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The Impact of Economic Openness on Capital Stock: An Empirical Analysis Based on Technological Innovation and Industrial Structure Optimization

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Abstract

Against the backdrop of the restructuring of economic globalization and the continuous advancement of high-level opening-up strategies, economic openness, as a key factor influencing regional capital accumulation, holds significant practical importance for promoting high-quality economic development. Based on provincial panel data from China for the period 1998–2019, this paper employs fixed effects models and panel instrumental variable methods to investigate the effect of economic openness on capital stock, its underlying mechanisms, and regional heterogeneity. The results show that economic openness significantly promotes the increase of capital stock. The mediation effect analysis indicates that economic openness promotes capital accumulation through two pathways: enhancing technological innovation capability and optimizing industrial structure. Heterogeneity analysis reveals that the promotional effect of economic openness on capital stock is more pronounced in the eastern and western regions. Based on these findings, the paper proposes policy recommendations including continuously advancing institutional opening-up, strengthening the mediating role of economic growth capacity between economic openness and capital stock, and implementing differentiated regional opening strategies.

Keywords

economic openness, capital stock, technological innovation, industrial structure optimization

1. Introduction

As globalization enters the third decade of the 21st century, the world economy is undergoing profound shocks and restructuring. Since 2025, the global trade landscape has experienced drastic changes under multiple impacts. The United States invoked the International Emergency Economic Powers Act under the pretext of a national emergency, imposing an additional 34% reciprocal tariff on Chinese goods. Sino–U.S. trade frictions have escalated sharply, with tariff rates on certain Chinese goods once reaching as high as 145% (Gong & Yuan, 2026). On December 18, 2025, the Hainan Free Trade Port officially launched island-wide customs closure operations, implementing an institutional framework of “first-line” liberalization, “second-line” control, and freedom within the island, with over 6,600 imported goods enjoying zero-tariff treatment (Li, 2026). At the same time, the situation in the Middle East remains tense, and the shipping security of the Strait of Hormuz continues to affect the nerves of the global energy supply chain (Huang, 2026). The

concentrated outbreak of these events has made a fundamental question increasingly urgent: In the context of violent fluctuations in the international economic and trade environment, how will changes in a country's economic openness affect its capital accumulation capacity? Through what channels is this impact transmitted? In an era when globalization faces headwinds and regionalization accelerates restructuring, a deep understanding of the intrinsic relationship between openness and capital accumulation holds important theoretical value and practical significance for countries in formulating sustainable development strategies.

From a theoretical perspective, the impact mechanism of economic openness on capital accumulation has long been a core issue in development economics and international trade theory. Neoclassical growth theory posits that the flow of capital from developed economies to developing economies reduces the latter's capital costs, thereby stimulating capital accumulation and economic growth. However, this process depends on prerequisites such as a sound institutional framework, financial development level, and macroeconomic stability (Damasceno & Guedes, 2024). Endogenous growth theory further argues that openness not only directly expands the supply channels of capital factors but also indirectly enhances capital allocation efficiency and total factor productivity through channels such as knowledge spillovers, technology diffusion, and institutional change. Nevertheless, empirical studies in recent years have produced inconsistent conclusions regarding this relationship. For example, Damasceno (2023) examined data from 104 emerging and developing economies between 1980 and 2019 and found that financial openness did not significantly stimulate growth in capital stock or total factor productivity, contradicting the assumptions of traditional liberalization policies (Damasceno & Guedes, 2024). Ulke (2024), based on data from 159 countries from 1995 to 2021, even found a negative correlation between financial openness and per capita GDP growth, suggesting that greater openness does not necessarily lead to higher growth. These findings indicate that the impact of economic openness on capital accumulation is not a simple linear relationship; its direction and intensity may depend heavily on a country's initial conditions, institutional quality, and the effectiveness of transmission channels.

