

Why Does Institutional Opening-up Promote the Enhancement of Innovation Capabilities in Chinese Enterprises?

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Abstract: China's involvement in global economic governance has been a progressive and step-by-step ascent. While the domestic and international environment has undergone major changes, the process of economic globalization has taken on new trends, and China has entered a new stage of high-level opening up. This paper's theoretical analysis suggests that high-level opening up helps enhance the quality of foreign capital utilization, thereby addressing the challenges associated with the lower technological benefits of previous foreign capital utilization and further facilitating the enhancement of innovation capabilities in Chinese enterprises. Guided by this theoretical framework, this study has measured the level of opening up in Chinese provinces from 2013 to 2022 using web crawling technology. Econometric tests conducted with Chinese enterprise panel data reveal that: firstly, First, it effectively promotes the improvement of the total innovation output of enterprises and significantly improves breakthrough innovation capabilities. This result still holds true under a series of robustness and endogeneity tests; secondly, it mainly improves local advantages and high-quality international The attraction of foreign capital and multinational companies enables local companies to achieve breakthroughs and catch-up in core technologies by learning and competing with advanced foreign companies, thereby enhancing their technological innovation capabilities; thirdly, for companies in different industries and different ownership attributes The impact of improving innovation capabilities may vary. This study helps promote a new paradigm of innovation-driven development in the context of high-level opening-up.

Keywords: High-level opening up, Utilizing Foreign Capital, Innovation.

1. Introduction and Review of Related Literature

In the context of rapidly changing globalization and geopolitical dynamics, China is at a crucial stage of high-quality economic transformation, where an innovation-driven development strategy has become the core driving force. According to the report of the 20th National Congress of the Communist Party, accelerating technological self-reliance and strength is not only a strategic direction but also essential for achieving national modernization. President Xi Jinping emphasized on May 28, 2018, during the 19th meeting of the Chinese Academy of Sciences and the 14th meeting of the Chinese Academy of Engineering, that "Innovation should occur in an open environment; it cannot be done in isolation but should integrate and leverage global resources." Since the reform and opening up, China has embraced the trend of economic globalization, seizing strategic opportunities brought about by it, which has significantly enhanced the cultivation of high-end elements and technological innovation capabilities of domestic enterprises. Specifically, domestic enterprises have integrated into the global value chain through the industrial transfer and technology diffusion initiated by multinational corporations from developed countries, achieving technological advancements and surpassing, which are key experiences for China's rapid economic growth. Clearly, enhancing enterprise innovation capability is a complex systematic project that needs to occur in an open economic environment and depends on the integration and utilization of global resources. Recognizing the strategic importance of high-level openness, especially institutional openness, is crucial. This leads to a highly theoretically and practically valuable question: Can high-level openness centered on institutional openness effectively enhance the innovation capabilities of Chinese

enterprises? If so, what are the specific mechanisms at work? A thorough discussion of these questions not only helps better understand the practical impact of institutional openness but also provides significant insights into exploring the mechanisms for enhancing enterprise innovation capabilities and better implementing strategies for high-level openness and building a strong technological nation.

Unfortunately, direct research on institutional openness and the innovation capabilities of Chinese enterprises remains scarce. The literature relevant to the questions discussed in this paper mainly falls into two categories: one focusing on institutional openness and the other on enhancing enterprise innovation capabilities. The essence and economic effects of institutional openness have been widely discussed from various perspectives. Dai Xiang and Zhang Erzhen (2019) define institutional openness based on the essence of forming common rules for the globalized economy on the basis of respecting all parties' wishes, promoting a more just, reasonable, and legalized open world economy. Moreover, many scholars have analyzed the economic benefits of institutional openness from multiple angles, such as Nie Zhengyan et al. (2023), who focus on how institutional openness can enhance urban economic efficiency by effectively promoting resource allocation, thus improving the overall operation efficiency of urban economies. Dai Xiang (2019) analyzes institutional openness from the perspective of high-end production element aggregation, suggesting that open policies can attract and accumulate high-end elements, thereby promoting urban industrial upgrading and economic structural optimization. Additionally, Zhuo Chengfeng et al. (2023) discuss the relationship between institutional openness and urban economic resilience, noting that openness promoted by institutional innovation can enhance a city's ability to withstand economic fluctuations, making cities

more resilient when facing external shocks. Jiang Xiaojun et al. (2023) focus on how institutional openness can enhance cross-border resource allocation efficiency, explaining that openness, through transparent rules and institutional compatibility, can reduce the friction in cross-border transactions and optimize the global resource allocation. These studies provide useful insights for discussing the impact of institutional openness on enhancing the innovation capabilities of Chinese enterprises.

