introduction

The report to the 20th National Congress of the CPC pointed out that "we should expand international scientific and technological exchanges and cooperation, strengthen the construction of an international scientific research environment, and form an open innovation ecology with global competitiveness". At present, China is in a critical period of accelerating the transformation of the economic development model, adjusting the economic structure and shifting the driving force of growth. As an emerging economy, China urgently needs to enhance its international competitiveness through innovation and research and development, and thus enhance its voice in the global division of labor system. With the continuous development of internationalization and globalization, enterprises are implementing more inclusive and open science and technology cooperation strategies, and more actively integrating into the global innovation network (Li Xuesong, 2022). At present, the degree of competition in domestic and foreign industries is becoming increasingly fierce, while Chinese enterprises' own innovation resources and innovation ability are insufficient, so enterprises begin to change their innovation strategies, gradually shifting from internal "closed innovation" to "open innovation". They break the organizational boundaries and systematically use external knowledge to fill the deficiency of internal resources (Arora & Gambardella, 2010). Compared with internal innovation, open innovation has the characteristics of fast speed, low cost and high return (Yang Zhenning, 2022), which is very attractive to enterprises. However, the characteristics of high risk and high externality of open innovation activities in manufacturing enterprises lead to greater demand for external resources and higher requirements for innovation and integration capabilities of enterprises. P&g adopted the innovation strategy of "connection and development" from 1999 to 2008 and achieved significant benefits. However, after entering the second decade of the 21st century, with the continuous practice of open innovation, the company excessively introduced and relied on external resources and technologies, but failed to effectively combine external resources with internal resources, and lacked the accumulation of its own technologies. Which has affected the innovation and development of the enterprise. It can be seen that if an enterprise fails to use external resources for its own use, it may reduce its innovation performance and even hinder its long-term development.

Access to external resources is the premise of enterprise open innovation, and the process of integrating external resources is the key to whether open innovation can bring benefits to enterprises. As an important choice of enterprises' opening up strategy, internationalization can not only help enterprises to explore overseas markets, but also bring cutting-edge information resources, advanced R & D resources and high-quality human resources to enterprises. According to the Statistical Bulletin of China's ODI 2022, China's ODI flows reached 163.12 billion U.S. dollars, ranking second in the world and among the top three in the world for 11 consecutive years. The manufacturing sector ranks third in the industry. For manufacturing enterprises, internationalization has become one of the important ways for enterprises to obtain external resources. However, considering the risks, externalities and complexity of open innovation, can the external resources brought by internationalization continue to promote the development of open innovation? At the same time, since the degree of internationalization of different manufacturing enterprises is quite different, are there differences in the management and utilization of internal and external resources under different degrees of internationalization? To answer the above questions, it is necessary to further explore the relationship between the degree of internationalization and open innovation.

Open innovation can be divided into inward oriented open innovation and outward oriented open innovation according to the direction of knowledge flow or transmission (Chesbrough, H, 2006). Compared with the outward-oriented open innovation, the endogenous open innovation has a more obvious effect on the improvement of enterprise innovation output and innovation efficiency

(Bianchi, M,2011). Therefore, how to promote the endogenous open innovation of enterprises has been widely concerned by the academic and industrial circles (Gao Zhaojun, 2018; He Bin-yuan, 2022). Existing literature mainly studies and explores the anthems of enterprise open innovation from two perspectives, internal and external. From the perspective of internal factors, enterprises' own absorptive capacity (Jiang Jihai, 2009), staff capacity (du Chatenier, E, 2010), network capability (Wang Haihua, 2012), innovation atmosphere (Popa, S, POPa, 2017) can promote the improvement of the level of open innovation, while the mentality of employees that devalues the external formality will hinder the implementation of open innovation (Burcharth, ALD, 2014). With the development of digital economy, IT capability (Ding Xiuhao, 2022) and digital transformation (Jia Xizimeng, The influence of IT on open innovation has also been paid attention; From the perspective of external factors, it mainly focuses on the influence of the acquisition of external resources and the network structure characteristics of the enterprise on open innovation. For example, the acquisition of resources by performing social responsibility (Zhang Xin, 2019) or getting tax incentives (Zeng Jianghong, 2022) can promote the improvement of open innovation. There is an inverted U-shaped relationship between external knowledge search and open innovation (Zhou Fei, 2022). 2020), the influence of location and characteristics of innovation network on open innovation (He Binyuan, 2022), etc.; In addition, some scholars integrate external environment and internal capabilities into the same framework for comprehensive analysis. For example, a study by Spithoven and Teirlinck (2015) shows that R&D intensity and network resources can promote cooperative innovation of enterprises. It can be seen that the academic circle has conducted multi-level and multi-angle research on the antecedents of open innovation, which provides important theoretical and practical support for promoting open innovation in enterprises.

Internationalization strategy is an important external activity in the process of enterprise development. From the perspective of resource-based theory and organizational learning theory, internationalization can improve the innovation performance of enterprises by influencing the diversification of international innovation networks (Wu Hang, 2023) and providing resource support for enterprises (Vanhaverbeke et al., 2009). Internationalization can also enhance the innovation capability of enterprises (Zeng Ping, 2012; Li Dongyang, 2019), promoting green innovation (Wang Chen, 2023) and breakthrough innovation (Kuemmerle, 1997), and promoting innovation cooperation (Zheng Wei, 2020). From the perspective of information asymmetry, internationalization will bring about an increase in transaction costs, management costs, and patent protection costs (Bahl et al., 2020), and increase the risk of technological innovation (Zhang, 2019), thus inhibiting the conduct of innovation activities. At the same time, some scholars have proposed an inverted U-shaped relationship between internationalization degree and innovation performance (Lv Mengli, 2023) and innovation efficiency (Liu Sukun, 2022). Therefore, internationalization strategy is not only the result of important strategic decisions of multinational enterprises, but also an important driving force of enterprise innovation. Compared with closed innovation, open innovation puts more emphasis on the acquisition and absorption of external resources, as well as the integration and supplement of internal and external resources, which is a relatively complex dynamic process. Then, based on the resource orchestration theory, will internationalization directly affect the open innovation of enterprises? If so, is it a single negative impact or a non-linear impact? This important issue of theoretical and practical significance has not been directly studied and explored by the academic circle. Therefore, based on the resource orchestration theory, this paper will construct A theoretical framework of the relationship between internationalization degree and open innovation and conduct context-based research. Based on the existing important literature on internationalization degree and open innovation research, China's A-share manufacturing listed companies from 2009 to 2021 will be selected as research samples for empirical test.

Compared with the existing researches, the possible contributions of this paper are as follows:

First, it enricfies the relevant researches on the relationship between internationalization degree and open innovation, and makes up for the shortcomings of the existing researches. At present, only a small number of studies have focused on the positive impact of internationalization on open innovation. These studies, mainly from the perspective of resource-based theory and organizational learning theory, believe that internationalization can promote the improvement of open innovation level (Zheng Wei, 2020). However, this paper finds an inverted U-shaped relationship between the degree of internationalization of manufacturing enterprises and open innovation through empirical testing. In addition, this paper explains the mechanism of internationalization on open innovation through resource orchestration theory, and expands the theoretical and empirical research on the relationship between internationalization degree and open innovation. Secondly, it enriches the application of resource orchestration theory in the research of innovation management. This paper innovatively incorporates the resource orcheography theory into the research framework of the relationship between internationalization and open innovation. It not only emphasizes the resource effect brought by internationalization into open innovation, but also pays attention to the ability of enterprises to use resources to create value. It explains the inverted U-shaped relationship between internationalization degree and open innovation through the joint action of positive and negative mechanisms. This research perspective has important guiding significance for the decision-making of innovation in the process of internationalization of enterprises, and also provides a new theoretical perspective for the development of subsequent relevant research. Thirdly, this paper further focuses on the moderating effects of organizational inertia and executive team heterogeneity on the relationship between internationalization and open innovation, and reveals the mechanism of the nonlinear relationship between internationalization and open innovation in different contexts from the aspects of organizational structure and executive characteristics, respectively, and expands the application space of resource orchestration in the study of internationalization strategy and innovation decision-making. Finally, the paper adds the influence of firm characteristics on the relationship between internationalization and open innovation. In this paper, enterprise characteristics such as enterprise scale, life cycle and ownership nature are included in the overall research framework of internationalization degree and open innovation, and the heterogeneous influence brought by each factor is comprehensively considered, so that the research and analysis in this paper can be more realistic and logical, and provide more valuable practical guidance for subsequent research and enterprise innovation development.