From a practical perspective, the global trade system is undergoing reconstruction. In 2025, Sino–U.S. trade relations experienced violent fluctuations amid high tariffs and frequent gamesmanship. Tariff shocks rapidly transmitted to the manufacturing sector through order, price, and inventory channels. The new export order index fell to a low of 44.7 in April, and the industrial producer price index accelerated its decline (Ye, 2025). However, under this external shock, the island-wide customs closure of the Hainan Free Trade Port signals that China is responding to the headwinds of globalization through institutional opening-up. Since the closure, the number of pilot enterprises enjoying duty-free processing value-added treatment has reached 129, with the cumulative domestic sales value exceeding 10 billion yuan. Policy dividends are being transformed into enterprise competitiveness (Wang, 2025). In recent years, the evolution of U.S. trade policy toward China has progressed from tariff increases during the Trump 1.0 era to technological blockades and supply chain restructuring under the Biden administration, and further to a parallel model of institutional competition and phased communication in the Trump 2.0 era, forming a multidimensional suppression system centered on strategic competition (Pei et al., 2025). These drastic fluctuations in the policy environment highlight the urgency of studying the relationship between economic openness and capital accumulation during the current period of global turbulence. If openness indeed promotes capital accumulation, then maintaining or even increasing the degree of openness during intensified external shocks may become an important strategy to resist capital outflows. Conversely, if the effect of openness on capital accumulation is limited, greater attention may need to be paid to domestic demand-driven capital formation pathways.

In the existing literature, researchers have primarily focused on the macroeconomic effects of trade openness or financial openness on economic growth, while paying relatively insufficient attention to how openness directly affects capital stock—a core factor of production. Zhang Zhongyuan, using panel data from 163 industrial sectors across 30 Chinese provinces, examined the impact of external economic openness on capital allocation efficiency and found that increased openness to foreign investment reduces capital allocation efficiency across regions, whereas increased openness in export trade helps improve it (Zhang, 2013). Cai and Zhou (2012) approached the issue from the perspective of FDI technology spillovers and used inter-provincial panel data from 1997 to 2009 to test the threshold characteristics of regional openness on technology spillover effects. Rong et al. (2016) studied the relationship between the rule of law and capital accumulation from the perspective of capital account openness using cross-country panel data, finding that developed countries can achieve capital accumulation after capital account opening, while developing countries do not. Additionally, Ma and Wang (2011) examined the capital effects of foreign direct investment across different regions in China and found that FDI in the eastern

region positively promotes regional capital stock, whereas it exerts a certain inhibitory effect on capital formation in the central and western regions. Overall, the above studies have provided useful explorations of the relationship between economic openness and capital from the perspectives of capital allocation efficiency, technology spillovers, and capital account openness. However, systematic and direct investigations of the relationship between economic openness and capital stock remain relatively scarce in the domestic literature.

In light of the above research gaps, this paper proposes corresponding research hypotheses. Using provincial panel data from China for the period 1998–2019, it constructs an empirical model with a mediation mechanism framework centered on "technological progress—industrial structure optimization" to examine the impact of economic openness on capital stock and its transmission pathways. The main contributions of this paper are as follows: First, it explores the direct relationship between economic openness and capital stock, enriching research in the fields of open economy and capital formation, and providing useful references and insights for capital allocation in various regions as they expand opening-up. Second, through heterogeneity analysis across the eastern, central, and western regions, it refines the differentiated effects of economic openness dividends on capital accumulation under different regional endowments. Third, by employing a mediation effect model, the study reveals the mechanism of "economic openness—technological progress and industrial structure optimization—capital stock," deepening the understanding of the relationship between economic openness and capital accumulation. This provides valuable references for understanding the implementation pathways of high-level opening-up strategies, coordinated regional development, and the cultivation of new quality productive forces.

2. Theoretical Analysis and Research Hypotheses

2.1 Economic Openness and Capital Stock

Economic openness refers to the degree to which a country or region participates in international economic and trade exchanges. It is typically measured by indicators such as import and export trade and foreign capital inflows. This paper uses the ratio of total imports and exports to regional gross domestic product (GDP) as the measurement indicator (Huang et al., 2025), which comprehensively reflects the level of trade openness. On the one hand, economic openness—particularly trade liberalization and investment facilitation—can attract foreign direct investment and portfolio investment, directly increasing capital formation and thereby expanding the supply of capital factors. On the other hand, under open economy conditions, intensified market competition leads to more rational factor prices, prompting capital to flow from low-efficiency sectors to high-efficiency sectors. This improves the marginal output and allocation efficiency of capital, thereby incentivizing further capital accumulation. In addition, economic openness enables domestic enterprises to import high-quality capital goods and intermediate products from developed countries. These products embody cutting-edge technologies and can promote the importation of advanced equipment and technologies into the country.