In the process of China's economic modernization, the factors affecting domestic enterprise innovation have always been a hot topic in the academic community, with numerous studies exploring this from various angles. These studies include topics such as service industry openness (Shao Chao et al., 2021), FTA network embedding (Liu Hui and Qi Jianhong, 2021), macro-industrial policies (Li Wenjing and Zheng Manni, 2016), and service market fluctuations (Yu Chunhai et al., 2023). Particularly, analyzing the impact factors of enterprise innovation from the perspective of institutional openness is closely related to the theme of this paper, thus deserving focused attention. Regarding the perspective of institutional openness, there are few existing literature studies on the factors affecting enterprise innovation, which needs further expansion. Wang Xiaosong and Chang Yuan (2023) conducted econometric tests based on the level of enterprise institutional openness, confirming that institutional openness significantly enhances the level of enterprise R&D innovation and identified the reduction in enterprise institutional transaction costs as a key mechanism. Although this study is closely related to the topic of this paper, the method of measuring institutional openness from the enterprise level and the theoretical analysis entry point of this paper are not consistent. Overall, although there is extensive discussion in the academic community about enhancing the innovation capabilities of local enterprises, most studies have not fully considered the perspective of breakthrough innovation, typically only using enterprise patent applications to measure enterprise innovation levels, which does not comprehensively reflect the true level of enterprise innovation. Moreover, few studies analyze the enhancement of enterprise innovation capabilities from the perspective of provincial institutional openness, and the discussion on enhancing enterprise innovation capabilities, especially breakthrough innovation capabilities, remains insufficient and requires further research.

In summary, the extensive discussions and research by scholars on the fields of interest in this paper are of great inspirational significance to this study. Especially the qualitative and quantitative research on China's institutional openness and the assessment of institutional effects on enterprise innovation proposed by the research conclusions are of great reference value to this paper. However, existing research on institutional openness mainly focuses on the analysis of the connotation and theoretical logic of institutional openness. Although existing research has measured institutional openness and conducted overall effect assessments using methods like "quasi-natural" experiments, it is difficult to provide more accurate understanding from the level of institutional openness and to identify the level of institutional openness in other non-free trade pilot zone cities, as well as to distinguish the heterogeneous effects of

institutional openness, including significant differences in different aspects of institutional openness. In view of this, this paper comprehensively considers the total amount of enterprise innovation output and breakthrough innovation capabilities to measure the level of institutional openness in various provinces, and comprehensively discusses the relationship between institutional openness and Chinese enterprise innovation behavior. Compared with the existing literature, the possible marginal contributions of this paper are as follows: First, in terms of research perspective, this paper attempts to expand the analysis of the factors that may increase the total amount of local enterprise innovation and breakthrough innovation capabilities from the specific perspective of institutional openness actively promoted in recent years, to some extent broadening the research scope of Chinese enterprise innovation; second, in terms of measurement methods, this paper starts from the connotation of institutional openness, uses the theoretical logic of "institutional innovation" in institutional openness, and measures the "internal" level of institutional openness in various provinces using a combination of crawling and text analysis methods for quantitative analysis of institutional openness. Third, this paper further analyzes the internal mechanism by which institutional openness enhances the innovation capabilities of Chinese enterprises and clarifies the differential impacts that may arise from heterogeneity in different industries and different property rights attributes of enterprises.

2. Theoretical Analysis and Research Hypotheses

Essentially, the core of institutional openness is the alignment of domestic institutional innovations with international high-standard economic and trade rules. Currently, various provinces in China are implementing a series of institutional innovations. These include streamlining administrative approval processes, optimizing the legal and market-oriented business environment, and implementing measures such as single windows, unified platforms, separation of permits and licenses, and delegation of government powers. Additionally, innovations in trade regulatory methods, such as mutual recognition of qualifications, remote customs delegation, and the integration of trade data management, all contribute to enhancing import trade liberalization. These measures reduce the import and institutional costs faced by domestic enterprises during production and innovation, thereby lowering their production costs. Existing studies have shown that enterprise innovation, particularly breakthrough innovation, requires sustained long-term capital investment and faces significant technological risks, financing constraints, and development cycle pressures (Jiang Wei et al., 2019). Under the backdrop of institutional openness, the reduction in production costs can alleviate financing constraints faced by enterprises, reduce the risks associated with innovation, and thus increase the propensity for enterprises to engage in innovation or breakthrough innovations.

Furthermore, from the perspective of integration into the global value chain, institutional openness facilitates the alignment of domestic regulatory rules with international standards, not only expanding the consumer market available to domestic enterprises but also enhancing the international