2. Theoretical basis and research hypothesis

2.1. Resource orchestration theory

The framework of resource orchestration theory mainly includes three sub-processes: resource construction, resource bundling and resource leverage, that is, resource structuring, capability and leverage (Sirmon et al., 2010; Sirmon et al., 2011; Chadwick et al., 2015). In the existing literature, resource orchestration theory has been applied in two related studies, internationalization and innovation respectively. In the former type of research, as the resource-based view is one of the important theories to explain the internationalization of enterprises, it is widely used in the fields of the internationalization performance of enterprises, but the application of the resource orchestration theory is relatively rare. Some studies have shown that the internationalization motivation can accelerate the internationalization of enterprises through resource orchestration (Yan Yan, 2021). Scholars based on resource orchestration explained how emerging economies create value from successive cross-border mergers and acquisitions (Xie Hongming, 2019) and the integration and diffusion of knowledge after mergers and acquisitions (Li, F, 2019). At the theoretical level, Qian Haiyan (2022), based on the paradox thinking, proposed a theoretical framework for the

comprehensive development of global resource orchestration and local incubation through the study and analysis of value chain reconstruction. In the latter type of research, from the perspective of resource action, the research shows that effective resource orchestration can obtain a higher input-output ratio of innovation resources, which provides a new research perspective for clarifying the relationship between innovation and firm performance (Davis-Sramek et al., 2015; Kaveh Asiaei, 2023). In addition, the theory of resource orcheography, combined with emerging concepts such as digitalization and green development, has been gradually applied to open innovation (Faridian, PH, 2023), digital innovation of traditional manufacturing enterprises (Li and Jia, 2018), and green innovation (Wang et al., 2019; Shehzad, MU,2023), business model innovation (Zhang Lu et al., 2019; Xu, S, 2023) have enriched the theoretical development and related research in the field of innovation.

Resource orchestration combines dynamic theory, emphasizes the selection, transformation and utilization of resources by managers, shapes the process of resources being utilized and managed in resource theory, and reflects the process attributes and action attributes of resources (Han Wei, 2021). Compared with the resource-based view, resource orchestration theory not only emphasizes that heterogeneous resources are the basis for the formation of competitive advantages of enterprises, but also believes that only by utilizing resources can value be created, thus truly endosing enterprises with competitive advantages (Sirmon, 2007). Based on the resource-based view, many scholars believe that internationalization can enrich the resource base of enterprises and thus facilitate the innovation activities of enterprises. However, the impact of internationalization on innovation is a complex and dynamic process, and only after reasonable orchestration and utilization of resources can it have an impact on innovation. This paper holds that, compared with traditional innovation activities, open innovation puts more emphasis on the effective complement and combination of internal and external resources. In the process of resource orchestration, the ability of managers and the existing resources of the organization are limited. With the continuous increase of internationalization, the process of resource orchestration changes from simple to complex, and when the dynamic capability is difficult to match the static resources, On the contrary, the resources brought by internationalization will have a negative impact on open innovation. In addition, the resource orchestration theory emphasizes the interdependence between static resources and dynamic capabilities (Zhang Qing and Hua Zhibing, 2020), arguing that resources are the basis for enterprises to carry out a series of activities, but resources themselves cannot create value, and managers' ability and decision execution are required to transform them into competitive advantages of enterprises. This paper holds that organizational inertia can provide path dependence for managers' actions, thus enhancing resource orchestration ability in the initial stage, while organizational rigidity will hinder the improvement of resource orchestration ability in the later stage. Heterogeneity of top management team can produce diversified thinking to a certain extent, and the collision of thinking will lead to conflicts in the early stage of internationalization, which will increase the complexity of resource orchestration and reduce the manager's resource orchestration ability. With the expansion of internationalization, the coordination of heterogeneous thinking can promote the improvement of resource orchestration ability.

2.2. Research hypothesis

2.2.1. Internationalization and open innovation

The existing researches on the impact of internationalization on enterprise innovation are mainly explained from the theoretical perspectives of resource-based view and organizational learning. Through internationalization, enterprises search for the resources and knowledge needed for innovation, and cooperate with market players to build innovation networks, thus promoting

enterprise innovation (Zheng Wei, 2022). However, enterprises also need to bear a lot of potential costs in cooperative innovation. When the degree of internationalization reaches a certain level, the diversity of resources will lead to complexity, making the search costs and coordination costs of enterprises increase rapidly and exceed the benefits of innovation and opening up, and the difficulty of resource orchestration will increase, which will be detrimental to the improvement of enterprises' innovation openness. Therefore, as the degree of internationalization of enterprises increases from the moderate stage to the excessive stage, the impact of continuous internationalization on the innovation openness of enterprises may also change from a positive to a negative impact.

On the one hand, from the perspective of resource orchestration objects, internationalization promotes the acquisition and accumulation of resources and changes the stock of resources of enterprises. First of all, internationalization can help enterprises acquire differentiated and diversified new knowledge. In the process of constructing resource portfolio, enterprises can internalize the acquired human, material and other resources as part of their own basic resources through resource orchestration in the growth stage, thus promoting their innovative behavior (Carens, 2017). International enterprises can have access to different markets, environments and cultures, and acquire the development dynamics of advanced technologies (Kotabe et al., 2007), thus bringing heterogeneous, diversified and unique knowledge and resources to enterprises, improving the freshness and breadth of enterprise resources, and providing sufficient resource base for open innovation. Secondly, international enterprises have a broader social network, and the deepening of internationalization will bring more social capital to enterprises (Zheng Wei, 2022). Enterprises can choose partners in a wider range. Social capital, as a special non-economic resource, provides enterprises with a broader vision, cognitive resources and overall problem solving ability. Moreover, it can provide enterprises with complementary resources (Goerzen A, 2005) and improve enterprises' willingness and ability of open innovation.

On the other hand, from the perspective of resource orchestration, internationalization changes the structure of enterprise resources and improves the ability of enterprise resources to integrate resources to build or change enterprises. First of all, international enterprises have more keen insight, they can perceive the changes in the market environment and the flow of resources, have higher flexibility, improve the resource integration ability of enterprises in the face of complex environment and diversified resources, so as to more effectively invest resources in open innovation activities. Secondly, internationalization provides enterprises with a social network with heterogeneous resources. Diversified social networks can help enterprises obtain complementary resources needed for innovation from more channels (Duysters G, 2011), improve the efficiency of resource acquisition, and enhance the willingness of enterprises to carry out open innovation. Finally, internationalization can promote the flow of resources and knowledge among countries, and promote the establishment of global innovation network. Enterprises can make use of global resources to upgrade technology and improve organizational capacity, which is not only conducive to the acquisition, transfer and creation of technology and knowledge in both domestic and international markets (Mansfield, 1985; Jiang Xiaojuan, 2004), it is also conducive to the integration and utilization of resources to form a new resource structure, promote the emergence of innovation cooperation among enterprises, and improve the ability of enterprises to carry out open innovation.

Just as the theory of resource orchestration says, although resources are important for the innovation of enterprises, the key lies in the process of integrating resources to create value for enterprises. On the one hand, the deepening of internationalization has increased the complexity of enterprise resource bundling, which has a negative impact on open innovation. Too wide external search means that a large amount of existing resources are used to select new resources. Even if an enterprise has the ability to accurately identify and acquire differentiated external resources, the

process of integrating internal and external resources to create value is highly complex, and at the same time, it will bring uncertainty of innovation results (Katila and Ahuja, 2002). At this time, the risk of open innovation continues to increase, and the willingness of enterprises to carry out open innovation decreases. Resource orchestration theory emphasizes that enterprises need to effectively assimilate, absorb and utilize resources and knowledge acquired through internationalization to transform resource advantages into the driving force of open innovation. Therefore, excessive internationalization increases the difficulty of resource orchestration and makes it difficult for enterprises to effectively acquire and integrate resources. In addition, as the risk increases, enterprises will stop expanding open innovation and even reduce cooperation.

