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# Standard Internationalization: A Strategic Driver of Global Competitiveness in the New Materials Industry

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**Abstract**

Against the backdrop of intensifying global technological competition, the internationalization of standards has emerged as a pivotal strategy for securing leadership in emerging industries. Using the new materials industry as a case study and grounding the analysis in the theory of national competitive advantage, this study constructs a novel measurement model to investigate the impact of standard internationalization on industrial international competitiveness. Employing stepwise regression analysis on a dataset encompassing 50 countries, we demonstrate that standard internationalization exerts a significant positive effect, which is primarily channeled through two mediating pathways: fostering industrial agglomeration and stimulating technological innovation. Heterogeneity analysis further reveals that the effect is more pronounced in developed countries and in nations with lower levels of international cooperation. These findings not only suggest a viable pathway for breaking China's vicious cycle of outdated standards but also offer valuable insights for enhancing the competitiveness of strategic emerging industries globally.

***Keywords:*** *standard internationalization, strategic emerging industries, international competitiveness, influence mechanism*

**JEL Classification**: C01,C33,C36,C52,F14,L15,L60,O25,O53

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## 1 INTRODUCTION

Recently, amid increasing economic globalization, standards have exerted a significant impact on economic and trade activities as well as industrial development. The internationalization of standards has emerged as a crucial factor in the competition for comprehensive national strength, encompassing economy, science, and technology—even military capabilities (Men, 2017). Its impact on industrial competitiveness is significant, particularly in the context of strategic emerging industries. Research by Tu et al. (2016) indicates that standardization serves as a crucial bridge for the new materials industry to transition from laboratory research to market application. Strategic emerging industries represent key sectors for securing new competitive advantages in future. Promoting the alignment of strategic emerging industry standards with international norms and advancing the "going global" initiative of Chinese standards not only serves as a bridge for establishing international innovation cooperation platforms and efficiently leveraging global innovation resources, but also constitutes a "first-mover strategy" to seize the leading edge in the upcoming new paradigms in science and technology and the comprehensive restructuring of industries. Therefore, advancing the internationalization of strategic emerging industry standards holds immense strategic significance for acquiring international competitive advantages (Liu et al., 2021). New materials guide progress in nearly all high-tech industries, such as aerospace, electronics and information technology, new energy, biomedicine, etc. While China's new materials sector has

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achieved a certain scale, its development remains uneven. Research by Xu et al. (2024) indicates that high-value patents exhibit significant spatial clustering, predominantly concentrated in coastal developed regions such as the Yangtze and Pearl River Deltas, as well as areas rich in scientific research resources. Nevertheless, the whole industry experiences severe challenges from critical technological bottlenecks. Reliance on imports persists for certain core materials and manufacturing processes, underscoring the urgency of enhancing independent innovation capabilities (Zhang et al., 2025). While industrial clusters such as the Pearl River Delta have developed synergistic advantages in specific sectors, their industrial structure and sophistication require further optimization, influenced by multiple factors including technology, capital, and policy (Sun, 2025). As a foundational and pioneering industry, it exhibits typical characteristics of high technology intensity, high capital investment, extended research and development (R&D) cycles, interdisciplinary integration, and high interconnectivity. Its development heavily relies on continuous R&D innovation and intellectual property accumulation (Xu et al., 2024). Simultaneously, the industry exhibits significant spatial clustering, with upstream and downstream enterprises, universities, and research institutions forming collaborative innovation ecosystems within specific regions (Sun, 2025). Breakthroughs in new materials can directly drive upgrades across numerous downstream sectors, including high-end manufacturing, new energy, and information technology, serving as a core engine propelling the overall industrial structure toward mid-to-high-end development. Presently, academic research on the international competitiveness of strategic emerging industries has predominantly centered on first-mover countries. He (2023) conducted industry-specific measurements of the international competitiveness of strategic emerging industries across major global economies and identified that developed countries exhibit robust international competitiveness compared to developing countries in multiple sub-sectors of strategic emerging industries. Research on the international competitiveness of strategic emerging industries in late-mover countries has remained largely theoretical. For instance, Liu (2024) explored the theoretical logic behind cultivating international competitiveness in strategic emerging industries, while Liu et al. (2021) theoretically examined the significance of standardization strategies in comprehensively enhancing the development capabilities of strategic emerging industries.

From a theoretical perspective, to explore the impact of standard internationalization on the competitiveness of the new materials sector at an international level, we can examine Porter's (1990) theory from the book, *The Competitive Advantage of Nations*, which links a country's industrial strength to the following four elements: factors available; nature of internal demand; presence of supporting and related businesses; and strategic mindset of companies about structure and competition. Collectively, these four aspects constitute a "diamond system," which determines the international competitive advantage of a country's industries (He, 2018). Standards form an imperative restriction of products, which can render products more specialized, leading to the achievement of economies of scale. Consequently, standards can be regarded as an advanced, or special factor of production (Bai, 2021).

The United Nations Industrial Development Organization (UNIDO)'s theory of industrial competitiveness posits that competitiveness stems from a dynamic system encompassing capacity building, market linkages, sustainability, and institutional foundations. It transcends traditional static cost advantages, emphasizing the development of sustainable long-term productivity through the synergistic advancement of technological innovation, value chain upgrading, resource efficiency, and social inclusiveness. This approach aims to guide policy formulation toward inclusive and sustainable industrial development. Standards are far from an isolated element in UNIDO's theory; they serve as a "systemic glue" and "upgrade lever." By establishing lucid, unified benchmarks, standards transform institutional rules within the

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"enabling environment" into concrete targets for enhancing "internal capabilities." This facilitates industries in achieving higher value in the "market" while ensuring the process aligns with the direction of "sustainable development." Therefore, the ability to develop, adopt, and lead standards is itself a crucial manifestation of advanced industrial competitiveness.

If domestic standards outclass international standards, it can stimulate international demand and elevate international competitiveness. This study applies an empirical analysis approach and sets up an econometric model with variables such as a new materials industry's exporting competitiveness index and the degree of standard internationalization. Additionally, we propose hypothesis 1 (H1): Standard internationalization has a positive effect on industrial international competitiveness.

This provides empirical proof for the analysis of the driving factors underlying the international competitiveness of the new materials industry, which also contributes to the quantified research in the existing body of literature. It makes two distinct contributions to the field. First, from the perspective of research, this study differs from the previous approaches that examine the impact of national standards on domestic industry ecosystems, and introduces new observational elements, such as the number of foreign-language editions of national standards. A dynamic analytical framework—linking the degree of national standard internationalization with industrial competitiveness—is constructed to systematically reveal the non-linear relationships among the international recognition of national standards, the degree of industrial clustering, and technological innovation. Second, to address the developmental challenges experienced by strategic emerging industries in late-developing countries and based on the current stage of China's new materials industry, the study identifies two key influencing mechanisms: industrial clustering and technological innovation. By promoting the mutual international recognition of standards, late-developing countries can overcome technological barriers, form industrial clusters to acquire a voice in standard-setting, and transcend the role of passive rule-followers to achieve leapfrog development.

## 2 MECHANISM OF INFLUENCE ANALYSIS

Specific production factors, standards, and the global extension of these standards drive industrial updating to facilitate industries' global competitiveness. Porter, in *The Competitive Advantage of Nations,* outlines that a nation's industrial competitiveness develops through four separate stages, with varying drivers of competitiveness, sources of advantage, and policy orientation: the factor-, investment-, innovation-, and wealth-driven stages (Porter, 1990). Currently, China's new materials industry is shifting from a purely investment-driven growth model to an innovation-driven model—an evolution underpinned by the industry's complex nature and its structural characteristics. The continuation of this phase for investment has certain technological limitations and large-scale production traits in some sectors. For example, basic materials and low- and medium-end new materials can be mass-produced, but high-end new materials technology remains imports-reliant. Furthermore, State-led investments are boosting capacity, but the focus on capacity over innovation remains, and the supply of high-end materials is constrained by foreign vendors.