market acceptance of their products and elements. In such a scenario, enterprises, in order to capture more market share in an open market, will enhance their willingness to engage in breakthrough innovations to establish sustained technological advantages in the market. Moreover, the improvements in the domestic institutional environment and the reduction in transactional costs brought about by institutional openness will effectively alter the locational advantages of domestic regions, compensating for the loss of traditional comparative advantages due to rising domestic factor costs. This, in turn, influences the investment location choices of multinational corporations, further enhancing China's attractiveness to high-quality multinational companies in the international division of production. Multinational corporations typically possess advanced production technologies and management experiences, which domestic enterprises can assimilate or learn through imitation, thus enhancing the innovation level of domestic enterprises (He Huanlang et al., 2021). Additionally, regional economic integration theory suggests that participation in economic integration organizations can better leverage comparative advantages to gain more trade benefits, yielding dynamic benefits such as scale economies and technological progress. The construction of new international economic and trade rules and the signing and upgrading of regional trade agreements, essentially establishing various degrees of regional economic integration organizations, mean that, theoretically, Chinese enterprises can enjoy benefits such as technological advancement and enhanced innovation efficiency, thereby enhancing the innovation capabilities of domestic enterprises. For example, the academic community has noted that the world free trade agreements China has signed with various countries and regions can enhance the technological innovation capabilities of domestic enterprises by expanding their trade scale, enhancing the competitive incentives they face, and enabling them to absorb more global information technology resources (Liu Hui and Qi Jianhong, 2021), revealing the benefits of enterprise innovation capacity enhancement brought about by the promotion of regional trade agreement signings and upgrades. On the basis of the above, this paper proposes several hypotheses:

Hypothesis 1: Institutional openness is conducive to enhancing the innovation capabilities of local enterprises.

The institutional openness initiatives carried out by various provinces in China facilitate the enhancement of local enterprises' innovation capabilities through direct mechanisms of increasing the "quantity" and improving the "quality" of foreign direct investment utilized by each province at a higher level of openness, as well as through indirect mechanisms such as the regulatory effect of the regional institutional environment.

Institutional openness provides substantial institutional safeguards for the movement of goods and factors within China, fostering both domestic and international factor mobility. The "14th Five-Year Plan and the Long-Range Objectives Through the Year 2035" explicitly emphasizes the "continuous deepening of the openness of goods and factor mobility and the steady expansion of rules, regulations, management, and standards in institutional openness." Essentially, the goal of institutional openness is to provide

more effective safeguards for the movement of goods and factors through higher standard institutions and regulations. The theory of international production compromise (OLI) suggests that a firm's locational advantages, which include labor costs, market potential, trade barriers, and government policies (Dunning, 1998), are crucial for engaging in foreign direct investment. From this perspective, the central government's emphasis on institutional openness is expected to enhance market potential, reduce trade barriers, and by transforming government functions, improve local locational factors, thereby influencing the investment decisions of multinational corporations and further promoting the movement and introduction of goods and factors. On a practical level, whether it is the innovative trade regulatory methods and investment management system reforms carried out by provincial governments, or active participation and promotion of the signing of global free trade agreements, all aim to enhance the integration and utilization of resources within and outside the region and strengthen the attraction and aggregation of international foreign investment. Moreover, considering the heterogeneity of international direct investment and locational advantages, different levels of international direct investment have varying demands for locational advantages. The institutional innovations led by governments at all levels and the signing and upgrading of regional trade agreements enhance institutional safeguards, thereby improving local locational advantages and making domestic enterprises and markets more attractive to higher levels of foreign investment. Institutional openness also promotes the transformation of the domestic market from a simple concession market to a fully open market, increasing market competitiveness. This enables domestic consumers to more conveniently choose and consume high-quality products from various countries and regions within the local market. This competitive effect, combined with market scaling and consumption upgrading effects, strongly encourages the entry of high-quality foreign investment (Zhang Erzhen and Dai Xiang, 2018), and promotes a shift towards "high-quality" utilization of foreign investment in China. Overall, institutional openness significantly enhances the quantity and level of foreign investment utilized by China.

Enterprise innovation is a long-term investment activity that requires substantial R&D funding support or lower financing constraints (Mao Qilin, 2019). Under open conditions, the full absorption and utilization of international direct investment are crucial for local enterprise technological innovation. From the perspective of China's institutional openness enhancing the attraction and aggregation capabilities for international foreign investment, firstly, the entry of more international foreign investors and multinational corporations into the local market brings high-end elements such as knowledge, international talent, and technology. These elements guide and exemplify the production operations and technological innovations of local enterprises. Enterprises can enhance their innovation capabilities through forward and backward spillover effects and the catch-up competition effects in different stages of value chain production, learning from the advanced experiences and technologies of exemplary enterprises through on-the-job training (Zhang Yu and Zhang Cheng, 2011). Secondly, the influx of substantial foreign capital not only provides local enterprises the opportunity to establish forward and backward linkages with foreign