On the other hand, the continuous increase of internationalization reduces the efficiency of enterprise resource construction. First of all, the continuous development of internationalization means the expansion of the scope of production and operation of enterprises. For the purpose of optimal complementarity of resources to maximize innovation benefits, enterprises need to spend a lot of practice and energy to establish an understanding of the norms, habits and practices of different external knowledge channels (Laursen, 2006) when selecting partners in a wider scope. In order to search for the optimal partner and realize the optimal combination of resources to carry out open innovation, the organization and management become complicated. Secondly, the process of enterprise resource construction includes not only the acquisition and accumulation of resources, but also the resource management behavior of enterprises to actively strip off invalid or redundant resources (Cao Yu, 2023). As the deepening of internationalization brings heterogeneous resources to enterprises, it also means that enterprises need to spend more energy on investigation and analysis to eliminate existing ineffective resources or terminate some projects. This process not only involves large-scale adjustment of the internal resource structure of enterprises, but also requires coordination and communication between enterprises and the outside world, which increases the cost of open innovation. The willingness of enterprises to open innovation will also decrease. Based on the above analysis, this paper proposes the following hypothesis:

Hypothesis 1: There is an inverted U-shaped relationship between the degree of internationalization and open innovation, that is, with the increase of the degree of internationalization, the level of open innovation first increases and then decreases.

2.2.2. The moderating effect of organizational inertia

Organizational inertia is a characteristic of an enterprise that tends to maintain its original state in the process of long-term interaction with the environment. It includes the company's stable way of thinking, logic and method of solving problems, and is a key situational variable in the company's decision-making process (Yi Jiabin, 2022). A stable organizational structure can ensure the smooth implementation of an organization's strategic decisions, but stability also means that the organization has path dependence, and the resulting negative effect will reduce the flexibility of an enterprise in the face of change. Therefore, the organizational inertia of an enterprise will affect the way an organization integrates and utilizes resources. When the organizational inertia is higher, the identification and utilization of external resources will be more dependent on the existing ways of the organization. As an innovative activity with high risk, open innovation requires the organization to have a strong ability to accept external changes, so as to make reasonable and effective use of diversified resources.

On the one hand, from the process of resource construction, organizational inertia will strengthen the positive impact of internationalization on open innovation in the early stage of international expansion. First of all, organizational inertia can improve the ability of resource construction and resource bundling. Specifically, organizational inertia emphasizes the successful experience

acquired and accumulated in the previous development process, which enables enterprises to have dynamic capabilities to acquire and integrate core resources when facing the complex and changeable external environment in the process of internationalization. The guidance provided by "past experience" for the selection and implementation of organizational activities can also help reduce the number of times for an organization to re-search and organize new resources (Lian Yanling, 2015), which can not only enhance the enterprise's ability to identify and acquire international resources, but also promote the reasonable optimization between internal and external resources of the enterprise, thus providing the core driving force for open innovation. Moreover, strong organizational inertia usually means the stability of organizational structure, and its internal operations are more standardized and institutionalized, so it can provide organizations with a set of reasonable operating guidelines (Bourdieu P, 1990), so that enterprises can fully complete the capture and utilization of resources according to rules even in the early stage of international expansion. It not only ensures the benign operation of internal resources and other elements of the enterprise, but also facilitates the accumulation of organizational capital and the coordination and control of internal and external resources, thus strengthening the resource advantages brought by international expansion to open innovation. Therefore, the greater the organizational inertia, the external resources and information brought by the internationalization of enterprises can be better absorbed and utilized by enterprises (Sun Hui, 2020), thus leading to the improvement of enterprises' ability to carry out open innovation. Secondly, organizational inertia can promote the transformation of enterprise resources. The theory of resource orchestration includes not only the acquisition and integration of resources, but also the process of resource transformation, that is, the decision and allocation after resource acquisition. First of all, the internal operation of enterprises with strong organizational inertia is more standardized and institutionalized, with a certain stock of knowledge and practices that are difficult to imitate (Peteraf et al., 1993), which helps to cushion the risks and uncertainties in cooperative innovation, thus leading to the willingness of enterprises to invest international resources in open innovation, and enhancing the positive impact of enterprise internationalization on open innovation.

On the other hand, with the continuous enhancement of internationalization, organizational inertia will strengthen the negative impact of internationalization on open innovation of enterprises. First of all, organizational inertia increases the difficulty of organizational coordination and reduces the ability of enterprise resource construction and resource bundling. Organizational inertia will reduce organizational flexibility, form a more "closed and rigid" organizational structure, limit the incremental scope of change, and exclude the external learning of the organization (Party Xinghua, 2016). Especially with the deepening of internationalization, the external resources faced by organizations become more complex and tend to be saturated. Organizational inertia makes innovation activities more dependent on existing methods and objects, thus inhibiting the organization's ability to explore and utilize external diversified resources, and further impeding the further deepening and expansion of open innovation behavior. Secondly, when internationalization reaches a certain level, organizational inertia will inhibit the transformation of enterprise resources to open innovation. Organizational inertia leads to "business myopia", that is, organizations focus on the present and lack foresight (Levinthal D, 1994; Lian Yanling, 2015). Organizational inertia will lead to redundant personnel and bloated organizations (Liu Haijian, 2009), which will reduce the entrepreneurial spirit of pursuing innovation, exploration and adventure in organizations. When internationalization brings enough resources, enterprises with high organizational inertia will be more inclined to invest more resources in short-term business activities, thus giving up open innovation with high risks and slow results. Hindering the transformation of enterprises' international resources into open innovation. Based on the above analysis, this paper proposes the following hypothesis:

Hypothesis 2: Organizational inertia will strengthen the inverse U-shaped relationship between the degree of internationalization and open innovation.

2.2.3. The moderating effect of professional background heterogeneity in senior management teams

Resource orchestration theory is based on resource management behaviors, including the focus on dynamic capabilities, and the ability of managers to construct, integrate and allocate internal and external resources plays an important role in an organization's adaptation to the environment (Wang Shiquan, 2022). Therefore, the characteristics of the top management team will also directly affect the resource orchestration of an enterprise. The heterogeneity of the professional background of the executive team refers to the degree of difference between the occupations or positions of the team members before they enter the enterprise as executives, which will lead to the different understanding of the job elements and professional knowledge of different executives (Zhao Jun, 2023), which will directly affect the absorption and utilization of external resources by the organization. The higher the heterogeneity of the professional background of the senior management team, the greater the differences in views and starting points of corporate decision-making among the members (Deng Xinming, 2021). Therefore, under the same degree of internationalization, compared with enterprises with low heterogeneity of professional background, enterprises with high heterogeneity of professional background of senior management team have greater differences in thinking and ways of doing things among the team members, and more diversified ways of using resources. Diversification means innovation and rationalization, but also brings contradictions and conflicts. Therefore, under different degrees of internationalization, the impact of heterogeneity of professional background of senior management team will be different, which is mainly reflected in the impact on the decision and allocation of resources after acquisition.

On the one hand, in the early stage of internationalization expansion, the professional heterogeneity of senior management team will weaken the positive impact of internationalization on enterprise open innovation. First of all, the heterogeneity of career background of senior management team will reduce the ability of resource construction and resource bundling. For an enterprise with high functional background heterogeneity of the executive team, when its internationalization degree continues to deepen, the enterprise will obtain a steady stream of resources from the international market. However, since the enterprise is still in the early stage of international expansion, the demand for resources is greater than the acquisition, so the resources in this process are still limited. How to allocate limited resources to a variety of innovative behaviors depends on the decision of the senior management team. At this time, heterogeneous thinking collisions will lead to disagreements and debates within the senior management team, and the possibility of conflicts within the team is high (Zhao Jun, 2023), which reduces the efficiency of decision-making and thus affects the effective identification and efficient absorption and utilization of resources by enterprises. Thus, the influence of internationalization on open innovation is weakened. Secondly, the occupational heterogeneity of top management team affects the resource leverage in resource orchestration, that is, the decision and allocation after resource acquisition. At this stage, enterprises still lack a complete communication system and coordination system, whether with external partners or internal members (Fan Yadong, 2019). The higher the occupational background heterogeneity of senior management team members, the more detrimental it is to the smooth progress of communication and collaboration, which increases the cost of resource utilization and affects the decision-making of enterprises to innovate through external cooperation. The inverted U-shape of internationalization towards open innovation becomes smooth.