Additionally, uneven development is evident in various sectors. Some areas have transitioned from an investment- to an innovation-driven phase; some, such as high-end semiconductor materials and carbon fibers, are in the process of making the transformation; and some have already achieved breakthroughs in innovation—as seen in new energy materials and lightweight alloys. An overall evaluation of the demand situation, industries, and the government's role indicates that the new materials industry in China is in a transition phase.

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On the one hand, industrial agglomeration serves as a key driver for healthy industrial growth. It extends industrial chains and refines industrial ecosystems, enabling enterprises enhance production efficiency, reduce costs, and foster a favorable environment for industrial development. By implementing industrial development plans and investment promotion strategies, governments can facilitate industrial agglomeration and achieve economies of scale (Xie & Duan, 2024). On the other hand, guiding industrial innovation through scientific and technological breakthroughs represents the essential path to achieving high-quality economic and social development in China (Wang, 2025). Mid- and low-end sectors need transformation, and high-end sectors need to overcome critical technological bottlenecks to accelerate the shift toward a fully innovation-driven development model. This study categorizes the impact mechanism of standard internationalization on the international competitiveness of the new materials industry into industrial agglomeration effects and technological innovation effects..

## 2.1 Industrial Agglomeration Effect

With the "investment-driven" phase giving way to an "innovation-driven" phase for the materials industry, the distinction between different industries becomes obscure, and the number of firms continues to increase. When the number of derivative enterprises attains a certain level, the agglomeration effect plays a crucial role. Economies of scale engender many similar firms as well as upstream and downstream supporting companies. Hence, a significant cluster effect exists (Hou et al., 2025). Standardization and internationalization—that is, the unification of standards—significantly reduce the costs of coordinated development across upstream and downstream industries. It minimizes technological mismatches and information asymmetry while boosting production efficiency. Simultaneously, standardization promotes technological spillovers within clusters. These spillovers elevate the overall technological level of the entire industrial cluster, thereby enhancing the industry's international competitiveness.

Therefore, the following hypotheses are obtained:

H2: Standard internationalization enhances the international competitiveness of industries by promoting industrial clustering.

Zhang et al. (2022) indicated that in China's new materials industry, the clusters show a trend of clustering around eastern coastal areas; the central, western, and northeastern areas also have characteristic development patterns. In terms of industrial development, these clusters demonstrate specialization, geographic concentration, and co-occurrence of large, medium, and small enterprises, and industrial integration. In terms of specialization, various specialties have developed across different regions of the new material industry, with immense competitive advantages domestically and internationally. Standardization also plays a key role in industrial clustering because the setting of standards involves the accumulation of technologies and the coordination of suppliers, users, research institutes. Individual enterprises' independent R&D involves a high risk, with sunk costs. The efficiency of industrial clusters stems from the technological compatibility and information symmetry between upstream and downstream enterprises. Standard internationalization first compels clusters to unify technical specifications internally, generating significant synergistic effects. Industrial clusters function as innovation systems comprising a full supply chain as well as customers and supporting bodies, thus lowering barriers collaboration barriers and facilitating rapid adoption of standards. Clusters function as natural platforms for establishing technical standards and concentrating industries, thus promoting effective cooperation and competition among enterprises (Hu & Tang, 2012).

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Therefore, the following hypothesis is proposed:

H2a: Standard internationalization has a positive effect on industrial agglomeration.

In his work, *The Competitive Advantage of Nations*, Porter introduced the concept of industrial clusters, emphasizing that industrial clusters promote the competitiveness of a country or region (Porter, 1990). He defined that an industrial cluster is "a geographically close agglomeration of interconnected firms and related institutions in a specific field" (Porter, 1998). Industry agglomeration substantially propels the region's quality competitiveness. According to Hong et al. (2025), industrial clusters create an advantageous market for skilled labor. Around the clusters, there are supporting industries, which provide tools and raw materials. The possession of industry-specific knowledge is no longer a closely guarded secret. However, it is essential to familiarize oneself with the environment (Marshall, 1920). Industrial agglomeration can achieve economies of scale, economies of scope, and technological spillovers, and thus promote industrial development. In new materials industry clusters, companies can purchase raw materials, control production, and inspect quality following common standards, lowering production costs and making products more consistent. Industry also spurs technology spillover, which elevates the overall technological level of the industry cluster, thus improving the international competitiveness of the industry.

Therefore, the following hypothesis is proposed：

H2b: Industrial agglomeration has a positive effect on industrial international competitiveness.

### 2.2 Technological Innovation Effect

To apply the results from technological innovation, standard internationalization would make industries focus more on researching leading-edge technologies, accelerate the iterations of key technologies and their collaborative breakthroughs, and achieve coordination among patents and standards. The mechanism is able to both create technical hurdles and further boost the efficiency of innovation resources accumulation. It can also improve the bargaining power and proportionate share within the global value chain by creating a global standard ecosystem, significantly improving the international competitiveness of industries. Standardization serves as a vital means to drive technological innovation, enhance industrial competitiveness, and achieve high-quality development. It is a key driver accelerating innovation within the new materials industry (Luo et al., 2025).

Therefore, the following hypothesis is proposed：

H3: Standard internationalization catalyzes technological innovation, thereby enhancing the international competitiveness of the industry.

Wang & Huang(2023) utilized the strategic emerging industry of next-generation information technology as an example to demonstrate the critical role of core technologies in the development of emerging industries. Although innovation activities are active across various sectors in China, a considerable gap remains compared to the world's leading standards, and the quality of research and development requires significant improvement. Both technological push and market pull are essential for the industrialization of cutting-edge technologies and the development of future industries. Innovation and market demand interactively contribute to technological advancement (Michael & Steven 1982). Standardization is a major economy, crucial for improving the innovation performance of the high-tech industry (Li, 2023). By formulating and implementing standards through transformation, scientific research outcomes can be standardized and systematized. This reduces uncertainties and risks in technology dissemination, enhances the reproducibility and reliability of research results, enables rapid

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conversion of scientific achievements into productive capacity, and provides technical support for innovation in new materials (Luo et al., 2025).

Therefore, the following hypothesis is proposed：

H3a: Standard internationalization has a positive impact on technological innovation capability.

Innovation and technological progress are the key influencing factors underlying a nation's global competitiveness (Cetin, M & Erkisi, K, 2023). Technological innovation refers to advancements in production technologies, including the development of new technologies or the innovative application of existing ones (Liu, 2025). Gan (2024) stated that new materials, which are either new or improved versions of high-performance materials that are newly developed, are crucial for the upstream segments of different industries' manufacturing chains. The growth of high-tech industries has stimulated the global demand for advanced materials. China's new materials sector now holds 30% of the global market and leads in certain areas. Nonetheless, it trails developed countries and regions such as the U.S., Japan, and Europe in research investment intensity and fundamental research capabilities because of the effect of technological innovation, which can be explained by the gap theory of technology. Posner (1961) posited that technology gap among countries is a key driver of international trade. Technologically advanced countries obtain temporary monopolistic benefits via creation until such technologies are copied by other nations. The transformation and application of technological achievements can also enhance product quality and safety reliability, and reduce production costs, thereby boosting market competitiveness and promoting industrial competitiveness.

Therefore, the following hypothesis is proposed:

H3b: Technological innovation capability has a positive impact on industrial international competitiveness.