enterprises (Blomström and Kokko, 1998) but also intensifies market competition in upstream industries. Local enterprises can integrate their fragmented R&D resources and knowledge through inter-industry linkages in learning and cooperation, enhancing their technological innovation and collaborative innovation capabilities. Additionally, intensified competition in upstream industries forces local enterprises to undertake breakthrough innovations to capture more market share and profit. Increased competition also reduces the market prices of intermediate goods used by upstream enterprises, thereby reducing the production costs of downstream local enterprises, alleviating their financing constraints, and further encouraging enterprises to undertake innovation and breakthrough innovation activities. Lastly, the “labor pool effect” brought by foreign enterprises reduces the information search costs and R&D sunk costs of local enterprises (Rodrik, 2006), which is conducive to improving the profit levels of local enterprises, thereby promoting their innovation capabilities. As the level of foreign investment increases, the introduction of high-quality foreign capital brings more high-end elements and intermediate products, enhancing local enterprise innovation capabilities through “spillover effects,” “demonstration effects,” “linkage effects,” and “competition effects.” Higher levels of foreign investment and the industries developed based on this have significant asset specificity and high “entry barriers,” relying more on technological monopolistic advantages rather than just cost advantages. They are unlikely to disinvest due to the reduction of China’s traditional cost advantages, thus mitigating the risks of the “floating economy” associated with the previous “low-end embedding” method of utilizing foreign investment, enhancing the economic resilience of local industries, creating a stable environment for enterprise innovation, and undoubtedly promoting enterprise innovation. On the basis of the above, this paper proposes several hypotheses:

Hypothesis 2: Institutional openness enhances the innovation capabilities of local enterprises in China by increasing both the “quantity” and “quality” of foreign direct investment utilized.

3. Research Design

3.1 Model Proposal

Based on the theoretical analysis above, this paper constructs the following two-way fixed effects model to empirically analyze the impact of provincial institutional openness on the enhancement of local enterprise innovation capabilities. The specific formula is as follows:

$$\text{innov}_{it} = \beta_0 + \beta_1 \text{instit_open}_{ct} + \sum \text{control}_{ict} + v_c + v_t + v_i + \varepsilon_{ict} \quad (1)$$

Here, innov_{it} represents the overall innovation capability and breakthrough innovation level of enterprise in year, instit_open_{ct} represents the level of institutional openness in province in year; $\sum \text{Control}_{ict}$ represents other control variables, v_c represents the fixed effects of the province, v_t represents the fixed effects of the year, v_i represents the fixed effects of the individual enterprise, and ε_{ict} represents the random error term.

3.2 Measurement of the Level of Institutional Openness at

the Provincial Level

Under the leadership of provincial governments, institutional innovation is a critical dimension for measuring the level of institutional openness. This paper adopts the approach used by Zhuo Chengfeng et al. (2023) to measure the level of institutional innovation at the provincial level, which is then used to represent the level of institutional openness in each province. The specific method is as follows:

This study initially selected 184 official texts related to “institutional innovation” from the State Council’s website. Using the Harbin Institute of Technology’s LTP Chinese word segmentation stop word list, it filtered and extracted keywords, applying the TF-IDF method to refine and de-duplicate the vocabulary. This process resulted in a benchmark lexicon of Chinese institutional innovation comprising 201 key phrases. These terms were reviewed by scholars in the free trade zone field and experts from the Ministry of Commerce to ensure the authoritative selection and accurate application of the terms. Subsequently, a Chinese institutional innovation text database was established. Utilizing the Scrapy framework for multi-threaded asynchronous web scraping, data from January 1, 2013, to mid-October 2023, was collected and categorized by province and year, forming a structured database for text mining. Finally, the standard lexicon was integrated into Python’s “jieba” Chinese word segmentation library. By matching with the content in the institutional innovation text database and scoring based on the frequency of matches, this study calculated the innovation score indices of 31 Chinese provinces across different years. Using natural language processing methods, it evaluated the performance of provincial institutional innovations in various dimensions such as government function transformation and investment liberalization. This methodology not only provides a scientific assessment tool but also offers empirical support for understanding and analyzing the progress of institutional innovation across Chinese provinces.

3.3 Variable Selection

1) Enterprise Innovation Capability. This paper, drawing on the approach of Xu Xiang et al. (2023), comprehensively measures the level of enterprise innovation capability in terms of total innovation output and breakthrough innovation ability. The total innovation output (patent) uses the natural logarithm of the sum of the annual number of invention patents granted plus one; breakthrough innovation ability refers to the method of Ahuja & Lampert (2001), measuring based on the number of new patent technology categories entered.

2) Mechanism Variables Selection. Based on the theoretical analysis presented earlier, this paper involves two key mechanisms: foreign direct investment and the quality of foreign direct investment, measured as follows: (1) Foreign direct investment: measured by the ratio of foreign direct investment to GDP. (2) Quality of foreign direct investment: measured by the ratio of annual foreign direct investment amounts to the number of foreign investment contract projects in each province, as the larger the amount associated with foreign investment contract projects, the greater the complexity and technical content involved, thus reflecting the

level of foreign capital utilization in each province to a certain extent.

3) Control Variables Selection. To consider other factors that might affect the innovation capability of Chinese enterprises, this paper plans to control for enterprise-level characteristic variables. These control variables include: enterprise size

(size), debt-to-asset ratio (lev), net profit margin of total assets (roa), return on equity (roe), book-to-market ratio (bm), price-to-book ratio (pb), and number of employees (employee). Definitions, specific calculation methods, and descriptive statistics of each control variable are shown in Table 1.