On the other hand, as the degree of internationalization continues to increase, the functional

heterogeneity of executive team will weaken the negative impact of internationalization on enterprise open innovation. First of all, in the face of a large number of international resources, heterogenous thinking promotes the integration and absorption of resources. Executives with different social and professional experiences have different professional abilities and knowledge bases, and experience and knowledge reconstruction in non-overlapping fields will affect the comprehensive evaluation of complex information by the executive team. Through information screening and team communication, functional heterogeneity of the executive team can enhance the judgment ability of the problem and improve the decision-making level of the enterprise (Zhao Jun, 2023), so as to enhance the resource orchestration ability of enterprises and the ability to cope with the risks of open innovation. Therefore, with the continuous increase in the degree of internationalization of enterprises, the increase of a large number of external resources requires enterprises to accurately screen and combine them. At this time, the senior management team with high professional background heterogeneity is more likely to generate innovative thinking and be able to integrate and absorb complex information in a reasonable and differentiated way, so as to reduce the uncertainty of open innovation results. Secondly, enterprises have formed a relatively complete working mechanism or a conventional business process in international operation (Fan Yadong, 2019), which reduces the difficulty of coordination and has a more obvious positive effect of occupational heterogeneity. Therefore, the occupational heterogeneity of senior management team reduces the difficulty of resource orchestration, improves the ability of enterprises to transform the advantages of international resources into the driving force of open innovation, and weakens the negative impact of internationalization on open innovation. Based on the above analysis, this paper proposes the following hypotheses:

Hypothesis 3: The heterogeneity of professional background of senior management team will weaken the inverse U-shaped relationship between internationalization degree and open innovation.

3. Research design

3.1. Sample and data source

Considering that the 2008 international financial crisis has A huge impact on the domestic and foreign market environment, this paper selects the manufacturing enterprises listed on the Shanghai and Shenzhen stock exchanges from 2009 to 2021 as the research object. The reasons for selecting the manufacturing industry are as follows: First, compared with other industries, the manufacturing industry has stronger innovation ability and innovation demand, which will lead to frequent cooperation and exchanges between different manufacturing enterprises, and the characteristics of open innovation are obvious; Second, the existing domestic and foreign researches on open innovation usually focus on manufacturing enterprises, so the selection of manufacturing industry can be consistent with the existing researches, so as to make the research results more universal (Ren Zhiguang, 2020). According to the purpose of the study, the following selection is carried out: First, the samples that have been ST and PT are excluded; Second, samples listed less than one year during the sample period were excluded; Third, the samples whose data were missing and could not be completed were excluded. Finally, unbalanced panel data of 21,854 observed values of 2,911 listed manufacturing multinational enterprises were obtained during the sample period. At the same time, in order to reduce the bias caused by extreme values and outliers on the research results, this paper carried out winsorize tail reduction treatment on the extreme values of 1% on both sides of all continuous variables. The overseas revenue data used in this paper comes from the Wind database, the open innovation data comes from the CNIPA database, and the other variable data mainly comes from the CSMAR database.

3.2. Definition and description of variables

Open innovation (OI). In innovation-related studies, the number of patents is generally used to describe the innovation performance of an enterprise (Feng Genfu, 2021). The types of patents applied by enterprises mainly include invention type, utility model type and design type. Among them, invention type patents are the most difficult and can better reflect the level of innovation performance of enterprises (Zheng Wei, 2020). Based on the practice of Brockman et al. (2018), this paper uses the number of jointly applied invention patents to measure the open innovation level of enterprises.

Degree of internationalization (IN). The measurement indicators of the degree of internationalization are mainly divided into three categories, namely, the depth of internationalization, the breadth of internationalization and the composite indicators (Chen Limin, 2014). The indicators of internationalization depth include the proportion of overseas business income, the proportion of overseas assets and the proportion of export sales; The indicators of internationalization breadth include the number of overseas subsidiaries, the proportion of overseas subsidiaries, etc. The composite index includes the three-dimension method proposed by Sullivan (1994) and the two-dimension method proposed by Goerzen et al. (2003). Due to the limited data disclosure of listed companies in China, considering the availability and representativeness of data, this paper refers to the practice of Liu Sukun (2022) and adopts the proportion of overseas business revenue in total revenue to measure the degree of internationalization of enterprises.

Organizational inertia (Iner). In this paper, referring to the research of Lian Yanling et al. (2015) and Sun Hui (2020), the two indicators of employee size and enterprise establishment period were standardized respectively and then added to measure organizational inertia. Employee size was measured by the natural logarithm of the total number of employees added by 1. The number of years of establishment of the enterprise is measured by the natural logarithm after the number of years of establishment of the enterprise is added by 1.

Functional background heterogeneity of executive team (CH). In this paper, the Herfindal-Hirschma coefficient (also known as Blau coefficient) is used to calculate functional background heterogeneity with reference to the research of Xuili Wang (2013). The calculation formula is as follows: $H = 1 - \sum_{i=1}^{n} Pi^2$, where Pi2 refers to the percentage of members with Class i functional background in the senior management team, and n refers to the number of categories of functional background. The value of H ranges from 0 to 1, and the larger the value, the higher the degree of functional background heterogeneity of the executive team.

Based on the studies of Zeng Jianghong (2022) and Jia Ximeng (2022), the factors that may affect open innovation are further controlled. The selected control variables include: Enterprise Size (Size), enterprise Age (Age), return on equity (Roe), asset-liability ratio (Lev), proportion of independent directors (Indep), shareholding ratio of the largest shareholder (Top1) and Fixed assets ratio (Fixed). In addition, in order to avoid the potential impact of time variation factors on the estimation results, the annual dummy variable (Year) was added to the model in this study.

The specific definitions and measurements of the above variables are shown in Table 1.

Table 1 Variable names, definitions and measurement sources

Variable names	Variable symbol	Variable definition
Open innovation	OI	Number of invention type patents jointly filed
Degree of internationalization	IN	Income/total revenue from overseas operations

Organizational inertia	Iner	The sum of two indicators, the size of employees and the period of establishment of the enterprise, after standardization respectively
Professional background heterogeneity of senior management team	CH	$H = 1 - \sum_{i=1}^{n} Pi^2$
Business size	Size	ln(revenue from operations)
Age of business	Age	ln(Year of observation - year of establishment +1)
Asset-liability ratio	Lev	Total liabilities/Total assets
Ratio of the largest shareholder	Top1	Number of shares held by the largest shareholder/total share capital
Return on equity	Roe	Net profit/average balance of shareholders' equity
Percentage of independent directors	Indep	Number of independent directors/total number of board members
Fixed assets ratio	Fixed	Fixed assets/total assets
Annual dummy variable	Year	The study sample spans 13 years and generates 10 dummy variables

3.3. Regression model

To test hypothesis H1, equation (1) is established:

$$OIi,t = \beta 0 + \beta 1INi, t2 + \beta 2IN + \sum j1 \delta jControlsi, t + Year\ dummy + Industry\ dummy + \varepsilon i, t \quad (1)$$

In order to test hypothesis H2 and H3, on the basis of equation (1), the interaction terms of enterprise inertia and executive team functional background heterogeneity with internationalization degree and internationalization degree squared are added, and equation (2) and equation (3) are established:

$$OIi,t = \beta 0 + \beta 1INi, t2 + \beta 2IN + 3\beta IN2i, t \times Ineri, t + \beta 4IN \times Iner + \beta 5Iner + \beta 6 \sum Controlsi, t + Year\ dummy + Industry\ dummy + \varepsilon i, t \quad (2)$$

$$OIi,t = \beta 0 + \beta 1INi, t2 + \beta 2IN + 3\beta IN2i, t \times CHi, t + \beta 4IN \times CH + \beta 5CH + \beta 6 \sum Controlsi, t + Year\ dummy + Industry\ dummy + \varepsilon i, t \quad (3)$$

3.4. Descriptive statistics and correlation analysis

Table 2 shows the descriptive statistics results of variables, showing the mean value, standard deviation, maximum value and minimum value of all variables, which can form a preliminary understanding of the sample data and pave the way for further regression analysis. Among them, the sample mean reflects the overall level of the variable data, the standard deviation reflects the fluctuation degree of the variable data, that is, whether the variable is stable, and the minimum and

maximum values reflect the differences of the variable data. As can be seen from Table 1, the maximum number of open innovation in Chinese manufacturing enterprises is 55, and the mean is 1.979, indicating that the overall activity of open innovation in Chinese enterprises is not high, and the results of open innovation are significantly different among enterprises. At the same time, the mean of internationalization level of manufacturing enterprises is 0.171, and the variance is 0.227, indicating that there is still a gap in the international expansion of manufacturing enterprises, and some enterprises have not carried out international operations.