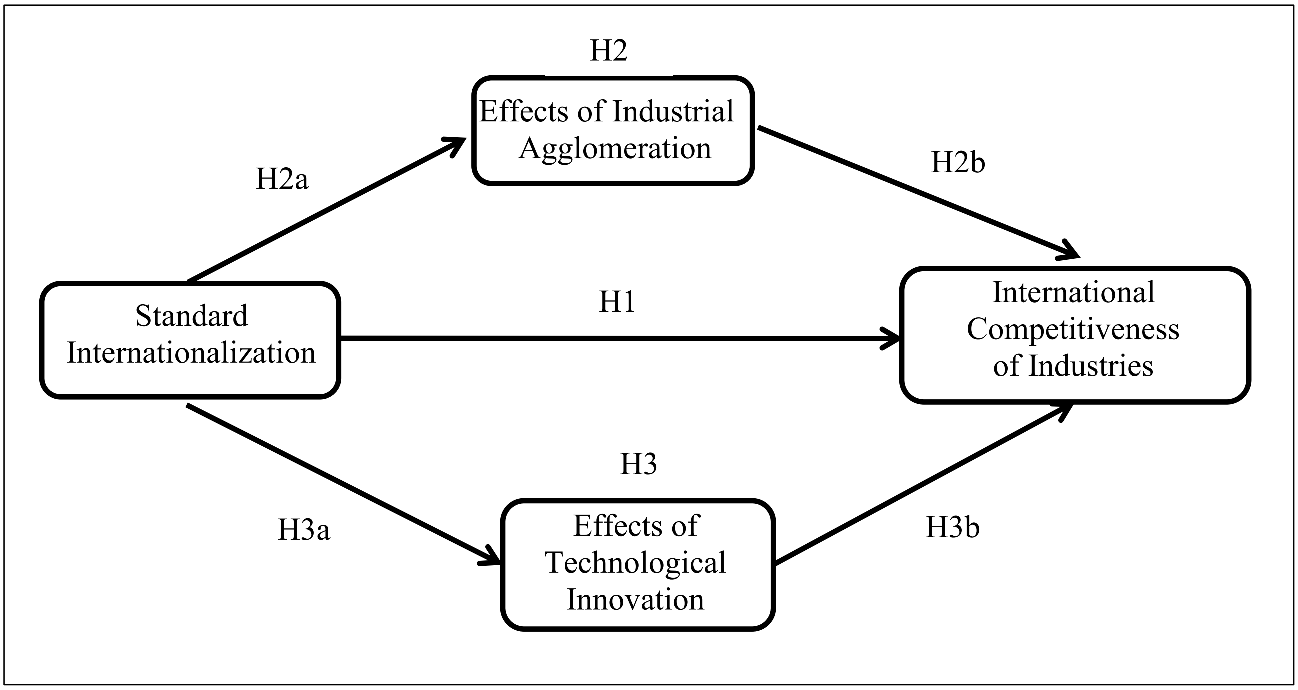


Fig. 1 – Impact Path.Source: own search

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# 3 CONSTRUCTION OF CORE INDICATORS

## 3.1 Sample Selection, Data Sources, and Data Processing

This study investigates the impact of standard internationalization on the international competitiveness of China's strategic emerging industries, with a particular focus on the new materials industry at the provincial level. Two micro-level datasets are employed: the foreign language versions of national standards (2002–2023), and the United Nations Comtrade Database (2014–2023). The sample period is set as 2014–2023.

The data on foreign language versions of national standards are sourced from the National Public Service Platform for Standards Information. This platform currently serves as the most comprehensive repository of national standards, offering search services for various types of standards, including national, industry, local, enterprise, and group standards. In this study, the foreign language versions of national standards were selected as the research subject. Based on the data obtained from the platform, all standards issued from 2002 to 2023 were gathered. Basic information on the foreign language versions was obtained, including the publication date of the foreign language version and the expiration date of the standard itself. Standards that had been withdrawn and lacked a publication date were excluded. Subsequently, data on foreign language versions of national standards related to the new materials industry were filtered and selected.

The data on international competitiveness are sourced from the United Nations Commodity Trade Statistics Database, which compiles import and export data of new material products from 50 countries. By matching the foreign language versions of national standards with the international competitiveness data, panel data for these 50 countries from 2014 to 2023 have been constructed.

## 3.2 Construction of Core Indicators

Dependent Variable

The international competitiveness of the new materials industry is chosen as the dependent variable. Generally speaking, industrial international competitiveness refers to the sustainable advantages an industry possesses relative to its competitors in the global market. From an economic perspective, industrial competitiveness represents a meso-level concept compared to corporate competitiveness and national competitiveness. Its analytical framework involves international or interregional comparisons (Porter, 2014). International competitiveness encompasses multiple dimensions, including export market performance, technological innovation capabilities, position within industrial and value chains, production efficiency, and sustainable development capacity. From an international trade standpoint, industrial international competitiveness reflects a country's ability to foster its enterprises to capture international markets and generate profits with specific products (Chen et al., 2025). The most common international competitiveness index measurement methods according to existing literature include the Revealed Comparative Advantage Index (RCA), Market Share (MS), and Trade Competitiveness Index (TC). Based on data availability and representation considerations, TC is applied as the indicator to evaluate the international competitiveness of the new materials industry. This indicator is defined as the ratio of a country's exports and imports of one product category compared to the total trade (exports + imports) of one product category. Thus, this index is generally applied to reflect the competitive advantage of a certain kind of product in the international market (Liu, 2008). In this study, this index is calculated based on the following formula:

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$$TC_{it}=\frac{EX_{it}\text{-}IM_{it}}{EX_{it}+IM_{it}} \tag{1}$$

Here, i is the country; t is the time; EX stands for the export value of the new materials industry; IM stands for the import value of the new materials industry. For the ratio ranging from -1 to 0 it is considered that the foreign trade is disadvantageous, and for ratios ranging between 0 and 1 it is advantageous.

The international competitiveness of the new materials industry within 50 countries differs greatly mainly because of the differences in their development levels, education standards, and policies. The most economically developed countries relying on their advantages in technology and capital have big industries and strong capacity for innovation. Conversely, developing countries strongly rely on resources, focusing on niche areas, and lag far behind in comparison.

Core Explanatory Variable

The core explanatory variable of this study is standard internationalization (standard). The degree of development of standard internationalization in China's new materials industry is measured by the annual increase in the number of foreign-language versions of national standards from 2014 to 2023. As shown in the chart, the number of such standards related to the new materials industry in China has a steadily rising trend up to 2023. However, the standard system and its classification for strategic emerging industries in China remain underdeveloped. Dong and Xiong (2021) emphasized the need to strengthen guidance, promote the development of standardization demonstration projects, focus on "green" development, conduct risk assessments, and facilitate the internationalization of the standardization system. Qiu et al. (2022) argued that it is essential to improve the standard system, enhance policy support, leverage the functions of standardization institutions, refine standard evaluation mechanisms, and accelerate the standardization of scientific research outcomes. The establishment of a standardized system for strategic emerging industries can further promote their international development and enhance their global recognition. As the level of internationalization of standards continues to rise, it will greatly facilitate China's efforts in certification and conformity assessment, bringing significant benefits to the development of its strategic emerging industries.