Table 1: Variable Descriptions and Descriptive Statistics

Variable Name	Variable Definition	Mean	Standard Deviation
size	Natural logarithm of the total assets of company	3.104	0.064
lev	Ratio of total liabilities to total assets at year-end	0.416	0.205
roa	Ratio of net profit to total assets at year-end	0.036	0.065
roe	Ratio of net profit to the average balance of shareholders' equity company	0.055	0.133
bm	Ratio of book value to total market value	0.613	0.259
pb	Ratio of stock price per share to net assets per share	3.529	2.962
employee	Natural logarithm of the number of employees	2.032	0.164

3.4 Source of Data and Sample Description

The enterprise sample data comes from Shanghai and Shenzhen A-share listed companies from 2013 to 2022. Breakthrough innovation indicators are constructed based on the volume of invention patent applications by listed companies and their affiliates in China, while overall innovation capability is based on the number of granted invention patents. Patent and financial data are primarily sourced from the Wind database and Tonghuashun Finance, among others. Data processing includes: 1) excluding companies in the financial sector; 2) excluding companies with missing variable observations. Data on provincial institutional innovation and control variables mainly come from Chinese provincial statistical yearbooks, government official websites, local government statistical bulletins, and commerce commission official websites.

4. Empirical Results and Analysis

4.1 Empirical Results

Table 2 presents the baseline regression results for the relationship between provincial institutional openness levels and local enterprise innovation capabilities. Columns (1) and (2) show the econometric results for institutional openness and the total innovation output of local enterprises, while columns (3) and (4) relate to the econometric results for institutional openness and the breakthrough innovation capabilities of local enterprises. The regression results indicate a positive correlation between institutional openness and both the overall and breakthrough innovation capabilities of local enterprises, significant at the 1% confidence level after controlling for fixed effects across various dimensions. This holds true regardless of whether control variables at the enterprise and provincial levels are included in the regression model. These findings suggest that institutional openness at the provincial level in China not only increases the total innovation output of local enterprises but also facilitates their breakthrough innovation capabilities, thereby enhancing local enterprise innovation capabilities and levels. This preliminary validation supports the theoretical hypothesis that institutional openness indeed contributes to enhancing the innovation capabilities of local enterprises in China.

Table 2: Baseline Regression Results

Variable	Innovation Output	Breakthrough Innovation
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	(1)	(2)	(3)	(4)
instit_open	0.002*** (4.99)	0.002*** (5.30)	0.001*** (3.42)	0.001*** (3.84)
size		6.367*** (16.24)		2.343*** (12.51)
lev		-0.261*** (-4.75)		-0.068*** (-2.59)
roa		-0.659*** (-3.66)		-0.264*** (-3.07)
roe		-0.024 (-0.29)		-0.007 (-0.19)
bm		-0.067* (-1.94)		-0.022 (-1.34)
pb		-0.002 (-0.62)		-0.001 (-0.84)
employee		1.173*** (9.98)		0.538*** (9.59)
Individual fixed effect	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes
N	28457	28336	28457	28336
R ²	0.123	0.159	0.094	0.121

Note: *, ** and *** denote significance at 10%, 5% and 1%, respectively, the same applies to the following tables.

4.2 Robustness Test Results

1) Replacement of dependent variables. This study first uses the proportion of corporate R&D investment as a proxy variable for measuring overall corporate innovation capability; secondly, it adopts the method of Makri et al. (2010) to measure the dispersion of patent technology applications by enterprises, which serves as a substitute variable for assessing the level of breakthrough innovation. The specific regression results are reported in columns (1) and (3) of Table 3. According to the regression outcomes, after replacing the measurement methods of these two explained variables and controlling for variables across dimensions and fixed effects, the positive correlation between institutional openness and these two variables was statistically significant at the 5% and 10% confidence levels, respectively. This regression result is consistent with the previous analysis, further confirming that institutional openness implemented by various provinces indeed helps enhance local enterprise innovation capabilities, thus preliminarily verifying the robustness of theoretical hypothesis 1.

2) Exclusion of competitive causality. As this study measures the dimension of institutional innovation in institutional openness by borrowing the textual analysis method used for free trade zones, there may exist competitive causality-that is,

the enhancement of local enterprise innovation capability driven by institutional openness might not stem from the provincial initiatives but from the policy effects of establishing free trade zones within the provinces (Zhuo Chengfeng et al., 2023). To address this, the study excludes provinces that have already established free trade zones to rule out potential competitive causal relationships. The excluded sample does not include provinces that established free trade zones in September 2020, as the timeframe of the study extends only until 2022, and the duration since these zones were established is relatively short. Additionally, the effect of their policies may have a latency period, making competitive views less likely. Thus, they are not excluded in this study. Specific regression results are seen in columns (2) and (4) of Table 3. Table 4 indicates that, after excluding the potential competitive causality from institutional innovation in the free trade zones, the regression outcomes still show a significant positive correlation between institutional openness and both total innovation output and breakthrough innovation capabilities of enterprises at the 1% confidence level, consistent with the previous findings and once again verifying the correctness of theoretical hypothesis 1—that institutional openness facilitates the enhancement of local enterprise innovation capabilities.