Based on the above analysis, the following hypothesis is proposed:

H1: The improvement of economic openness can positively promote an increase in capital stock.

2.2 The Mediating Effect of Economic Growth Drivers

Economic openness not only directly affects capital stock but also indirectly promotes capital accumulation by influencing economic growth drivers (China Macroeconomic Research Institute Research Group et al., 2026). This paper analyzes the mediating role from two dimensions: technological progress and industrial structure optimization.

2.2.1 Technological Progress

Economic openness promotes an increase in capital stock by driving technological progress. Specifically, economic openness facilitates technological innovation through three mechanisms: First, the technology spillover effect. The entry of foreign-invested enterprises brings advanced production technologies and management experience. Through demonstration effects, competition effects, and personnel mobility effects, local enterprises can learn and absorb these technologies, thereby enhancing their own innovation capabilities (Shen & Geng, 2001). Second, the learning-by-exporting effect. The more products a country exports to high-income countries, the faster the quality of its products improves, indicating a significant learning-by-exporting

effect (Kang & He, 2014). This implies that exporting is not merely a sales activity, but a process in which enterprises interact with international frontier demand, accumulate experience, and achieve technological upgrading. Relevant studies further find that China's spillover effects on economic growth depend on the quality of the labor force, while the export learning effect is essentially a form of passive technological progress, and its effect strengthens as the income level of the export destination countries increases (Luo, 2019).

Based on this, the following hypothesis is proposed:

H2a: Economic openness promotes an increase in capital stock by driving technological progress.

2.2.2 Industrial Structure

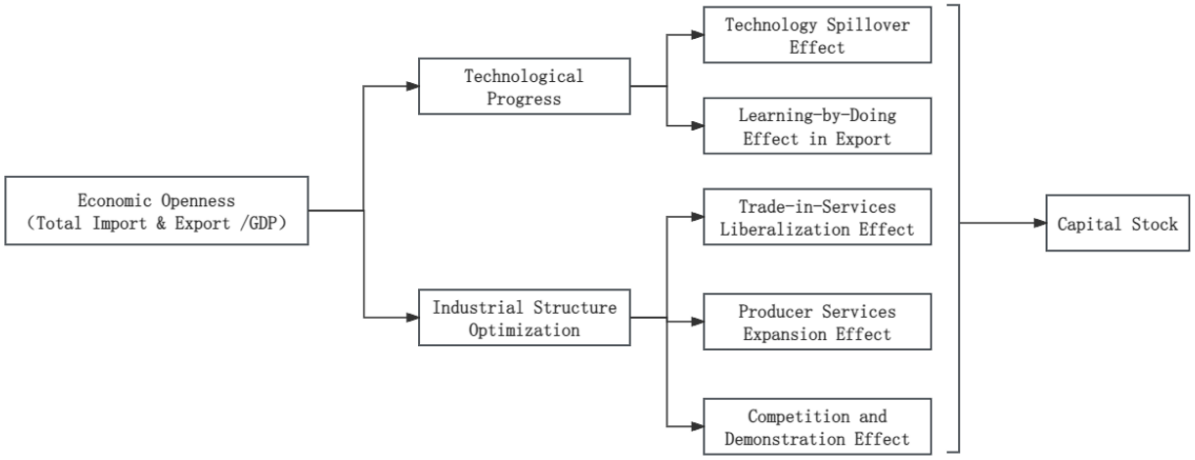
Economic openness promotes an increase in capital stock by raising the added value index of the tertiary industry. First, the service trade liberalization effect. Economic openness lowers the entry barriers for foreign investment in modern service industries such as finance and information, thereby driving rapid growth in the added value of the tertiary industry (Han et al., 2025). Second, the expansion effect of producer services. The finer division of labor induced by manufacturing openness stimulates the development of producer services such as R&D, design, and technical services, thereby increasing the added value of the tertiary industry (Tang et al., 2024). Third, the competition and demonstration effect. The entry of international service providers brings advanced management models, forcing local service enterprises to improve efficiency and promoting the growth of the tertiary industry (Fu et al., 2025). The improvement in the tertiary industry added value index, on the one hand, directly expands the scale of fixed asset investment in the service sector; on the other hand, it promotes capital accumulation across society by enhancing the efficiency of capital allocation in manufacturing.