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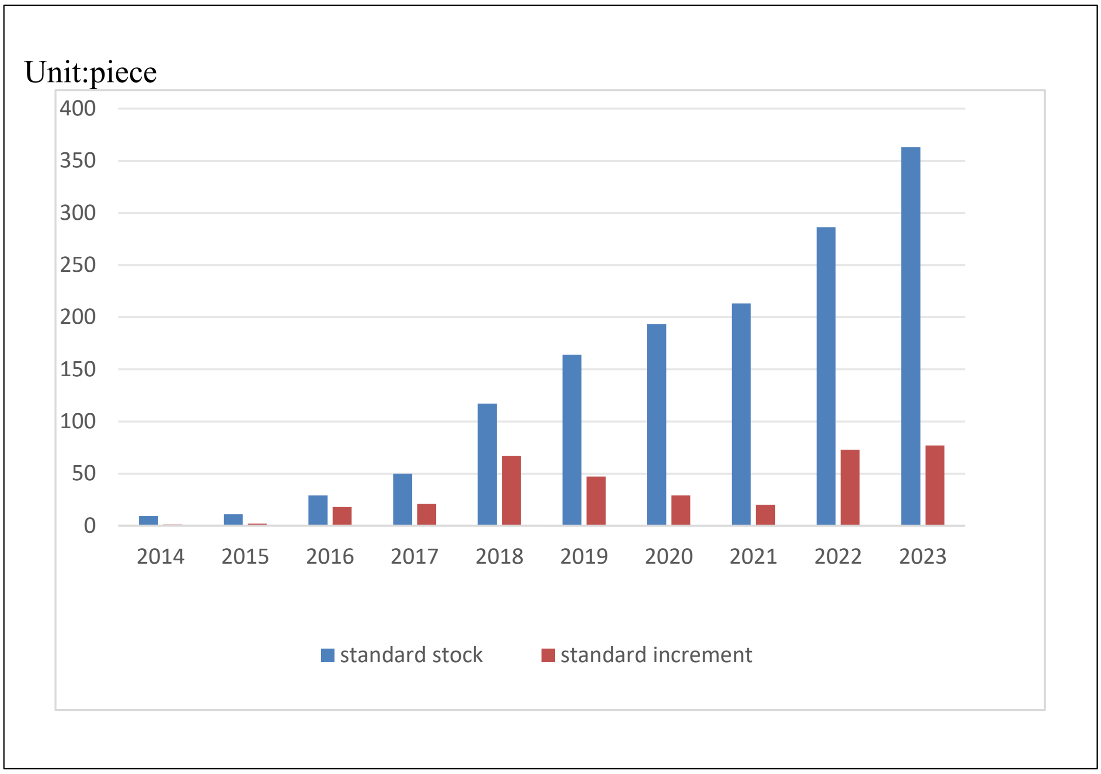


Fig. 2 – Standard Growth Trend.Source: own search

### 3.3 Control Variables

Drawing on the research findings of Yu and Wang (2018); Yang and Luo (2023); and Luo (2023), six factors that have a significant impact on the international competitiveness of the new materials industry are selected as control variables: Gross Domestic Product (GDP), Education Level (EDU), Total Factor Productivity (TFP), Political Stability (Stable), Foreign Direct Investment (FDI), and Geographical Distance (Distance), as detailed below:

Gross Domestic Product (GDP): As a core indicator that directly reflects a country's economic development, the scale and growth trend of GDP significantly influence the foundational development and market potential of the new materials industry.

Education Level (EDU): Assessed based on national education expenditures from 2014 to 2023, with data sourced from the World Bank. High-quality education can effectively boost labor productivity. In terms of the competitive advantages generated in today's knowledge economy, more and more people believe that these advantages are due to intangible assets, such as formal and informal education (Denkowska et al., 2020). As for new materials, improving international competition is mainly dependent on a skilled workforce. Cultivation and retention of such talent requires a robust and high-quality education system.

Total Factor Productivity (TFP): This is an important measure to reflect the level of high-quality economic development. It includes the contributions of technology improvement, efficient use of resources, and institutional innovation to the whole output. In this study, we applied the estimation approach proposed by Tian et al. (2017) on TFP, and estimated the TFP of every country by fixing the effects model. An increase in TFP implies that it is possible to produce greater output with smaller input, which will have a significant positive effect on the new materials industry with emphasis on technology.

Political Stability (Stable): Political stability implies a basic push for international competition in the new materials industry. A stable political environment engenders long-term economic and industrial growth . Such conditions are conducive to conducting research and development (R&D), expanding manufacturing capacity, and accessing international markets in the new materials sector.

Foreign Direct Investment (FDI): This is a major driving force and plays a key role in industrial development through foreign capital inflow, technological transfer, and market access. From an economic perspective, globally, FDI has many benefits because it promotes competitiveness, employment generation, and foreign trade (Skare & Cvek, 2020). These benefits foster the new material products to enhance the technology level, reduce the cost of product production, and promote the export of the material products.

Geographical distance (Distances): Proximity will affect China's export freight of its new materials and the cross-border promotion of related standard efficiency. The proximity of China to key markets and raw materials is a significant factor in the country's capacity to compete globally.

Tab. 1 – Indicator Description.Source: own search

| Variable | Symbol | Measurement Indicator (Unit) | Data Source | Expected Sign |
|---|---|---|---|---|
| Explained Variable | TC | International Competitiveness | United Nations Comtrade Database | / |
| Core Explanatory Variable | standard | Standard Number of National Standards Available in Foreign Languages | National Public Service Platform for Standards Information | + |
| Mediating variable | M | Gather | Qichacha, China Statistical Yearbook | / |
| | | patent | Incopat | / |
| Control Variables | GDP | GDP Gross Domestic Product | World Bank | + |
| | FDI | Foreign Direct Investment | | + |
| | EDU | Education Level | | + |
| | Stable | Political Stability | | + |
| | Distances | Distances Geographical Distance | | - |

### 3.4 Model Specification

The model will be specified to ascertain how standard internationalization influences industrial international competitiveness.

$$TC_{it} = \beta_0 + \beta_1 L2.standard_{it} + \beta_2 \mathrm{GDP}_{it} + \beta_3 \ln FDI_{it} + \beta_4 EDU_{it} + \beta_5 Stable_{it} + \beta_6 Distances_{it} + \varepsilon_{it} \quad (2)$$

In which "i" is the country, "t" is the year, and ε is the random error term. TC is the dependent variable, which is measured by the Trade Competitiveness index. The central explanatory variable, standard, is measured as the yearly improvement in the quantity of national standards produced in foreign languages. Additionally, this model includes five control variables: EDU (Education level); GDP (Gross domestic product|); FDI (Foreign direct investment); Stable (Political stability); and Distance (Geographical distance). The standard is lagged by two periods for use as the main explanatory variable for the analysis.

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## Descriptive Statistics

Descriptive statistics for the variables applied in this study are presented in Table 2. The dataset comprises 500 observations from 50 countries over a 10-year period from 2014 to 2023. Owing to limitations in data availability, the control variable EDU has missing values. The proportion of missing data was 0.8%, which were filled using linear interpolation to ensure data completeness. As shown in Table 2, the dependent variable, TC, representing international competitiveness, is measured using the trade competitiveness index. Its values range from a minimum of -0.924 to a maximum of 1, with a standard deviation of 0.291, which falls within the expected range of [-1, +1]. The core explanatory variable, standard, is measured using the increase in the number of international standards published in foreign languages. The maximum value is 67, the minimum is 1, and the standard deviation is 20.500, suggesting that the promotion of international standards in foreign languages within China's new materials industry needs to be strengthened. The values for EDU, FDI, GDP, Stable, and Distance fall within a reasonable range, and no outliers are present in the statistical data.

Tab. 2 – The descriptive statistics for the variables included in the study.Source: own search

| Variable name | Sample size | Mean | Standard deviation | Min | Max |
|---|---|---|---|---|---|
| TC | 500 | 0.224 | 0.291 | -.9242263 | 1.000 |
| L2standard | 400 | 25.625 | 20.500 | 1 | 67.000 |
| GDP | 500 | 1.15e+12 | 3.49e+11 | 1.21e+10 | 2.77e+13 |
| lnFDI | 441 | 23.010 | 23.010 | 18.14754 | 26.960 |
| EDU | 500 | 24.863 | 23.010 | -6.16997 | 98.224 |
| Stable | 500 | 7.904 | 8.000 | 5 | 10.000 |
| Distance | 500 | 8451.000 | 7500.000 | 950 | 19500.000 |

## Model Selection

This study employs panel data, and the construction of the panel data model requires selection from among mixed-effects models, fixed-effects models, and random-effects models. First, the F-test determines whether a mixed-effects model or a fixed-effects model is more appropriate. Next, the LM test assesses whether a mixed-effects model or a random-effects model is more suitable. Finally, the Hausman test evaluates whether a fixed-effects model or a random-effects model is preferable. As shown in Table 3, P=0.0000 < 0.05, leading to the selection of the fixed-effects model.