Table 3: Robustness Test

Variable	Innovation Output		Breakthrough Innovation	
	(1)	(2)	(3)	(4)
instit_open	0.000** (2.19)	0.003*** (4.63)	0.000* (1.80)	0.001*** (3.25)
Control variable	Yes	Yes	Yes	Yes
Individual fixed effect	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes
N	28336	6333	28336	6333
R ²	0.140	0.178	0.071	0.139

4.3 Addressing Endogeneity

1) Multicollinearity Test. To minimize the endogeneity in the baseline regression analysis, this study uses a two-way fixed effect and incorporates several control variables to mitigate potential endogeneity issues. However, to further assess whether there is multicollinearity between the explanatory variables and control variables, a basic OLS regression model is used to determine if multicollinearity affects the estimation of the impact of institutional openness on firms' "overall innovation capacity" and "breakthrough innovation capacity." The calculated Variance Inflation Factor (VIF) of 4.55 suggests that the regression analysis avoids endogeneity issues caused by multicollinearity effectively.

2) Exclusion of Reverse Causality. Although the two-way fixed effect model and control variables at the firm and provincial levels mitigate endogeneity in the baseline regression, potential reverse causality could still induce endogeneity. Following Aghion et al. (2016), this study lags the control variables by one period to test for reverse causality within the model, reporting the specific regression results in Table 4, columns (1) and (2). The regression coefficients of the variable *instit_open* in columns (1) and (2) are 0.001 and 0.000, respectively, neither of which is statistically significant, indicating that local firms' technological innovation capabilities do not inversely affect the level of regional institutional openness. This result confirms the reliability of the baseline regression.

3) Instrumental Variable Method. To further exclude potential endogeneity in the model, this study employs an appropriate instrumental variable and uses the two-stage least squares (2SLS) method for endogeneity testing. The lag of the provincial level of institutional openness from the previous period is selected as the instrumental variable (IV1). Given the continuity of policy, the level of institutional openness in the current period is highly correlated with that of the previous period, meeting the relevance requirement for the instrumental variable. From the exclusivity perspective, the previous period's level of institutional openness does not directly affect current firm innovation, fulfilling the exclusivity criterion for selecting instrumental variables. The results of the endogeneity test using the instrumental variable are reported in Table 4, columns (3) and (4). The regression results indicate that the core explanatory variable, the level of provincial institutional openness, remains significantly positive at the 10% confidence level after considering potential endogeneity issues, reaffirming the theoretical hypothesis that institutional openness indeed aids in enhancing local firms' innovation capabilities. Furthermore, the effectiveness of the two instrumental variables is reported in lines 6 and 7 of Table 4. The Cragg-Donald Wald F statistics for both instrumental variables exceed the Stock-Yogo critical value at the 10% significance level, passing the Stock-Yogo weak identification test, and the LM statistic also rejects the null hypothesis at the 1% significance level, indicating that the construction of these two instrumental variables is both reasonable and effective.

Table 4: Endogeneity Test

Variable	Exclude Reverse Causality		IV1	
	Innovation Output (1)	Breakthrough Innovation (2)	Innovation Output (3)	Breakthrough Innovation (4)
instit_op en	0.001 (1.61)	0.000 (0.58)	0.003* (1.66)	0.001* (1.76)
Control variable	Yes	Yes	Yes	Yes
Fixed effect	Yes	Yes	Yes	Yes
LM statistic	\	\	4167.179***	4167.179***
F statistic	\	\	4876.717***	4876.717***
N	22451	22451	22451	22451
R ²	0.138	0.102	0.202	0.158

5. Testing Impact Mechanisms

Translation: As analyzed theoretically earlier, China's institutional openness enhances both the "quantity" and "quality" of foreign direct investment (FDI) used by the provinces, thereby promoting the innovation capacity of local enterprises. The institutional openness initiatives undertaken by the provinces lead to reduced regional institutional transaction costs, enhanced locational advantages, and regional integration benefits. These initiatives not only stabilize FDI in terms of "quantity" but also improve its "quality" on a stable basis, thus presenting a "stable and enhanced quality" posture in provincial utilization of FDI. The "stable and enhanced quality" of provincial FDI utilization encourages local enterprises to improve their innovation capabilities through methods like imitation absorption, learning by doing, and competition. Based on this analysis, this paper first tests the channel through which institutional openness promotes enterprise innovation by

increasing the "quantity" of FDI utilized by the provinces. Specifically, by adopting the mechanism testing method of Yu Minggui et al. (2016), and building on model (1), further variables related to the utilization of FDI and their interaction terms with institutional openness are introduced into the econometric model, resulting in the following extended model (2):

$$\text{innov}_{it} = \beta_0 + \beta_1 \text{instit_open}_{ct} + \beta_2 \text{fdi}_{ct} + \beta_3 \text{instit_open}_{ct} \times \text{fdi}_{ct} + \sum \text{control}_{ict} + v_c + v_t + v_i + \varepsilon_{ict} \quad (2)$$