Based on this, the following hypothesis is proposed:

H2b: Economic openness promotes an increase in capital stock by driving industrial structure optimization.

The mechanism framework of how economic openness affects capital stock, based on the theoretical analysis and hypotheses constructed in this paper, is shown in Figure 1.

Figure 1: Research Mechanism Framework of Economic Openness Affecting Capital Stock



3. Research Design

3.1 Data Sources

This paper conducts an empirical study using panel data of Chinese provinces from 1998 to 2019. The provincial-level data are sourced from the China Statistical Yearbook. Data preprocessing was performed as follows: first, samples from years earlier than 1998 were deleted; second, samples with missing key variables were removed.

3.2 Variable Selection

3.2.1 Dependent Variable

Capital stock (*ln_cap2*) is a core indicator measuring the scale of physical capital accumulation in a country or region and reflects the foundation of production capacity. This variable is selected because capital stock directly represents the level of production factor accumulation. It serves as the ultimate focus for studying the effects of economic openness, and existing research has shown that capital stock plays a decisive role in economic growth.

3.2.2 Independent Variable

The independent variable in this paper is economic openness (*ln_EconomyOpenness*), calculated as the ratio of total imports and exports to the corresponding regional GDP. The measurement of economic openness in this paper draws on the approach of Huang Weitong et al., using the ratio of total imports and exports of free trade zones to the GDP of free trade zones to reflect the level of economic openness (Huang et al., 2025).

3.2.3 Mediating Variables

(1) Number of invention patent applications (*ln_pat1*)

Invention patents are one of the most direct indicators for measuring technological innovation capability. This paper selects the number of invention patent applications (rather than grants) as a proxy for technological innovation because application numbers can more promptly reflect the intensity of innovation activities and are less affected by external factors such as the working efficiency of patent examination institutions.

(2) Tertiary Industry Added Value Index (*x3index*)

Industrial structure is measured by the tertiary industry added value index. This indicator comprehensively reflects the development level of the service sector and the degree of economic structure transformation and upgrading, serving as a core measure of industrial structure.

3.2.4 Control Variables

To mitigate omitted variable bias, the control variables selected in this paper mainly include: average employment at the end of the year (*ln_labor*), measured by the total number of employed persons in each province at year-end; RMB to USD exchange rate (*ln_rate*), using the annual average exchange rate of RMB against the USD; and total factor cost (*ln_Tcost*), measured by the sum of capital and labor factor costs in the production process.

Table 1: Descriptive Statistics of Variables

Variable Type	Variable Name	Symbol	Mean	Std. Dev.	Min	Max	Obs
Dependent Variable	Capital Stock	*ln_cap2*	9.0060	1.2582	4.6705	11.4418	616
Core Explanatory Variable	Economic Openness	*ln_Economy~s*	-3.7157	1.0307	-6.2913	-1.46971	616
Control Variables	Average Employment at Year-end	*ln_labor*	5.9683	1.0049	2.8273	8.5308	616
	RMB to USD Exchange Rate	*ln_rate*	6.5858	0.1150	6.4205	6.7189	616
	Total Factor Cost	*ln_Tcost*	8.2128	1.0635	4.9855	10.5334	616
Mediating Variables	Invention Patent Applications	*ln_pat1*	8.0980	1.8974	3.5264	12.2852	616
	Tertiary Industry Added Value Index	*x3index*	3.3611	1.8917	1.0000	7.1212	616

3.3 Model Design

3.3.1 Baseline Regression Model

To examine the overall impact of economic openness on capital stock, this paper establishes the following baseline regression model:

$$lncap2_{i,t}=\alpha_0+\alpha_1 lnEconomyOpenness_{i,t}+\alpha_2 lncontrol_{i,t}+\mu_i+\lambda_t+\varepsilon_{i,t} \quad (1)$$

where i denotes the province, t denotes the year, $lncap2_{i,t}$ and $lnEconomyOpenness$ represent capital stock and economic openness respectively, α_1 indicates the impact of economic openness on capital stock z, $lncontrol_{i,t}$ is a vector of control variables, α_2 is the coefficient vector of the control variables, α_0 is the intercept term, μ_i, λ_t, and $\varepsilon_{i,t}$ represent province fixed effects, time fixed effects, and the random disturbance term, respectively.