Tab. 3 – Results of F-test, LM-test and Hausman test.Source: own search

| Explanatory variable | F-test | | Hausman test | |
|---|---|---|---|---|
| L2.standard | F-statistic | P-value | X2 | P-value |
| | 105.77 | Prob > F = 0.0000 | 882.36 | Prob > chi2 = 0.0000 |

This table displays the model selection.

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# 4 EMPIRICAL ANALYSIS

## 4.1 The Fundamental Return of Standard Internationalization and Industrial International Competitiveness

This study employs Stata 18.0 software and applies a fixed effects model for empirical analysis. A stepwise regression is conducted using a two-way fixed effects model that controls for both time and country. The baseline regression results are demonstration in Table 4. After controlling for variables such as EDU, FDI, GDP, Stable, and Distance, the level of standard internationalization is found to have a positive and statistically significant impact on the international competitiveness of the new materials industry at the 5% significance level, with a coefficient of 0.05. These findings indicate that standard internationalization significantly enhances the international competitiveness of the new materials industry. In this study, the dependent variable is advanced by one period, while the core explanatory variable is lagged by two periods. Consequently, the impact on the new materials industry becomes apparent three years after the promotion of the foreign-language version of the national standard. Wang and Luo (2019) suggest that the lag in standardization in China is intimately associated with the staged characteristics of economic development. The legacy of the planned economy, the transition period after joining the WTO, and challenging economic reforms together prevent the standardization system from catching up with economic development in time. The new materials industry, as an emerging industry, has its own standard system. This system is not conducive to the acceleration of the realization of foreign standards in the context of industry globalization. Furthermore, the industry's slow pace results in a less competitive global environment. The hypothesis that political stability across different countries has a positive effect on the global competitiveness of the new materials sector is supported by the estimated value of 0.038, which is significant at the 10% level. Conversely, an increase in geographic distance has exerts a detrimental effect on competition within the industry, with this effect becoming statistically significant at the 5% level. Concurrently, GDP, FDI, and EDU have been demonstrated to exert a positive and significant influence on the development of the new materials industry.

Tab. 4 – Basic regression results.Source: own search

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | TC | TC | TC | TC | TC | TC |
| L2standard | 0.004*** | 0.004*** | 0.003** | 0.003* | 0.005** | 0.005** |
| | (3.04) | (3.11) | (2.29) | (1.69) | (2.41) | (2.41) |
| GDP | | 0.000 | 0.000* | 0.000* | 0.000 | 0.000 |
| | | (1.59) | (1.72) | (1.78) | (1.61) | (1.61) |
| lnFDI | | | 0.014 | 0.016 | 0.016 | 0.016 |
| | | | (1.13) | (1.26) | (1.30) | (1.30) |
| EDU | | | | 0.004 | 0.004 | 0.004 |
| | | | | (1.62) | (1.47) | (1.47) |
| Stable | | | | | 0.038* | 0.038* |
| | | | | | (1.72) | (1.72) |
| Distances | | | | | | -0.000** |

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| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | (-2.46) |
| _cons | -0.520*** | -0.569*** | -0.892*** | -1.082*** | -1.410*** | -1.336*** |
| | (-10.13) | (-9.53) | (-2.92) | (-3.31) | (-3.74) | (-3.48) |
| id | Yes | Yes | Yes | Yes | Yes | Yes |
| year | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 400 | 400 | 348 | 348 | 348 | 348 |
| $R^2$ | 0.1214 | 0.1279 | 0.1252 | 0.1330 | 0.1418 | 0.1418 |

This table presents the basic regression results for standard and TC. ***, **, and * indicate coefficients significant at the 1%, 5%,and 10% levels, respectively. T-statistics appear in parentheses below the coefficients.

### 4.2 Robustness Test

Endogeneity Test

There is possibly an endogeneity issue with this analysis, in which case our core explanatory variable and the one we are examining (the dependent variable) are themselves mutually causal. The enhancement of the international competitiveness of the new material industry is facilitated by the implementation of internationalization standards. This, in turn, has the potential to encourage the dissemination of domestic standards on a global scale, thereby further promoting standard internationalization. Studies by Huang et al. (2021) and Sun et al. (2025) suggest that the IV approach is often adopted to test for endogeneity. This study employs the number of testing and certification bodies in the new materials sector from 2014 to 2023 as an instrumental variable(Z). Its rationale lies in the fact that a robust quality infrastructure—including testing and certification—serves as the foundation for implementing standards and advancing industrial upgrading. Enhanced testing and certification capabilities typically accompany improved standard-setting capacity and deeper understanding of international rules, exhibiting a strong correlation with the level of “standard internationalization.” The development of testing and certification systems primarily reflects the overall improvement of a nation's quality infrastructure. For the short-term export competitiveness of a specific industry, its impact is indirect and more readily satisfies exogenous conditions.I estimate the model with 2SLS. According to Table 5, Kleibergen-Paap rk LM Statistic=49.76, and it is significant at the 1% level, indicating that the endogenous regressor and the instrument have a high correlation. The Cragg-Donald Wald F statistic is 164.17, which exceeds the 10% critical value of 16.38, implying that the instrument has enough explanatory power. The first-stage regression passed the instrument relevance test as well. The coefficient is statistically significant. The instrumental variable has a good correlation with the key explanatory variable, and the problem of weak instruments is ruled out. When we incorporate these results into the second stage, it shows that the newly created explanatory variable remains significant at the 5% level with an estimated coefficient of 0.0096. So, the positive effect of standard internationalization on the international competitiveness of the new materials industry still exists, thus indicating that endogeneity is not an issue with the model.

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Tab.5 – Endogeneity test.Source: own search

| | First | Second |
|---|---|---|
| VARIABLES | L2standard | TC |
| L2standard | | 0.0030*** |
| | | (2.75) |
| Z | 3.2949*** | |
| | (140.09) | |
| lnGDP | -0.3208 | -0.0218 |
| | (-0.93) | (-0.52) |
| FDI | 0.0000 | -0.0000 |
| | (0.24) | (-1.19) |
| EDU | 0.0239*** | -0.0105* |
| | (2.65) | (-1.93) |
| distanceskm | -0.0000 | 0.0000 |
| | (-1.01) | (1.55) |
| Constant | -48.9681*** | 0.6592 |
| | (-5.76) | (0.55) |
| Kleibergen-Paap rk LM statistic | 49.76*** | |
| Cragg-Donald Wald F statistic | 164.17 (16.38) | |
| code | Yes | Yes |
| year | Yes | Yes |
| Observations | 348 | 348 |
| $R^2$ | 0.2982 | 0.2792 |
| Number of code | 49 | |

This table presents the results of the endogeneity tests for standard and TC.***, **, and * indicate coefficients significant at the 1%, 5%,and 10% levels, respectively. T-statistics appear in parentheses below the coefficients.

## Replacement of the Core Explanatory Variable

A systematic robustness test is conducted on the baseline regression by changing the measurement method of the main explanatory variable. The original “standard increment” indicator is replaced with the “standard stock” indicator. Consequently, we are now measuring the time dimension of the variable as a stock rather than a flow; more importantly, it raises the query: what would happen to the results if we measured the research finding differently? Based on the empirical results, we see that even when the variable is redefined, standard internationalization has a significant positive effect on the new material industries. The sign, statistical significance, and economic interpretation of the coefficient for core explanatory variables are still remarkably similar to those in the baseline regression results. This robustness test reveals that this study’s core finding that standard internationalization fosters new materials industry development is not due to the specific ways these variables were measured, but rather

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because it is based on solid empirical grounds. The findings are consistently very solid when we examine them from different perspectives. This renders our assertion more reliable and good for schools to learn from, and facilitates effective rule-making.