Table 2 Descriptive statistics of variables

Variable name	Average	Minimum	median	Maximum	Standard deviation
OI	1.976	0.000	0.000	55.000	7.329
IN	0.171	0.000	0.068	0.912	0.227
Size	21.373	18.658	21.223	25.210	1.350
Age	2.839	1.609	2.890	3.497	0.352
Lev	0.386	0.050	0.376	0.861	0.195
Top1	0.340	0.090	0.320	0.732	0.142
Roe	0.074	-0.503	0.078	0.364	0.117
Indep	0.375	0.333	0.333	0.571	0.053
Fixed	0.223	0.015	0.197	0.618	0.135
Iner	0.063	-3.534	0.106	3.045	1.321
CH	0.689	0.320	0.711	0.817	0.093

Table 3 shows the correlation analysis results of variables. According to the results, it can be preliminarily judged that there is a correlation between independent variables and dependent variables, and the correlation coefficient between each variable is less than 0.8, indicating that there is no serious multicollinearity between variables. In addition, variance inflation factor (VIF) diagnosis was performed on all variables of the regression model in this paper. The results showed that the mean VIF of each model was less than 3, and the VIF value of all variables was less than 10, indicating that there was no serious multicollinearity between the variables in this study, and further regression analysis could be conducted.

Table 3 Correlation coefficient matrix of variables

	OI	IN	Size	Age	Lev	Top1	Roe	Indep	Fixed	Iner	CH
OI	1										
IN	0.017 **	1									
Size	0.276 ***	0.00200	1								
Age	0.070 ***	0.035 ***	0.188 ***	1							
Lev	0.106 ***	0.036 ***	0.513 ***	0.143 ***	1						
Top1	0.00700	0.017 **	0.142 ***	0.116 ***	-0.00600	1					
Roe	0.062 ***	0.016 **	0.162 ***	0.071 ***	0.243 ***	0.134 ***	1				
Indep	0.021 ***	0.024 ***	0.019 ***	0.016 **	-0.00900	0.058 ***	0.021 ***	1			
Fixed	-0.0100	0.029 ***	0.174 ***	0.047 ***	0.209 ***	0.029 ***	0.133 ***	0.034 ***	1		

Iner	0.201 * * *	0.022 * * *	0.662 * * *	0.782 * * *	0.391 * * *	0.008 00	0.006 00	-0.00400	0.181 * * *	1	
CH	0.039 * * *	0.048 * * *	-0.0090 0	0.061 * * *	0.066 * * *	0.027 * * *	0.010 0	0.017 * *	0.055 * * *	0.022 * * *	1

Note:*,** and*** indicate that P values are significant at the 10%, 5%, and 1% levels, respectively.

4. Empirical results and analysis

4.1. Benchmark regression results

In this paper, 21,854 observations from 2,911 manufacturing enterprises during 2009-2021 are used to estimate the model using panel data regression method. First of all, the results of Hausman test show that all regression results reject the random effects model, so this paper adopts the fixed effects model for regression analysis. The regression results are shown in Table 4.

Model 1 is the base model and contains only all the control variables. The regression model of Model 2 incorporates the degree of internationalization and its quadratic terms. Model 3 adds the interaction term between degree of internationalization and organizational inertia (IN×Iner), and the interaction term between degree of internationalization and organizational inertia (IN^2 ×Iner). IN Model 4, the interaction term between degree of internationalization and the heterogeneity of professional background of the senior management team (IN×CH) and the interaction term between degree of internationalization and the heterogeneity of professional background of the senior management team (in ² ×CH) are added.

The regression results of Model 2 show that the coefficient of internationalization degree is 3.337, and the coefficient of square term is -3.078, both at the level of 1%, which is significant, indicating that the level of open innovation of enterprises increases first and then decreases with the deepening of internationalization degree, and there is an inverted U-shaped relationship between internationalization degree and open innovation. At the same time, utest command test is carried out on the inverse U-shaped relationship, and the results show that the relationship between internationalization degree and open innovation is first positive (3.337, $p<0.01$) and then negative (-2.278, $p<0.01$). The extreme point of internationalization degree is 0.542, which is in the 99% Fieller range [0.379, 10.743], the p value of the overall test result of the inverted U-shaped relationship is less than 0.05, rejecting the null hypothesis. Therefore, it can indicate that the inverted U-shaped relationship between the degree of internationalization and open innovation is established, and hypothesis H1 is verified.

Model 3 verifies the moderating effect of organizational inertia on the relationship between internationalization degree and open innovation. The regression results show that the interaction term (IN^2 × Iner) between the degree of internationalization and organizational inertia is significantly negative at the level of 1%, which indicates that organizational inertia will strengthen the inverse U-shaped relationship between the degree of internationalization and open innovation, that is, when the degree of internationalization is at a low to medium level, organizational inertia strengthens the relationship between the degree of internationalization and open innovation. When the degree of internationalization exceeds a certain level, organizational inertia strengthens the negative influence of internationalization on open innovation. Hypothesis H2 is verified.

Model 4 further verifies the moderating effect of professional background heterogeneity on the relationship between internationalization degree and open innovation. The regression results show that the interaction term (IN^2 ×CH) between the square term of the degree of internationalization and the heterogeneity of the professional background of the executive team is significantly positive at 5%, which indicates that the heterogeneity of the professional background of the executive team

will weaken the inverted U-shaped relationship between the degree of internationalization and open innovation, that is, when the degree of internationalization is at a medium or low level, The heterogeneity of the professional background of the top management team weakens the relationship between internationalization degree and open innovation; When the degree of internationalization exceeds a certain level, the heterogeneity of professional background of the executive team weakens the negative impact of internationalization on open innovation. Hypothesis H3 is verified.

Model 5 is used as a complete regression model to further test the above research model, and the results still support the results of model 2, Model 3 and model 4, thus verifying the stability of the study findings.

Table 4 Results of fixed effects regression analysis

Name of variable	(1) OI	(2) OI	(3) OI	(4) OI	(5) OI
Size	0.659 * * *	0.642 * * *	0.557 * * *	0.646 * * *	0.572 * * *
	(7.54)	(7.30)	(4.96)	(7.35)	(5.09)
Age	-0.730	-0.789	1.171 *	-0.820	1.184 *
	(-1.32)	(-1.42)	(-1.68)	(-1.47)	(-1.70)
Lev	-0.114	-0.112	-0.154	-0.135	-0.191
	(-0.30)	(-0.30)	(-0.41)	(-0.36)	(-0.51)
Top1	0.297	0.316	0.437	0.306	0.457
	(0.48)	(0.52)	(0.71)	(0.50)	(0.75)
Roe	-0.032	0.033	0.098	0.028	0.092
	(-0.08)	(0.09)	(0.25)	(0.07)	(0.24)
Indep	-0.786	-0.804	-0.743	-0.843	-0.853
	(-0.77)	(-0.78)	(-0.73)	(-0.82)	(-0.83)
Fixed	0.204	0.121	0.100	0.112	0.089
	(0.41)	(0.25)	(0.20)	(0.23)	(0.18)
IN		3.038 * * *	3.109 * * *	11.791 * *	16.041 * * *
		(3.19)	(3.23)	(2.53)	(3.30)
IN2		3.107 * * *	3.365 * * *	20.476 * * *	27.378 * * *
		(-2.65)	(-2.83)	(-3.08)	(-3.97)
Iner			0.053		0.050
			(0.33)		(0.31)
IN×Iner			2.346 * * *		2.358 * * *
			(4.82)		(4.74)
IN2×Iner			3.076 * * *		3.006 * * *
			(-4.86)		(-4.67)
CH				0.199	0.530
				(0.26)	(0.69)
IN×CH				12.610 *	17.688 * * *
				(-1.91)	(-2.64)
IN2×CH				24.973 * * *	31.759 * * *
				(2.65)	(3.33)