3.3.2 Mediating Effect Model

To further explore the possible transmission role of economic growth drivers between economic openness and capital stock, this paper constructs a mediating effect model, following the approach of Wen and Ye (2014):

$$lnegd_{i,t}=\beta_0+\beta_1 lnEconomyOpenness_{i,t}+\beta_2 lncontrol_{i,t}+\mu_i+\lambda_t+\varepsilon_{i,t} \quad (2)$$

$$lncap2_{i,t}=\delta_0+\delta_1 lnEconomyOpenness_{i,t}+\delta_2 lnegd_{i,t}+\delta_3 lncontrol_{i,t}+\mu_i+\lambda_t+\varepsilon_{i,t} \quad (3)$$

where $lnegd_{i,t}$ represents the economic growth driver (here divided into technological progress (lnpat1) and industrial structure ($x3index$) for separate empirical analysis); β_1 represents the effect of economic openness on the mediating variable; δ_2 represents the effect of the mediating variable on capital stock after controlling for economic openness; δ_1 represents the effect of economic openness on capital stock after controlling for the mediating variable; β_2 and δ_3 are coefficient vectors of the control variables; β_0 and δ_0 are intercept terms. The remaining symbols have the same meanings as in Equation (1).

4. Empirical Analysis

4.1 Baseline Regression

According to the Hausman test results, the corresponding p-value is 0.0000. This indicates that the estimation results of the random effects model differ significantly from those of the fixed effects model. Using a random effects model would lead to inconsistent estimates. Therefore, this paper adopts the fixed effects model as the baseline regression model.

Based on the baseline regression results, this paper employs a stepwise estimation strategy to examine the robustness of the impact of economic openness on capital stock. Column (1) presents the basic fixed effects model, showing that the estimated coefficient of economic openness is 0.389, significant at the 1% level. Column (2) uses province-level clustered robust standard errors; the coefficient and significance remain unchanged, indicating that the clustering adjustment of standard errors does not alter the core conclusion. Column (3) further incorporates time fixed effects, with the core coefficient being 0.206, still significant at the 1% level. Column (4) adopts heteroskedasticity-robust standard errors, and the results are consistent with those in Column (2). Columns (5) to (7) employ panel-corrected standard errors, accounting for cross-sectional heteroskedasticity, and generalized least squares (GLS) estimation, respectively. In all cases, the coefficient of economic openness is 0.117 and significant at the 1% level. The signs and significance levels of the control variables are largely consistent across all models, and the overall model fit is good.

In summary, regardless of the model specification or standard error correction method used, economic openness consistently exhibits a robust positive promoting effect on capital stock. The baseline regression results are therefore credible.

Table 2: Baseline Regression Results of Economic Openness on Capital Stock

	(1) ln_cap2	(2) ln_cap2	(3) ln_cap2	(4) ln_cap2	(5) ln_cap2	(6) ln_cap2	(7) ln_cap2
ln_Economy~s	0.389***	0.389***	0.206***	0.389***	0.117***	0.117***	0.117***
	(0.0291)	(0.0495)	(0.0240)	(0.0495)	(0.0411)	(0.0221)	(0.0130)
ln_labor	-0.209***	-0.209***	-0.113***	-0.209***	-0.178	-0.178***	-0.178***
	(0.0318)	(0.0619)	(0.0217)	(0.0619)	(0.112)	(0.0619)	(0.0345)
ln_rate	1.511***	1.511***	-4.667***	1.511***	-0.960***	-0.960*	-0.960***
	(0.166)	(0.154)	(0.883)	(0.154)	(0.291)	(0.492)	(0.161)
ln_Tcost	1.550***	1.550***	1.230***	1.550***	1.184***	1.184***	1.184***
	(0.0334)	(0.0547)	(0.0622)	(0.0547)	(0.148)	(0.0849)	(0.0383)

_cons	-10.98***	-10.98***	30.88***	-10.98***	7.104***	7.104**	7.104***
	(1.253)	(0.979)	(6.334)	(0.979)	(1.816)	(3.474)	(1.186)
N	616	616	616	616	616	616	616

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust standard errors are reported in parentheses.*

4.2 Robustness Tests

4.2.1 Replacing the Independent Variable

This study replaces the core independent variable with total imports and re-estimates the fixed effects regression. The results in Column (4) of Table 3 show that the coefficient of total imports is 0.366, significantly positive at the 1% level, consistent with the baseline conclusion.