Tab. 6 – Robustness test.Source: own search

| | TC |
|---|---|
| L2standard2 | 0.0005** |
| | (2.41) |
| GDP | 0.000 |
| | (1.43) |
| lnFDI | 0.017 |
| | (1.33) |
| EDU | 0.004 |
| | (1.42) |
| Stable | 0.039* |
| | (1.76) |
| Distance | -0.000** |
| | (-2.14) |
| _cons | -1.369*** |
| | (-3.49) |
| code | Yes |
| year | Yes |
| N | 348 |
| $R^2$ | 0.1414 |

This table presents the results of robustness tests for the standard and TC models by replacing explanatory variables.***, **, and * indicate coefficients significant at the 1%, 5%,and 10% levels, respectively. T-statistics appear in parentheses below the coefficients.

## Data Truncation Processing

Apparently, there are no obvious outliers or extreme numbers in the dataset. However, to prove that the discovery is valid, we applied the same sample regression data and winsorized them at the 1st and 99th percentiles following the method proposed by Hou et al. (2023). Thereafter, we re-analyzed (see Table 7): the core explanatory variable is significant at the 5% level with a coefficient of 0.01; thus, the core variable of the regression results in this study is robust.

Tab. 7– Treatment of indentations.Source: own search

| | TC |
|---|---|
| L2standard | 0.001** |
| | (2.15) |
| GDP | 0.000 |
| | (1.42) |
| lnFDI | 0.011 |

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| | |
|---|---|
| | (0.91) |
| EDU | 0.003 |
| | (0.93) |
| Stable | 0.025 |
| | (1.22) |
| Distance | -0.000** |
| | (-2.44) |
| _cons | -1.042*** |
| | (-2.90) |
| id | Yes |
| year | Yes |
| N | 394 |
| $R^2$ | 0.1185 |

This table presents the results of robustness tests conducted on the standard and TC models through data truncation.。 ***, **, and * indicate coefficients significant at the 1%, 5%,and 10% levels, respectively. T-statistics appear in parentheses below the coefficients.

### 4.3 Heterogeneity Test

The level of economic development in various countries also influences progress in the new materials industry, as economic conditions differ across nations. Therefore, based on the Human Development Index (HDI) released by the United Nations Development Programme, the 50 sample countries were categorized into developed and developing nations for separate regression analyses. The regression results in Table 8 indicate that standard internationalization enhances the international competitiveness of China's new materials industry in developed countries. This suggests that elevating standard internationalization levels can break the vicious cycle created by outdated standards. Furthermore, owing to varying cooperation levels, the 50 countries were further categorized into Belt and Road (B&R) countries and non-B&R countries based on China's signed B&R cooperation documents, with separate regression analyses conducted. The results indicate that in countries with moderate cooperation levels, enhancing standard internationalization capacity benefits the international competitiveness of China's new materials industry. Finally, given the varying standard internationalization capabilities among nations, countries were classified based on their ISO P-member and O-member counts—indicators of standard internationalization contributions as defined by the China National Institute of Standardization. Regression analysis revealed that in nations with lower ISO contributions, enhancing standard internationalization capacity also promotes the international competitiveness of China's new materials industry.

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Tab. 8 – Heterogeneity test.Source: own search

| | Developed Countries | Developing Countries | Belt and Road Countries | Non-Belt and Road Countries | High Contribution to Standardization | Low Contribution to Standardization |
|---|---|---|---|---|---|---|
| | TC | TC | TC | TC | TC | TC |
| L2standard | 0.008*** | -0.001 | -0.003 | 0.007** | 0.002 | 0.008** |
| | (3.37) | (-0.19) | (-0.78) | (2.35) | (0.79) | (2.10) |
| GDP | 0.000 | 0.000* | 0.000*** | 0.000 | 0.000 | 0.000* |
| | (1.38) | (1.82) | (3.13) | (1.34) | (1.35) | (1.70) |
| lnFDI | 0.013 | 0.031 | 0.033 | 0.002 | 0.021 | 0.009 |
| | (1.15) | (0.72) | (1.43) | (0.14) | (1.43) | (0.33) |
| EDU | -0.000 | 0.003 | 0.002 | 0.008 | 0.005 | -0.002 |
| | (-0.09) | (0.41) | (0.52) | (1.59) | (1.35) | (-0.29) |
| Stable | 0.048** | 0.027 | 0.030 | 0.057* | 0.026 | 0.030 |
| | (2.00) | (0.58) | (0.92) | (1.87) | (0.90) | (0.78) |
| Distance | -0.000** | -0.000 | -0.000** | -0.000** | 0.000*** | -0.000 |
| | (-2.54) | (-1.08) | (-2.12) | (-2.31) | (6.09) | (-0.77) |
| _cons | -1.228*** | 0.000 | 0.000 | -1.317*** | -1.590*** | -1.120 |
| | (-3.34) | (.) | (.) | (-2.66) | (-3.34) | (-1.44) |
| id | Yes | Yes | Yes | Yes | Yes | Yes |
| year | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 223 | 125 | 149 | 199 | 254 | 94 |
| $R^2$ | 0.1200 | 0.2111 | 0.1683 | 0.2079 | 0.1298 | 0.2530 |

This table presents the results of the heterogeneity test between the standard and TC models.***, **, and * indicate coefficients significant at the 1%, 5%,and 10% levels, respectively. T-statistics appear in parentheses below the coefficients.

### 4.4 Mechanism Test of Influence

This section draws upon the research by Wen and Ye (2014) and employs a three-step causal inference test to empirically examine the mechanism through which standard internationalization influences the international competitiveness of the new materials industry. Previous empirical studies indicate that enhancing the level of standard internationalization can significantly boost the international competitiveness of the new materials industry. To ascertain the cause of this impact, this study constructs and validates the following model:

$$TC_{it} = \beta_0 + \beta_1 M_{it} + \beta_2 \mathrm{GDP}_{it} + \beta_3 \ln FDI_{it} + \beta_4 EDU_{it} + \beta_5 Stable_{it} + \beta_6 Dis\tan ces_{it} + \varepsilon_{it} \tag{3}$$

$$M_{it} = \beta_0 + \beta_1 L2.s\tan dard_{it} + \beta_2 \mathrm{GDP}_{it} + \beta_3 \ln FDI_{it} + \beta_4 EDU_{it} + \beta_5 Stable_{it} + \beta_6 Dis\tan ces_{it} + \varepsilon_{it} \tag{4}$$

Industrial Agglomeration Test

Standard internationalization can enhance the competitiveness of the new materials industry by promoting industrial agglomeration. This study constructs its agglomeration variable (gather)

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by referencing the methodology for building industrial agglomeration variables proposed by Xing, and Li. (2026), which is essentially a variant of the location quotient.

The specific calculation formula is as follows:

Step 1: Calculate the annual relative agglomeration index for each province.

$$LQ_{pt}=\frac{Company_{pt}/Area_p}{\sum_{p=1}^{N} Company_{pt}/\sum_{\square=1}^{\square} Area_p} \tag{5}$$

Where p denotes province, t denotes year, $Company_{pt}$ represents the number of new materials enterprises in province p during year t, and $Area_p$ denotes the area of province p.