Constant	11.576 * * *	11.308 * * *	8.450 * *	11.433 * * *	8.722 * *
	(-5.44)	(-5.31)	(-2.46)	(-5.13)	(-2.50)
Observations	21,835	21,835	21,835	21,835	21,835
R-squared	0.037	0.038	0.039	0.038	0.040
Number of stock	2,911	2,911	2,911	2,911	2,911
Company FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
F	38.55	35.40	32.09	31.36	26.55

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.2. Endogenous processing

4.2.1. Propensity score matching method

For the endogeneity problems that may be caused by data omission, the propensity score matching method (PSM) is used in this paper for re-regression analysis. Specifically, this paper presents the dummy variable of internationalization degree, that is, divides it into a group of high internationalization degree (assigned 1) and a group of low internationalization degree (assigned 0) according to the median, selects the factors that may affect open innovation, that is, the control variable in the regression model, as the matching variable of internationalization degree index, and uses the Logit model for regression. The propensity score (PS value) of sample firms entering the treatment group (high degree of internationalization) was calculated by the fitting value, and the propensity score PS value of the treatment group (high degree of internationalization) and the control group (low degree of internationalization) was matched by the "nearest neighbor matching method". The kernel density function before and after PS value matching is shown in Figure 1. It can be seen that before the matching, the PS value probability distribution of the treatment group (high degree of internationalization) and the control group (low degree of internationalization) is different. After the matching is completed, the PS value probability distribution of the two groups is closer, which has a good matching effect.

Considering the average difference between the treatment group and the control group, the average treatment effect (ATT) method was further used to estimate the result, that is, the average effect of the treatment when the total sample contains only the samples that are really likely to be processed. The estimated ATT average effect using PSM method shows that the gap is 0.763, and the T-test is significant at the level of 1%, indicating that there is a significant difference in the level of open innovation between the treatment group and the control group, and the degree of internationalization has a significant impact on open innovation.

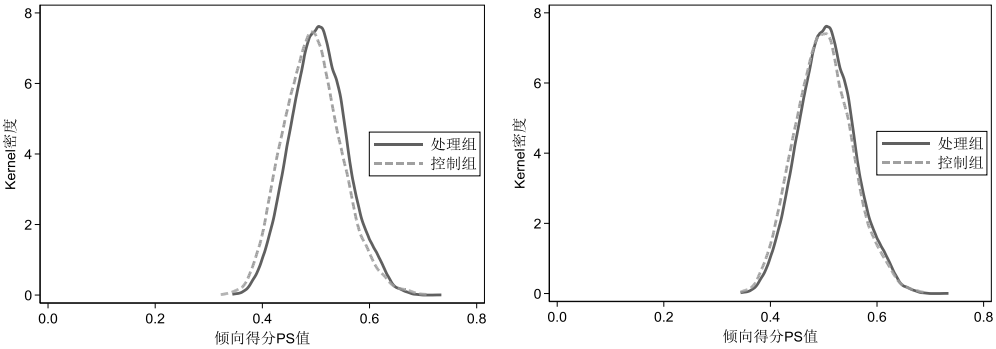

Figure 1 (a) before the matching Figure 1 (b) after the matching

Table 5 Processing effects of propensity score matching

Treatment effects	Sample	Handling Group	Control Group	Gaps	Standard Error	T-value
ATT under logit model	After matching	2.401	1.638	0.763	0.105	7.24***

Table 6 shows the estimation results of the constructed sample based on nearest neighbor matching. The results show that the relationship between internationalization degree and open innovation is still an inverted U-shaped relationship with first increase and then decrease, which is consistent with the baseline regression results.

Table 6 Test results of propensity score matching method and nearest neighbor matching method

	(6)
Variable name	OI
IN	3.037 * * *
	(3.14)
IN2	3.124 * * *
	(-2.62)
Constant	11.168 * * *
	(-5.14)
Controls	Yes
Observations	21,340
R-squared	0.038
Company FE	Yes
Year FE	Yes
Industry FE	Yes

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.2.2. Instrumental variable method

With the improvement of the level of open innovation, enterprises may participate in the global market competition with a more open mind, thus promoting the improvement of the level of internationalization of enterprises (Zheng Wei, 2020), that is, there may be reverse causality between internationalization and open innovation. In order to reduce the potential endogenous bias in parameter estimation, this study draws on the method used by Zhang Jie et al. (2011) to construct instrumental variables. The cubic index of (degree of internationalization -- the mean value of the estimated degree of internationalization) is selected as the instrumental variable (IV) of the degree of internationalization indicator, and the degree of internationalization lags by one stage is taken as another instrumental variable (IVV) of the degree of internationalization indicator. And IV square (IV2) and IVV square (IVV2) were used as the two instrumental variables of the quadratic term of internationalization degree of endogenous variables, respectively, and the two-stage least square method (2SLS) was used for estimation. The logic of choosing one period lag as the instrumental variable is that enterprises usually regard internationalization as a long-term strategy, so the internationalization degree of the previous period has a strong connection with the internationalization degree of the current period, but from the perspective of the current period, the internationalization of the previous period has become a fact of the past, so it has nothing to do with the error term of the current period. As shown in the second half of Table 7, the Kleibergen-Paap rk LM statistic of the instrumental variable is 1345.169 (p=0.000), indicating that there is no problem of insufficient recognition; The Kleibergen-Paap rk Wald F statistic was 1194.565, higher than 15% of the Stock-Yogo standard (7.56), which passed the weak tool variable test. The Hansen J statistic is 1.491 (p=0.4744), indicating that there is no overrecognition problem, so the instrumental variables selected in this paper are reasonable. The top half of Table 7 is the result of estimation using two-stage least square method. In the first stage, the correlation between instrumental variables and the degree of internationalization and its quadratic index is tested, and the result shows that the instrumental variables are highly correlated with the degree of internationalization and its quadratic index (p<0.01). In the second stage, the estimation of open innovation is conducted, and the result shows that after controlling the reverse causality, The relationship between the degree of internationalization and open innovation is still an inverted U-shaped relationship with first increase and then decrease, which is consistent with the result of baseline regression.

Table 7 Results of two-stage least square method (2SLS) test

Variable names	first stage		second stage
	IN	IN2	OI
IV	3.845 * * *		
	(57.50)		
IVV	0.763 * * *		
	(44.38)		
IV2		3.877 * * *	
		(-59.60)	
IVV2		0.166 * * *	
		(-17.38)	
IN			4.057 * *
			(2.55)

IN2			4.179 * * (-2.47)
Controls	Yes	Yes	Yes
Company FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Kleibergen-Paap rk LM statistics	1345.169 [0.0000]		
Kleibergen-Paap rk Wald F statistic	{1194.565, 7.56}		
Hansen J statistic	1.491 [0.4744]		
Observations	18,408	18,408	18,408

Note: ***, ** and * indicate significance levels at 1%, 5% and 10%, respectively; () values are robust standard error, [] values are p-values, {} values are critical values at the 10% level of the Stock-Yogo weak recognition test.

4.3. Robustness test

4.3.1. Control fixed effect test

The external macroeconomic environment will affect the company's strategic decision and related innovation behavior. On the one hand, different economic situations may affect managers' judgment on the future, which will change the willingness of enterprises to invest abroad and the choice of internationalization strategy; On the other hand, different geographical environments will lead to different international resources available to enterprises. In China, each province has its own provincial policies, and some policies may change with time, so enterprises in different regions will face different external environments. In order to eliminate the differences caused by policies and policy changes in different provinces, this paper further controls the province effect and the combined effect of province and year on the basis of the above empirical analysis. The model in Table 8 is the result of controlling the province effect, and the model is the result of controlling the province effect and the joint effect of the province and the year. The results are consistent with the conclusion of the baseline regression, and the assumptions are robust.