4.2.2 Replacing the Dependent Variable

This paper replaces the dependent variable capital stock with the number of invention patent applications and per capita GDP, respectively, to measure technological innovation and economic development levels. The results in Columns (2) and (3) of Table 3 show that the estimated coefficients of economic openness on patents and per capita GDP are 0.238 and 0.0930, respectively, both significant at least at the 5% level.

4.2.3 Replacing Control Variables

First, the marketization index is added as an additional control variable to the baseline model. Second, the labor quantity is replaced with the average years of schooling to examine the impact of human capital quality. The results in Columns (5) and (6) of Table 3 show that the sign and significance of the core explanatory variable remain highly consistent with the baseline regression.

In summary, whether replacing the independent variable, dependent variable, or adjusting the control variables, the positive impact of economic openness on capital stock remains significant. The baseline regression results demonstrate strong robustness.

Table 3: Robustness Tests by Replacing Core Variables

	(1) Baseline	(2) Replace DV: Patent	(3) Replace DV: Per Capita GDP	(4) Replace IV	(5) Add Control Variable	(6) Change Control Variable
ln_Economy~s	0.389***	0.238**	0.0930**		0.327***	0.438***
	(0.0495)	(0.114)	(0.0381)		(0.0501)	(0.0485)
ln_labor	-0.209***	0.466**	0.110	-0.275***	-0.224***	
	(0.0619)	(0.172)	(0.0728)	(0.0562)	(0.0644)	
ln_rate	1.511***	-0.776**	-0.580***	1.761***	1.383***	1.581***
	(0.154)	(0.373)	(0.132)	(0.158)	(0.148)	(0.146)
ln_Tcost	1.550***	1.344***	0.807***	1.252***	1.451***	1.287***
	(0.0547)	(0.161)	(0.0601)	(0.0678)	(0.0557)	(0.0439)
ln_import				0.366***		
				(0.0385)		
ln_market					0.332***	
					(0.0895)	
ln_hr2						1.192***
						(0.352)
_cons	-10.98***	0.279	6.850***	-13.16***	-9.994***	-13.15***
	(0.979)	(2.770)	(0.850)	(1.035)	(0.959)	(1.291)
N	616	616	616	616	616	616
R^2	0.961	0.927	0.977	0.962	0.962	0.960

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust standard errors are reported in parentheses.*

4.3 Endogeneity Test

Since the baseline regression may suffer from endogeneity problems caused by reverse causality and omitted variables, leading to biased OLS estimates, this paper selects the first-order and second-order lags of economic openness as instrumental variables and performs two-stage least squares (2SLS) regression while controlling for province fixed effects. The results are shown in Table 4.

The p-value of the identification test is 0.0000, strongly rejecting the null hypothesis of "under-identification of instruments." The F-statistic is 430.823, far exceeding the Stock-Yogo 10% critical value of 19.93, ruling out the weak instrument problem. The p-value of the Hansen J over-identification test is 0.0624, which does not reject the null hypothesis that "all instrumental variables are exogenous" at the 5% significance level. These tests indicate that the instrumental variables selected in this paper are valid. Regarding the estimation results, the coefficient of economic openness passes the 1% significance level test, indicating that after accounting for potential sample selection bias, the above research conclusions remain unchanged, ensuring the robustness of the empirical findings.

Table 4: Comparison of Instrumental Variable Regression Results

	(1) ln_cap2	(2) ln_cap2
ln_Economy~s	0.389***	0.290***
	(0.0495)	(0.0263)
ln_labor	-0.209***	-0.0704**
	(0.0619)	(0.0344)
ln_rate	1.511***	0.671***
	(0.154)	(0.103)
ln_Tcost	1.550***	1.254***
	(0.0547)	(0.0325)
_cons	-10.98***	
	(0.979)	
N	616	560

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust standard errors are reported in parentheses.*

5. Further Analysis

5.1 Mediation Effect Test

The baseline regression verifies research hypothesis H1, that is, economic openness can increase capital stock. However, the mechanism through which economic openness affects capital stock requires further exploration. Based on the theoretical analysis, economic openness may influence capital stock through two pathways: technological progress and industrial structure optimization.