Step 2: Constructing Agglomeration Indicators at the National Level

$$gather_t=\sqrt{\frac{1}{N}\sum_{p=1}^{N}(LQ_{pt}-\overline{LQ_t})^2} \tag{6}$$

Where: $\overline{LQ_t}$ represents the arithmetic mean of $LQ_{pt}$ across provinces. A higher value indicates greater industrial imbalance and a higher degree of concentration.

This indicator measures the spatial agglomeration intensity of an industry by comparing regional industrial density (number of enterprises/regional area) with the national average density. Its theoretical basis lies in the fact that agglomeration economies stem from knowledge spillovers, shared labor pools, and interrelated intermediate inputs resulting from spatial proximity among enterprises. Density directly quantifies the average distance between enterprises per unit of space; higher density increases the frequency of enterprise interactions and the likelihood of knowledge diffusion, thereby facilitating the emergence of agglomeration externalities. For technology-intensive industries (such as new materials), innovation activities heavily rely on tacit knowledge dissemination, rendering enterprise density an effective proxy variable reflecting interaction potential. Furthermore, this indicator is normalized by regional area, eliminating the interference of regional scale differences on absolute numbers and focusing on relative concentration levels. This aligns with the essence of locational entropy but more prominently highlights the role of spatial density in characterizing agglomeration mechanisms.

We set the industrial agglomeration level (gather) as our dependent variable, and the level of standard internationalization (standard) as our main independent variable. The core explanatory variable is lagged by two periods. The regression also controls for many other control variables. Regression results, presented in Table 9, show that a standard internationalized level lagged two time periods (L2.standard) has a positive effect on the standard internationalization level and a positive effect on the standard internationalization level of the new materials industry. L2.standard has a significant and positive impact on the gathering level (gather) of the new materials industry at the 1% significance level, that is, 0.0003. The result indicates that the standard internationalization level can significantly improve the degree of the industrial agglomeration of the new materials industry, thereby generating synergy throughout the entire industrial chain, and promoting the development of the industry in an international competitive situation. The lagging effect is explicable by industrial agglomeration; while the advantages of agglomeration may manifest late, they facilitate more competitive international markets.

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Tab.9 – Mechanism Test of Influence:Industrial Agglomeration Test.Source: own search

| | Baseline Regression | Testing Industrial Agglomeration Mechanisms |
|---|---|---|
| | TC | lngather |
| lngather | 2.157* | |
| | (1.76) | |
| L2standard | | 0.000*** |
| | | (529.31) |
| GDP | 0.000* | -0.000* |
| | (1.81) | (-1.95) |
| lnFDI | 0.010 | -0.000 |
| | (0.92) | (-1.03) |
| TFP | -0.357*** | 0.000 |
| | (-3.07) | (0.79) |
| EDU | 0.002 | 0.000 |
| | (1.05) | (0.79) |
| _cons | 0.300 | -0.412*** |
| | (0.47) | (-1.9e+04) |
| id | Yes | Yes |
| year | Yes | Yes |
| N | 441 | 348 |
| $R^2$ | 0.1263 | 0.8722 |

This table presents the results of the standard and TC model for industrial cluster effects.***, **, and * indicate coefficients significant at the 1%, 5%,and 10% levels, respectively. T-statistics appear in parentheses below the coefficients.

### Technological Innovation Test

Innovative technology is a key push and can reduce related economic costs. The internationalization of standards can help raise the level of technical innovation in the new material industry. These technologies drive innovation, thereby reducing economic costs and enhancing industrial international competitiveness (Uzar, 2024). This study investigated how many invention patents were awarded each year from 2014 to 2023 for listed companies in China's new materials industry, and organized that information. Using the annual number of new materials industry invention patents as a substitute for the new materials industry's degree of technical innovation (patent), it serves as an endogenous variable. Standard internationalization (Standard), the core independent variable, and a series of control variables are applied for the empirical regression of the degree of technological innovation. The regression result is as follows: standard internationalization encourages technological innovation (0.009), which is statistically significant (1%) (see Table 10). The results show that standard internationalization can lead to technological innovation in the new materials industry, upgrade technology, and boost industrial international competitiveness.

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Tab.10– Mechanism Test of Influence:Technological innovation effects. Source: own search

| | Baseline Regression | Testing of Technological Innovation Mechanisms |
|---|---|---|
| | TC | lnpatent |
| lnpatent | 0.078* | |
| | (1.76) | |
| L2standard | | 0.009*** |
| | | (25.36) |
| GDP | 0.000* | |
| | (1.81) | |
| lnGDP | | 0.031** |
| | | (2.33) |
| lnFDI | 0.010 | -0.004 |
| | (0.92) | (-1.09) |
| EDU | 0.002 | 0.001 |
| | (1.05) | (0.90) |
| TFP | -0.357*** | 0.036 |
| | (-3.07) | (0.70) |
| _cons | -1.555*** | 11.357*** |
| | (-2.84) | (28.52) |
| id | Yes | Yes |
| year | Yes | Yes |
| N | 441 | 348 |
| $R^2$ | 0.1399 | 0.8210 |

This table presents the results of the standard and TC models' technological innovation effect mechanisms.***, **, and * indicate coefficients significant at the 1%, 5%,and 10% levels, respectively. T-statistics appear in parentheses below the coefficients

# 5 DISCUSSION AND CONCLUSIONS

Against the backdrop of global technological competition evolving into a battle for standards, standards have emerged as a core strategic element, receiving high priority from countries worldwide. Enhancing international standard leadership has become an indispensable path to strengthening industrial competitiveness on the global stage. This study employs an empirical research approach, utilizing data from 50 countries as a sample and controlling for relevant confounding variables, to systematically analyze the impact of standard internationalization on the industrial international competitiveness. The study reveals that an increase in the level of standard internationalization has a significant positive effect on the international competitiveness of strategic emerging industries, and this effect exhibits a certain degree of lag. Further analysis reveals that this positive effect primarily operates through two pathways: industrial agglomeration and technological innovation. Standard internationalization reduces corporate collaboration and transaction costs, guiding the aggregation of production factors into industrial clusters that optimize resource allocation and foster synergistic development.

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Simultaneously, it steers innovation directions, compels enterprises to increase R&D investment, promotes international technological exchange, and enhances industrial innovation efficiency and technology commercialization capabilities. In summary, standard internationalization establishes a comprehensive impact system through these two intermediary pathways, providing empirical evidence and strategic guidance for countries to formulate relevant industrial and standardization strategies and enhance the international competitiveness of strategic emerging industries.

### 5.1 Theoretical Contributions

On the one hand, this study delves into the impact of standard internationalization on industrial international competitiveness. Simply put, it examines how the "going global" strategy for standards influences industrial international competitiveness. It innovatively employs the number of foreign-language editions of Chinese standards as a metric for standard internationalization, differing from approaches proposed by scholars such as Bai (2021) and Han, et al. (2024), who predominantly measure standard internationalization by the number of equivalent or identical international standards adopted. This study prioritizes the number of overseas versions of national standards as an indicator of standard internationalization, expanding the research scope from domestic markets to the realm of international industrial competition. This metric not only directly quantifies the international dissemination of national standards but also implicitly reflects their acceptance and recognition in global markets.

The regression results of the main effects show that the enhancement of standard internationalization levels significantly boosts the global competitiveness of the new materials industry. This conclusion aligns with the findings of He (2023), Zhang (2018), and Hui-Bo et al. (2023). He (2023) demonstrates that standardization levels exert a significant positive effect on enhancing the international competitiveness of the manufacturing sector. Zhang (2018) indicates that standardization significantly boosts the export competitiveness of high-tech industries. This study reaches the same conclusion as these two studies, as the new materials industry is inherently a part of the high-tech manufacturing sector. Hui-Bo et al. (2023) identified that standardization significantly enhances the international competitiveness of agricultural products. Although the new materials industry and agricultural products belong to different sectors, both are deeply integrated into global value chains and experience common challenges of quality information asymmetry and stringent market access. Therefore, establishing trust through standard internationalization is essential. Consequently, these two studies across different industries reached the same conclusion.