Table 8 Robustness test of control fixed effects

	(7)	(8)	(9)	(10)	(11)	(12)
Variable Names	OI	OI	OI	OI	OI	OI
IN	3.022 * * *	3.087 * * *	12.060 * * *	3.346 * * *	3.462 * * *	15.035 * * *
	(3.16)	(3.20)	(2.58)	(3.46)	(3.55)	(3.17)
IN2	3.096 * * *	3.350 * * *	20.686 * * *	3.311 * * *	3.658 * * *	24.871 * * *
	(-2.64)	(-2.81)	(-3.10)	(-2.79)	(-3.04)	(-3.69)
Iner		0.036			0.039	
		(0.22)			(0.24)	

IN×Iner		2.423 ***			2.211 ***	
		(4.97)			(4.43)	
IN2×Iner		3.157 ***			2.999 ***	
		(-4.98)			(-4.67)	
CH			0.250			0.497
			(0.33)			(0.64)
IN×CH			13.023 **			16.851 **
			(-1.96)			(-2.50)
IN2×CH			25.290 ***			31.008 ***
			(2.67)			(3.24)
Constant	11.979 ***	9.273 **	12.192 ***	9.607 ***	7.339 *	9.998 ***
	(-4.57)	(-2.47)	(-4.49)	(-3.50)	(-1.90)	(-3.53)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	21,835	21,835	21,835	21,835	21,835	21,835
R-squared	0.039	0.040	0.039	0.057	0.058	0.057
Company FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Indystry FE	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year*Province	No	No	No	Yes	Yes	Yes
F	18.99	18.32	17.88	2.775	2.814	2.786

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3.2. Change the model test

In this paper, the number of joint invention patents is used to measure the open innovation level of enterprises. Because the data is greater than or equal to 0, if only the ordinary least square method is used to estimate, the regression result may be biased because the data does not fully conform to the characteristics of normal distribution. Therefore, this study uses Tobit regression to replace the least square regression in the baseline regression, and further conducts the robustness test. The regression results are shown in Table 9. The results show that the quadratic coefficient of internationalization degree is significantly negative, that is, the impact of internationalization on open innovation is inverted U-shaped, organizational inertia strengthens the impact of internationalization on open innovation, and the heterogeneity of professional background of senior management team weakens the impact of internationalization on open innovation, which is consistent with the conclusion of benchmark regression.

4.3.3. Shorten the sample time

The COVID-19 pandemic, which began in 2020, has reduced the volume of foreign trade of

countries around the world, which has had an impact on the operations of Chinese multinational companies, which in turn will affect the outbound investment of enterprises. In order to reduce the possible impact of COVID-19 on the global economy and transnational corporations and cause errors in the research results, this paper chooses to shorten the sample time to conduct a robustness test, and the sample size is still sufficient after excluding 5,289 sample data in 2020 and 2021. The regression results are shown in Table 9. The results show that after the sample interval is shortened, the relationship between internationalization and open innovation is still inverted U-shaped, and the moderating effects of organizational inertia and the heterogeneity of the professional background of the executive team are also consistent with those mentioned above.

Table 9 Robustness test of changing the regression model and shortening the sample interval

	Tobit model			Subsample intervals		
	(13)	(14)	(15)	(16)	(17)	(18)
Variable names	OI	OI	OI	OI	OI	OI
IN	13.956 * * *	10.020 * * *	74.510 * * *	3.259 * * *	3.530 * * *	14.012 * * *
	(6.49)	(4.58)	(4.63)	(3.01)	(3.22)	(2.75)
IN2	20.633 * * *	16.262 * * *	79.327 * * *	3.571 * * *	3.968 * * *	24.480 * * *
	(-6.96)	(-5.45)	(-3.38)	(-2.67)	(-2.89)	(-3.33)
Iner		2.029 * * *			0.044	
		(4.89)			(0.25)	
IN×Iner		9.605 * * *			2.498 * * *	
		(6.23)			(4.49)	
IN2×Iner		12.967 * * *			2.886 * * *	
		(-6.16)			(-4.02)	
CH			14.703 * * *			-0.153
			(5.96)			(-0.18)
IN×CH			87.697 * * *			15.671 * *
			(-3.81)			(-2.15)
IN2×CH			85.105 * *			30.406 * * *
			(2.54)			(2.88)
Constant	146.754 * * *	94.781 * * *	156.835 * * *	13.287 * * *	9.823 * *	13.044 * * *
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	21,835	21,835	21,835	16,546	16,546	16,546
Company FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Expansion analysis

The impact of internationalization of manufacturing enterprises on open innovation may vary according to the characteristics of enterprises, so some characteristics are included in the model as control variables in the aforementioned regression analysis. This part further carries out an expansive analysis from three aspects: ownership nature, firm scale and firm life cycle. Details are as follows:

5.1. Further analysis based on the nature of ownership

State-owned enterprises and non-state-owned enterprises have different access to resources, which may have a different impact on the relationship between internationalization and open innovation. In this paper, all samples are divided into two sub-samples of state-owned enterprises and non-state-owned enterprises according to whether they are state-owned enterprises or not. The sample sizes are 6035 and 15800 respectively. The results of respective regression are shown in the first two columns of Table 10. In model (18), the quadratic coefficient of the degree of internationalization is not significant, while in model (19), the quadratic coefficient of the degree of internationalization is negatively significant at the level of 5%. The results show that for non-state-owned enterprises, the influence of internationalization on open innovation is inverted U-shaped. However, for state-owned enterprises, the increase of internationalization degree does not have a significant impact on open innovation. The reason for the difference may be the existence of "ownership discrimination". In the process of enterprise development, state-owned enterprises enjoy more support of resources and information policies provided by the government, have rich innovation resources, face less competitive pressure and willingness to open up (Pang Ruizhi, 2022), and enterprise innovation activities are less dependent on enterprises' own access to external resources. Therefore, the resource effect brought about by internationalization has no obvious influence on open innovation. Compared with state-owned enterprises, non-state-owned enterprises are faced with more serious resource constraints, whether it is financial support from banks or policy resources from the government. With the establishment of market economic order, non-state-owned enterprises are more motivated to explore and innovate. Therefore, they need to supplement innovation resources through internationalization, and have a more open and inclusive mentality. Thus, the open innovation activities of enterprises are promoted and the market competitiveness of enterprises is enhanced.

5.2. Further analysis based on enterprise scale

The ability of listed manufacturing companies of different sizes to access and integrate internationalized resources may vary, and the impact of enhanced internationalization on open innovation may vary (Rio de Janeiro et al, 2013). In this paper, the mean value of firm Size (Size) is used as the segmentation point, and the sample is divided into large multinational enterprise group above the mean value and small and medium-sized multinational enterprise group below the mean value. The sample size is 9950 and 11,885 respectively. The empirical results are shown in the middle two columns of Table 10. In model (21), the quadratic coefficient of internationalization degree is significantly negative at the level of 1%, while in model (22), the quadratic coefficient of internationalization degree is not significant. The results show that for large enterprises, with the increase of internationalization degree, their open innovation increases first and then decreases; But for small and medium-sized enterprises, internationalization has no significant impact on open

innovation. This may be because large manufacturing enterprises, with their abundant capital and rich operating experience, have a high acceptance of the costs and risks required by international expansion and open innovation. Moreover, large manufacturing enterprises have a relatively stable market position and high technological innovation capability. The control of external environment and risks enhances their open mentality. Therefore, enterprises can flexibly adjust their internationalization strategy according to their own goals, and invest the acquired external resources into open innovation activities; As for small and medium-sized manufacturing enterprises, they are generally in the rising stage of rapid development and have low ability to predict environmental uncertainty. Maintaining their own survival and improving independent innovation are the necessary ways for them to obtain further development and competitive advantages. Therefore, the impact of internationalization on open innovation is not significant.