Where represents the "quantity" of foreign direct investment utilized by province c in year t , with other variables and subscripts consistent with previous discussions. In model (2), the primary focus is on the sign of the coefficient; if it is significant and positive, it indicates the existence of a channel effect through the "quantity" of utilized FDI, otherwise, it indicates the opposite. The specific regression results for the "quantity" of utilized FDI are reported in columns (1) and (2) of Table 5, and the results for the "quality" of utilized FDI are reported in the last two columns. Subsequently, this paper tests the channel through which institutional openness enhances enterprise innovation capacity by improving the "quality" of FDI utilized by the provinces, constructing model (3) as follows:

$$\text{innov}_{it} = \beta_0 + \beta_1 \text{instit_open}_{ct} + \beta_2 \text{fdi}_{ct} + \beta_3 \text{instit_open}_{ct} \times \text{fdi}_{ct} + \sum \text{control}_{ict} + v_c + v_t + v_i + \varepsilon_{ict} \quad (3)$$

In equation (3) represents the quality of foreign direct investment used in region c in year t . Specific regression results are reported in the last two columns of Table 5. As indicated in the table, columns (1) and (3) analyze the channels through which institutional openness affects the total innovation output of enterprises, with the interaction coefficients in both columns being significantly positive. This suggests that regions with higher levels of foreign direct investment "quantity" and "quality" see a more pronounced effect of institutional openness on the total innovation output of local enterprises, indicating that institutional openness can promote regional enterprise innovation output by stabilizing local utilization of foreign direct investment and enhancing the quality of such investment. Columns (2) and (4) analyze the channels through which institutional openness enhances enterprises' breakthrough innovation capabilities. It can be seen that the interaction coefficient of foreign investment quality with institutional openness is significantly positive, while the interaction of foreign investment quantity with institutional openness does not show economic significance. This implies that in regions with higher quality foreign direct investment, institutional openness is more effective in enhancing local enterprises' breakthrough innovation capabilities, suggesting that improving the quality of foreign direct investment plays a key role in fostering local enterprises' breakthrough innovation capabilities under institutional openness, whereas an increase in the quantity of foreign investment does not play a mechanistic role in this process. This might be due to the fact that breakthrough innovation refers to fundamental changes to existing technologies, often involving the development of new technologies, which require higher technical content, more research and development time, investment, and entail greater risks. High-quality foreign investment, compared to general foreign investment, involves more advanced technologies,

knowledge, and skilled personnel, not only facilitating local enterprises in learning advanced technologies from high-quality foreign investment to lay a foundation for their own breakthrough innovations but also by entering the market with new technologies, forcing local enterprises to enhance their propensity for breakthrough innovation, thus promoting the enhancement of local enterprises' breakthrough innovation capabilities through learning and competition.

In summary, the empirical analysis results of this study's mechanism test indicate that institutional openness can indeed promote local enterprise innovation capabilities through the "quantity" and "quality" of foreign direct investment utilized. However, it should be further noted that under conditions that distinguish the heterogeneity of enterprise innovation behavior, the roles played by the "quantity" and "quality" of utilized foreign investment are not the same. That is, institutional openness can enhance overall enterprise innovation capabilities through the "quantity" of utilized foreign investment, but it does not play a role in enhancing enterprises' breakthrough innovation capabilities. On the other hand, the improvement in the quality of utilized foreign investment plays a crucial role in the process of promoting local enterprises' overall innovation capabilities and breakthrough innovation capabilities under institutional openness. Thus, the theoretical hypothesis 2 presented earlier is also validated.

Table 5: Testing the Mechanism of Utilizing Foreign Investment

Variable	Fdi		Fdiq	
	Output (1)	Breakthrough (2)	Output (3)	Breakthrough (4)
instit_open#fdi	0.047* (1.91)	0.019 (1.58)		
instit_open#fdiq			0.000* (1.96)	0.000** (2.13)
instit_open	0.002*** (2.78)	0.000 (1.54)	0.001* (1.68)	0.000 (0.96)
Control variable	Yes	Yes	Yes	Yes
Individual fixed effect	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes
N	22455	18431	22455	18431
R ²	0.141	0.104	0.106	0.075

6. Heterogeneity Analysis

In the baseline regression analysis mentioned earlier, we did not distinguish the impact of institutional openness on the innovative behaviors of different types of enterprises, such as enterprises in different industries, stages of development, or ownership types. The estimated results represent the average effect of institutional openness on the overall local enterprise innovation behaviors. Therefore, this paper explores the heterogeneous effects of institutional openness on different enterprises by distinguishing between enterprises in different industries and ownership types within the sample.