It is noteworthy that this study differs from the conclusions of the three aforementioned scholars in that it also identifies a lag effect in the impact of standard internationalization on the international competitiveness of the new materials industry. As a strategic emerging industry, the standardization and promotion levels of the new materials sector are still lagging behind those of the more mature manufactured industry. Theoretical transmissions from two stages model of standard internationalization (i.e., "Domestic Consolidation – International Diffusion"), which is the biggest reason for the lagging effect. After the implementation of China's national standard "Polyacrylonitrile-Based Carbon Fiber" since its publication in 2012, it took five years for Chinese enterprises to implement and iterate with standardization technology applications, finally promulgating it internationally with ISO certification in 2017. At this time, firms had to invest significant effort adjusting to the standard, while the international marketplace endured some delay in embracing the new specifications. It was only

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several years after the standard was promoted that China's carbon fiber exports saw a significant increase of 47% year on year. This evidences the lag.

On the other hand, this study innovatively proposes a dual-impact pathway of industrial agglomeration plus technological innovation. Primarily based on the current state of industrial development and the high-tech, technology-intensive characteristics of the new materials industry, it discusses two major factors that can significantly enhance the international competitiveness of the new materials industry at this stage: industrial agglomeration and technological innovation. Empirical research indicates that, regarding the industrial agglomeration effects, standard internationalization can promote the formation of agglomeration effects within industries, enabling economies of scale and reducing production costs, thereby enhancing industrial international competitiveness. Studies by Li et al. (2024), Tao et al. (2024), and Guo et al. (2024) demonstrate that industrial agglomeration significantly enhances international competitiveness across diverse sectors, including the new materials industry. Building upon these findings, this study examines the impact of standards on industrial agglomeration. Results indicate that standard internationalization significantly promotes agglomeration within the new materials industry, thereby boosting its international competitiveness.

Regarding technological innovation effects, standard internationalization facilitates technology diffusion and adoption, elevates the sector's overall technological capabilities, and drives innovation to enhance international competitiveness. This aligns with prior research concluding that standards positively promote technological innovation. Three studies—by Gregoire-Zawilski and Popp (2024), Jaeyun and O'Sullivan (2018), and Liu (2020)—examined clean energy, the photovoltaic industry, and the entire industrial sector, respectively. Their findings demonstrate that standards exert a significant positive influence on technological innovation. Clean energy and photovoltaics, particularly the photovoltaic and new materials industries, are technology-intensive sectors. Thus, the findings on technological effects in this study align with their conclusions. Shuai et al. (2022) examined the impact of technological innovation on the international competitiveness of the rare earth industry, concluding that technological innovation positively promotes the international competitiveness of the rare earth sector. The new materials industry and the rare earth industry collectively form the "foundation" and "pillars" of modern high-tech industries. Both possess strategic importance, are technology-intensive, feature extended industrial chains, and are highly dependent on innovation-driven added value. Consequently, this study reaches the same conclusion as the aforementioned research. Furthermore, these studies fully validate the influence pathway of "standards-technological innovation-international competitiveness." This study contributes to the area of strategic emerging industries and provides theoretical support for the international competitiveness of strategic emerging industries through the internationalization of standards.

In summary, this research presents two major innovations. First, it innovatively employs the number of foreign-language editions of Chinese standards to measure standard internationalization, more effectively conveying the strategic essence of promoting standards globally. Second, based on the current development stage and characteristics of the new materials industry, it proposes a dual-path approach combining industrial clustering and technological innovation.

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### 5.2 Practical Implications

Corporate Level: Transition from “adhering to standards” to “setting standards,” adopting differentiated strategies based on their technological development stage:

For Technology-Leading Enterprises: Encourage them to adopt a standards-first strategy to drive industrial innovation. Proactively establish or lead industry standards alliances, deeply engage in—even spearhead—the formulation and revision of national and international standards. Transform technological advantages into standard advantages, actively participate in shaping global industrial rules, and enhance international influence.

For technology-catching enterprises: They should be encouraged to actively pursue mutual recognition of standards and benchmark against international advanced standards. Through benchmarking, they should continuously optimize their technological pathways and product quality to reduce technological gaps, lower export barriers, and gradually integrate into the international standards system. Startups should conduct preliminary standard research during early R&D phases to avoid sunk costs resulting from deviating from mainstream technological trends. Through this tiered approach, China’s new materials industry will collectively enhance its participation and influence in standard-setting, propelling the sector toward higher value-added segments of the industrial chain.

Government Level: Optimizing the Policy Framework for Standard Internationalization

Government support policies for standard internationalization should be formulated and strengthened. Dedicated funds should be established to encourage enterprises—particularly those in strategic and emerging industries—to lead or participate in the development and promotion of industry standards. Differentiated support, such as tax incentives and financial incentives, should be provided to enterprises that spearhead or deeply engage in standard-setting activities. It is recommended to establish a “Standard Internationalization Capability” assessment system, evaluating enterprises across multiple dimensions including international standard participation, technical contribution, market application level, and talent development mechanisms. Differentiated support policies should be implemented based on assessment results, directing resources toward enterprises with outstanding capabilities. Standard development requires a dynamic update and rapid response mechanism to ensure timely iteration and upgrading in critical areas. Concurrently, promote the construction of public standard service platforms to provide enterprises with consulting, international standard comparisons, and pathway planning services. This will help enterprises better address challenges in standard internationalization and advance global progress in industries such as new materials.

At the industrial level: Establish a collaborative platform integrating “standards, technology, and industry” to advance standard-setting alongside R&D innovation and market expansion.

Industrial clusters should leverage internationalization and collaborative development to form industry standard alliances aimed at integrating full-chain resources and promoting technological exchange and cooperation among enterprises, thereby enhancing the comprehensive capabilities and international competitiveness of industrial clusters. Leading enterprises should play a guiding role in attracting upstream and downstream supporting industries to cluster, improving the industrial cluster ecosystem, and forming a virtuous cycle of development where “standards drive innovation, innovation enhances clusters, and clusters boost competitiveness.”

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At the international level: Strengthening exchange and leading the rules

In the field of international standards development, actively participate in activities organized by international standardization associations and deepen technical exchanges and cooperation with international counterparts. China participates in formulating international standards and exerts influence by dispatching experts to join the formulation of international standards and hosting international standards seminars. It is necessary to strive for the internationalization of China's advantageous technologies and standards, and to participate in or lead the formulation of international standards to integrate China's complete technical solutions, industrial experience, etc., into the global standardization system, further enhancing the global competitiveness and influence of Chinese industries. Similarly, research on tracking and comparison of international standards should be promoted to remain abreast with latest developments and enable timely adaptation to technical standards, minimizing possible disruptions to Chinese industries due to changes in international standards.

## 5.3 Limitations and Prospects

This study has a few limitations. First, as the new materials industry has yet to establish a unified standardization system, relevant data are scattered across sources. The collection process relies heavily on manual screening, which may introduce subjective bias and, thus, impact the generalizability of research conclusions. Second, limitations exist in the measurement of core indicators. Constrained by data availability, only foreign-language versions of Chinese standards could be applied as a proxy variable for standard internationalization, which may not reflect the actual degree of internationalization. Finally, while exploring the non-linear relationship between standard internationalization and industrial competitiveness, the model's control over exogenous variables (such as international trade policies and geopolitical factors) remains relatively limited, somewhat diminishing its explanatory power.

Future research could leverage the development of the "Digital China" standards database, utilizing technologies such as blockchain and big data to enhance data security and objectivity. Methodologically, incorporating dynamic analysis tools such as complex network analysis and simulation modeling could enhance the model's descriptive power and enrich the diversity of conclusions.

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