5.1.1 Technological Progress

This paper selects the number of invention patent applications (pat1) as the mediating variable for technological progress. The natural logarithm of invention patent applications is taken; a larger value indicates a higher level of technological progress in the region. As shown in the test results in Table 5, the coefficient of economic openness on invention patent applications is significant, indicating that the technological progress mechanism plays a mediating role in the process by which economic openness increases capital stock. Thus, hypothesis H2a is supported.

Table 5: Mediation Effect of Technological Progress

	(1) ln_cap2	(2) ln_pat1	(3) ln_cap2
ln_Economy~s	0.389***	0.238**	0.375***
	(0.0495)	(0.114)	(0.0468)
ln_labor	-0.209***	0.466**	-0.237***
	(0.0619)	(0.172)	(0.0601)
ln_rate	1.511***	-0.776**	1.558***
	(0.154)	(0.373)	(0.155)
ln_Tcost	1.550***	1.344***	1.469***
	(0.0547)	(0.161)	(0.0846)
ln_pat1			0.0606*
			(0.0350)
_cons	-10.98***	0.279	-11.00***
	(0.979)	(2.770)	(0.995)
N	616	616	616

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust standard errors are reported in parentheses.*

5.1.2 Industrial Structure Optimization

This paper uses the tertiary industry added value index as the mediating variable for industrial structure optimization. A larger tertiary industry added value index indicates a higher degree of industrial structure optimization in the region. As shown in the test results in Table 6, the coefficient of economic openness on the tertiary industry added value index is significant, indicating that the industrial structure optimization mechanism plays a mediating role in the process by which economic openness increases capital stock. Thus, hypothesis H2b is supported.

Table 6: Mediation Effect of Industrial Structure Optimization

	(1) ln_cap2	(2) x3index	(3) ln_cap2
ln_EconomyOpenness	0.389***	-0.594***	0.303***
	(0.0495)	(0.139)	(0.0568)
ln_labor	-0.209***	0.568**	-0.127*
	(0.0619)	(0.254)	(0.0620)
ln_rate	1.511***	1.925***	1.789***
	(0.154)	(0.384)	(0.171)
ln_Tcost	1.550***	2.273***	1.879***
	(0.0547)	(0.205)	(0.106)
x3index			-0.145***
			(0.0312)
cons	-10.98***	-33.58***	-15.84***
	(0.979)	(2.871)	(1.613)
N	616	616	616

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust standard errors are reported in parentheses.*

5.2 Heterogeneity Analysis

According to the regional heterogeneity regression results in Table 7, there are significant regional differences in the impact of economic openness on capital stock across the country. Specifically, the coefficient of economic openness in the eastern region is 0.576, significant at the 1% level, and is the highest among the three major regions. The coefficient in the central region is 0.277, significant at the 5% level. The coefficient in the western region is 0.307, also significant at the 1% level. The above results indicate that the promoting effect of economic openness on capital stock holds in all regions, but the magnitude of the effect follows the pattern "eastern > western > central."

The eastern region, with its superior geographical conditions, well-developed infrastructure, and higher level of marketization, can more fully utilize the capital, technology, and market opportunities brought by opening-up, thereby driving capital accumulation to a greater extent. Although the western region is located inland, it has benefited from national strategies such as the Belt and Road Initiative and the Western Development Strategy, leading to rapid development of its open economy. Its promoting effect on capital stock even exceeds that of the central region. The relatively lower opening-up effect in the central region may be related to the stage-specific characteristics of its industrial structure and opening-up model, and further improvement in the quality of openness and capital absorption capacity is still needed. Overall, economic openness is an important driving force for capital accumulation across regions. However, policy formulation should take into account regional heterogeneity and implement differentiated opening-up strategies.