5.3. Further analysis based on the enterprise life cycle

Enterprises have different demand for resources in different life cycle stages, and the impact of internationalization on open innovation will also change accordingly. Based on the practice of Liang Shangkun (2019), this paper measures the life cycle of a company by using the comprehensive scores of four variables: sales revenue growth rate, retention rate of return, capital expenditure rate and company age. In other words, according to the comprehensive score, about 1/4 of the enterprises with the highest score are in the growth stage, and about 1/4 of the enterprises with the lowest score are in the recession stage. And the middle half are mature enterprises, with sample sizes of 5055, 5000 and 9938, respectively. Models 23, 24 and 25 examined the impact of internationalization on open innovation at maturity, growth and decline stages respectively. In model 23 and model 25, the quadratic coefficients of the degree of internationalization are -3.493 and -0.504 respectively, and the corresponding P-values are not significant. In model 24, the quadratic coefficients of the degree of internationalization are negatively significant at the level of 5%. The results show that for enterprises in the growth stage, the influence of internationalization on open innovation is inverted U-shaped. However, for enterprises in mature and declining stages, the increase of internationalization degree does not have a significant impact on open innovation. This may be because for enterprises in the growth stage, they are in a period of rapid development, and they urgently need to form their own competitive advantages in the market. They have a large demand for external resources, and they have not yet formed an inherent structural system, so they can flexibly adjust their strategies to realize the combination of internal and external resources. The fast open innovation activity is also an important way for enterprises at this stage to quickly occupy the market with resources and gain competitive advantages. However, enterprises in the mature stage have already occupied a certain position in the market, have rich resources accumulation, and pay more attention to the improvement of independent innovation ability, while enterprises in the declining stage lack innovation motivation. Therefore, for enterprises in these two stages, the increase of internationalization degree has no significant impact on open innovation.

Table 10 Results of heterogeneity test

	Nature of ownership		Business size		Business life cycle		
	(19)	(20)	(21)	(22)	(23)	(24)	(25)
	State-owned enterprises	Non-state-owned enterprises	Large enterprises	Small and medium-sized	Mature stage	Growth stage	Decline phase

				businesses			
Variable name	OI	OI	OI	OI	OI	OI	OI
IN	3.966 ***	3.014 ***	6.852 ***	0.966	1.509	6.344 ***	1.896
	(1.77)	(2.92)	(3.26)	(1.44)	(0.98)	(2.72)	(0.82)
IN2	-4.614	3.056 **	8.123 ***	-0.579	-1.967	6.028 **	-0.873
	(-1.57)	(-2.47)	(-3.09)	(-0.71)	(-1.04)	(-2.16)	(-0.29)
Constant	32.675 ***	9.650 ***	21.459 ***	12.160 ***	7.402 *	-5.497	-6.873
	(-6.07)	(-4.12)	(-3.92)	(-7.35)	(-1.90)	(-1.01)	(-0.92)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,035	15,800	9,950	11,885	9,938	5,055	5,000
R-squared	0.064	0.030	0.052	0.021	0.040	0.042	0.031
Number of stock	666	2,428	1,573	2,278	2,246	1,719	1,352
Company FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6. Conclusion and Enlightenment

6.1. Research conclusions

Based on the resource orchestration theory, this paper examines the relationship between internationalization and open innovation of manufacturing enterprises, and the moderating effects of organizational inertia and the heterogeneity of professional background of senior management teams, using the sample data of listed manufacturing enterprises in China from 2009 to 2021. The empirical results show that there is an inverted U-shaped relationship between internationalization and open innovation in manufacturing enterprises. When the degree of internationalization is relatively low, the positive impact of internationalization on open innovation exceeds the negative impact, and the internationalization resources of enterprises can be more effectively invested in open innovation. However, when the degree of internationalization reaches a certain inflection point, the negative impact of the promotion of internationalization on the open innovation of enterprises exceeds the positive impact, and the internationalization of enterprises is not conducive to the expansion of open innovation. It is further found that organizational inertia can enhance the path dependence in the process of resource orchestration, thus strengthening the inverse U-shaped relationship between internationalization and open innovation, while the heterogeneity of professional background of senior management team can enhance the diversity of opinions in the process of resource orchestration, thus weakening the inverse U-shaped relationship between internationalization and open innovation. The expansion study finds that compared with listed companies and non-state-owned enterprises in the manufacturing industry in the growth stage, enterprises in the maturity and decline stage and state-owned enterprises have less dependence on and demand for external resources, and the driving force of internationalization resource construction is weaker. Compared with the small and medium-sized manufacturing listed

companies, the impact of internationalization on open innovation of large enterprises is more obvious.

6.2. Management implications

6.2.1. At the government level

Strengthen the implementation of the comprehensive opening-up strategy and create a favorable business environment for enterprises. Nowadays, trade protectionism is on the rise and the international competition environment is becoming increasingly fierce. China, as a responsible major country, should continue to firmly implement the strategy of opening up, establish stable trade and cooperation relations with other countries in the world, and actively integrate into the global innovation network, so as to provide a good institutional environment for the open innovation of Chinese enterprises. At present, China has signed investment protection agreements with many countries or regions, but there are few protection agreements concerning China's overseas investment. Therefore, the Chinese government should further promote the iron hook protection in this aspect, and achieve the purpose of cooperation with other countries through negotiation and exchange, so as to promote the internationalization process of enterprises and create a good atmosphere for innovation and opening up.

We will increase financial subsidies for open innovation and increase the willingness of enterprises to open innovation. This study shows that in the early stage of internationalization, open innovation can bring great driving force to open innovation, while enterprises need to face greater risk and financial pressure. Enterprises will choose among various innovation methods when making innovation decisions, and open innovation may not be the first choice for enterprises. Therefore, the government can introduce relevant tax policies and financial policies, which on the one hand can directly alleviate the capital pressure of enterprises, on the other hand, encourage enterprises to actively participate in open innovation, so as to give full play to the role of internationalization in promoting enterprise innovation.

6.2.2. Enterprise level

Firmly implement the "going global" strategy and promote the coordinated development of opening up and innovation. From the sample data, we can see that there is still a lot of room for improvement in the internationalization of Chinese enterprises. Therefore, enterprises should implement a more open and proactive strategy, actively cooperate with foreign research and development institutions, and constantly seek complementary resources that fit with themselves to promote the development of open innovation. However, in the global network layout, enterprises should pay attention not to over-invest in international expansion. After reaching a certain inflection point, enterprises should consider the matching problem of resources and capabilities, in order to maximize the level of open innovation and enhance their own technical capabilities in the process of internationalization with the help of resource effects.

Enhance the resource orchestration ability of enterprises, and strengthen the driving force of resources for open innovation. Enterprises engaged in internationalization should evaluate the benefits of internationalization and their own capabilities accordingly. The research results show that, in the initial stage of internationalization, the external resources brought by internationalization can be effectively identified and fully absorbed by enterprises, thus forming complementary resources to promote the open innovation of enterprises. However, after reaching a certain threshold, when the resources brought by internationalization exceed the resource orchestration ability of enterprises, it is not only difficult to generate innovation impetus, but also aggravate the cost of

open innovation of enterprises, thus changing from positive to negative impact. Based on the above analysis, in the process of international expansion, enterprises should continuously improve the ability of enterprise resource orchestration and enhance the ability to identify and integrate international resources, so as to delay the inverted U-shaped curve between internationalization and open innovation in the above model from peak to decline.

Timely update the organizational structure according to the changes in the external environment, and actively improve the internal management system of the organization. This study finds that organizational inertia can strengthen the impact of internationalization on open innovation through path dependence. Therefore, enterprises should improve their insight into the changes of external environment, and timely update and improve the overall organizational structure to improve the correctness of resource orchestration and integration with path dependence. In addition, considering the moderating effect of the heterogeneity of the senior management team on the relationship between internationalization and open innovation, enterprises should conduct a comprehensive evaluation of personnel when selecting talents to join the senior management team, strengthen the communication between the senior management team, and set up a senior management team with complementary advantages and efficient coordination, so as to improve the efficiency and innovation of the enterprise resource orchestration.

6.2.3. Research limitations and prospects

Inevitably, there are some limitations in this study. First of all, the research object of this paper is manufacturing enterprises. For enterprises in emerging markets or high-tech enterprises and other enterprises, whether this relationship is established still needs further research and verification. Secondly, this paper only considers the influence of internal situational factors on the relationship between internationalization and open innovation. Future studies can also study the influence of external factors such as the degree of market competition on the relationship between internationalization and open innovation, so as to further expand this research model.

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