1) Heterogeneity analysis based on different industries. Drawing from Yang Xingzhe et al. (2020), this paper classifies companies with classification codes C25 to C29, C31 to C32, C34 to C41, I63 to I65, and M73 as high-tech industry companies, and others as non-high-tech industries for heterogeneity analysis. Specific regression results are

reported in Part A of Table 6. The results show that institutional openness promotes the overall innovative output of companies, regardless of whether they are in the high-tech industry. However, there is a significant positive relationship between institutional openness and breakthrough innovation capabilities in high-tech industries, while it does not significantly promote breakthrough innovation capabilities in non-high-tech industries. The reason may be that enterprises in high-tech industries must continually innovate to avoid being eliminated in fierce market competition (Gu Xiaoming et al., 2018), and thus they have more practices in breakthrough innovation and accumulate more experience and knowledge, making it easier to enhance their breakthrough innovation capabilities under institutional openness.

2) Heterogeneity analysis based on different ownership types. The paper divides the sample according to different property rights attributes into state-owned enterprises and private enterprises for heterogeneity analysis. As shown in Part B of Table 6, the results indicate that institutional openness significantly promotes the increase in innovative output of both state-owned and private enterprises. Moreover, institutional openness significantly promotes the enhancement of breakthrough innovation capabilities in private enterprises, while its effect is not significant for state-owned enterprises. The possible reason is that small enterprises, which are often private, are at a disadvantage in market competition and are more inclined to undertake breakthrough innovations. Additionally, compared to state-owned enterprises, private enterprises face greater financing constraints when undertaking breakthrough innovations. Therefore, under the various opportunities brought by institutional openness, private enterprises are more inclined to undertake breakthrough innovations, which facilitates the promotion of their breakthrough innovation capabilities by institutional openness.

Table 6: Heterogeneity Analysis

Variable	Output	Breakthrough	Output	Breakthrough
	(1)	(2)	(3)	(4)
PlanA	High-tech industry enterprises		Non-high-tech industry enterprises	
instit_open	0.002*** (3.97)	0.001*** (3.38)	0.002*** (3.27)	0.001 (1.62)
PlanB	State-owned enterprises		Private enterprises	
instit_open	0.002*** (2.82)	0.000 (1.53)	0.002*** (3.55)	0.001*** (3.17)
Control variable	Yes	Yes	Yes	Yes
Individual fixed effect	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes

7. Conclusion and Policy Implications

This paper starts from the concept of institutional openness and innovatively constructs a measurement framework based

on provincial institutional innovations. Based on this framework, it first uses text analysis to measure the level of institutional innovation within provinces (internal rules of institutional openness), representing the level of provincial

institutional openness in China from 2013 to 2022. Guided by this, and based on a comprehensive measurement of firms' innovative output and breakthrough innovation capabilities, the paper conducts an empirical analysis of the impact of provincial institutional openness on local enterprises' innovation capabilities. The findings are as follows: First, institutional openness at the provincial level effectively enhances both the total innovative output and breakthrough innovation capabilities of local enterprises, and these conclusions remain valid under various robustness and endogeneity tests. Second, provincial institutional openness primarily influences enterprise innovation capabilities through the utilization of foreign direct investment (FDI). The "heterogeneity" of FDI utilization shows that while an increase in the "quantity" of FDI plays a mechanistic role in promoting total innovative output, it does not impact the enhancement of breakthrough innovation capabilities; conversely, an improvement in the "quality" of FDI plays a mechanistic role in enhancing both total and breakthrough innovation capabilities. Third, further analysis reveals that institutional openness has heterogeneous effects on the breakthrough innovation capabilities of different industries and ownership types of enterprises, and that the degree of trade liberalization in institutional innovations still needs to be strengthened to further leverage domestic institutional innovations for boosting enterprise innovation.

The conclusions of this study not only deepen our understanding of the practical effects of institutional openness on overall and breakthrough innovation capacities of enterprises but also provide significant insights on how leveraging a higher level of openness, exemplified by institutional openness, can enhance the innovative capabilities of domestic enterprises, particularly in breakthrough innovations, and accelerate the building of a technologically advanced nation with high levels of self-reliance and strength.

To further promote institutional openness across various provinces, China must strengthen the protection of intellectual property rights and ensure alignment with international technical standards, thereby providing a more robust institutional framework for enhancing enterprise innovation capabilities. The theoretical analysis and empirical tests from this study suggest that institutional openness has a positive effect on enhancing the innovative capabilities of local enterprises at higher levels of openness. Consequently, local governments should refine legal regulations, particularly by expanding specific legal provisions; further deregulate to minimize interference in economic activities, thereby boosting market vitality; enhance the development of product and factor markets to facilitate the commercialization of innovations; and strengthen intellectual property protections to increase the exclusivity of enterprise innovations and ensure internalization of innovation benefits, thus enhancing the willingness of enterprises to engage in innovative practices.

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