Table 7: Heterogeneity Analysis

	(1) Eastern	(2) Central	(3) Western
ln_Economy~s	0.576***	0.277**	0.307***
	(0.054)	(0.108)	(0.061)
ln_labor	-0.143*	-0.336**	-0.137
	(0.075)	(0.133)	(0.083)
ln_rate	1.651***	1.282***	1.257***
	(0.297)	(0.282)	(0.203)
ln_Tcost	1.427***	1.633***	1.546***
	(0.084)	(0.101)	(0.056)

_cons	-11.251***	-9.722***	-9.678***
	(1.981)	(1.571)	(1.221)
N	220	176	220
adj. R2	0.951	0.975	0.964

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust standard errors are reported in parentheses.*

6. Conclusions and Policy Recommendations

6.1 Conclusions

Based on existing research findings, this paper constructs a mechanism framework for how economic openness affects capital stock, explores the promoting effect of economic openness on capital stock and its transmission pathways, and conducts empirical testing using provincial panel data from 1998 to 2019. The main research conclusions are as follows:

(1) Economic openness can significantly promote the increase of capital stock, and this conclusion remains valid after robustness tests and consideration of endogeneity issues.

(2) Through mediation effect analysis, it is found that the mechanism pathways by which economic openness empowers capital accumulation mainly involve the technological innovation effect and the industrial structure optimization effect. These pathways promote capital stock growth by increasing the number of invention patent applications and the tertiary industry added value index.

(3) There exists regional heterogeneity in the effect of economic openness on capital accumulation. The opening-up effects in the eastern, central, and western regions are all positive, but the magnitude follows the pattern "eastern > western > central." The eastern region achieves a larger promoting effect due to its geographical advantages and high level of marketization, while the western region outperforms the central region under strategic support.

6.2 Policy Recommendations

In the context of accelerating restructuring of global trade and investment rules, all regions should pay greater attention to the role of economic openness in capital accumulation. Based on the empirical findings, this paper puts forward the following three policy recommendations:

(1) Continuously promote institutional opening-up and optimize the external environment for capital accumulation. China should proactively align with high-standard international economic and trade rules and steadily expand institutional opening-up. On the one hand, it should further reduce the negative list for foreign investment access and increase openness in modern service sectors such as finance, telecommunications, and healthcare to attract high-quality foreign capital inflows, thereby directly expanding the supply of capital factors. On the other hand, it should optimize the import and export structure, encourage the importation of advanced technologies and key components, and enhance the technological content of domestic capital goods through the "learning-by-doing" effect. At the same time, it is necessary to improve the market-oriented exchange rate formation mechanism, maintain the basic stability of the RMB exchange rate at a reasonable level, reduce exchange rate fluctuation risks in an open economy, and create a stable and predictable macroeconomic environment for capital accumulation.

(2) Smooth the transmission channels for technological progress and industrial structure optimization. First, accelerate the pace of technological innovation and strengthen its pivotal role. All regions should increase R&D investment, improve the intellectual property protection system, and stimulate the endogenous motivation of enterprises for technology absorption through imports and learning through exports. Support should be given to enterprises to establish overseas R&D centers and engage in technological cooperation with foreign-invested enterprises, so as to enhance independent innovation capabilities through technology spillover effects and transform innovation achievements into new productive capital. Second, focus on the development of the tertiary industry and leverage the supporting role of industrial structure optimization. All regions can take the expansion of service sector openness as an opportunity to promote the specialization and high-end extension of producer services in the value chain and facilitate deep integration between manufacturing and services. By increasing the share of the tertiary industry's added value, expanding the scale of fixed asset

investment in the service sector, and improving capital allocation efficiency in manufacturing, capital can be guided toward high value-added industries.

Implement differentiated regional opening-up strategies to promote coordinated regional capital accumulation. This study finds that the promoting effect of economic openness on capital stock follows the pattern "eastern > western > central." Therefore, policy formulation should fully consider regional heterogeneity. For the eastern region, it should leverage its geographical, market, and institutional advantages to build high-level opening-up platforms and accelerate the exploration of new models of capital accumulation. For the western region, it should continue to rely on national strategies such as the Belt and Road Initiative and the Western Development Strategy, strengthen cross-border transportation infrastructure and port construction, and enhance the level of inland open economy. The western region should focus on attracting foreign investment projects that match its local resource endowments and industrial foundation, while avoiding low-level duplicated construction. For the central region, efforts should be made to optimize the business environment, enhance its attractiveness to high-end capital and technology-intensive industries, and strengthen industrial collaboration and gradient transfer acceptance with the eastern region, so as to narrow the gap in capital accumulation between regions and achieve coordinated progress in economic openness and capital growth across the eastern, central, and western regions.

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Conflicts of Interest

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