The Game of Rules: Advanced Equipment Imports and Firm Standard-Setting

By Guorui Tang[1]

Abstract: *Advanced equipment imports serve as a core driving force enabling firms to participate in national standard-setting and shape technological discourse. Based on a matched database constructed from China's National Tax Survey Data and Customs Trade Data covering 2007–2016, this paper systematically examines the impact of advanced equipment imports on firms' participation in national standard-setting and its transmission mechanisms at the micro level. The findings reveal that advanced equipment imports significantly promote firms' engagement in national standard-setting. Mechanism analysis demonstrates that the enhancement of monopoly power, the elevation of supply chain position, and the improvement of organizational efficiency and strategic lock-in constitute important pathways through which advanced equipment drives firms' standardization efforts. Heterogeneity analysis shows that the marginal gains from advanced equipment imports are more pronounced among firms with high supply chain risk, in industries with high concentration, superstar firms, firms with high management costs, private firms, firms in industries with high entry barriers, and firms with high market promotion intensity. In further discussion, this paper examines the resource flows and reallocations potentially triggered by import-driven standard-setting—labor factor structure complementarity, market competition weakening, and industry ecology polarization—and reveals the structural consequence of the coexistence of the network concentration of standard-setting power and the fragmentation of standards at the industry level from the perspectives of collaboration network power concentration and standard fragmentation. In addition, import source concentration further strengthens a firm's hub position within the standard ecosystem. Taken together, this study enriches the theoretical framework linking capital goods imports*

[1] Guorui Tang, School of Economics, Nankai University (e-mail: tangguorui@mail.nankai.edu.cn). I thank Professor Wei Jin for careful guidance. All errors are my own.

and standardization from a micro perspective, and provides useful insights for China's manufacturing sector to achieve the capability leap from technology introduction to rule-making and to build a resilient modern industrial system.

Keywords: Advanced Equipment Imports; Standard-Setting; Monopoly Power; Supply Chain Position; Organizational Efficiency

I. Introduction

Against the backdrop of deepening globalized production, advanced equipment imports—as the core vehicle for the cross-border flow of embodied technology—are profoundly reshaping firms' technological capabilities and the landscape of market competition. As an important pathway for latecomer countries to achieve technological catch-up, imported advanced equipment embodies the frontier processes and quality standards of exporting countries and generates spillovers to domestic firms through channels such as learning-by-doing, reverse engineering, and complementary investments. It constitutes a critical measure for developing countries to narrow the distance to the technological frontier and accumulate indigenous innovation capabilities. Since the reform and opening-up, by deeply integrating into the global trading system, China has relied on advanced equipment imports to fill the technological gaps in its early industrial system, thereby realizing rapid productivity growth and continuous industrial structure upgrading. However, with the profound restructuring of the global value chain division of labor, rule-based games—exemplified by "small yard, high fence" technology blockades and the "de-risking" of critical supply chains—have become increasingly intense, and the external technology acquisition environment facing Chinese firms is undergoing profound changes. How to maintain strategic autonomy in a complex international environment and achieve a capability leap from "technology introduction" to "rule-making" has become a critical proposition for firms seeking to enhance their core competitiveness and for the nation's endeavor to build a "Quality Power."

Standard-setting is the core form of the institutionalized expression of technical rules (Lerner & Tirole, 2015), profoundly influencing firms' discourse power and the distribution of benefits along the industrial chain. The 2023 Outline for Building a

Quality Power explicitly calls for "using advanced standards to drive quality improvement and efficiency gains in traditional industries and high-starting-point development in emerging industries" and for "deepening innovation in the operational mechanisms of standardization." The Fourth Plenary Session of the 20th Central Committee further stressed "accelerating the building of a Quality Power," and the proposals for the 15th Five-Year Plan also highlight "strengthening the guiding role of standards and raising the level of internationalization." However, whether firms can substantively participate in national standard-setting depends critically on their mastery of frontier technologies and their coordination capabilities along the industrial chain. Firms lacking technological advantages find it difficult to propose convincing schemes during standard drafting and struggle to gain recognition in complex interest-driven negotiations (Simcoe, 2012). How to build and enhance firms' capacity to participate in standard-setting through advanced equipment imports thus becomes an important issue with both theoretical value and policy significance. This paper is the first to empirically document the promoting effect of advanced equipment imports on firms' participation in national standard-setting, and it uncovers the transmission channels through three pathways: monopoly power, supply chain position, and organizational efficiency and strategic lock-in. Furthermore, this paper reveals the resource flows and reallocations potentially triggered by import-driven standard-setting from three dimensions—labor factor structure complementarity, market competition weakening, and industry ecology polarization—and offers a structural institutional explanation from the perspective of the coexistence of collaboration network power concentration and standard fragmentation.

In summary, the marginal contributions of this paper are mainly reflected in the following three aspects. First, in terms of broadening the research perspective, existing literature on capital goods imports mostly focuses on traditional economic outcomes such as productivity and innovation (Mo et al., 2021), while standardization research concentrates on the economic effects of standard-setting. However, against the backdrop of standard-setting increasingly becoming a national strategy, no study has yet integrated advanced equipment imports and firms' standard-setting behavior

into a unified analytical framework. This paper is the first to empirically examine the impact of advanced equipment imports on national standard-setting, thereby filling this research gap. Second, in terms of mechanism analysis, this paper constructs three transmission pathways—"monopoly power—supply chain position—organizational efficiency and strategic lock-in"—systematically elucidating how advanced equipment imports reshape firms' standard-setting capabilities through market power, supply chain relationships, and asset structures. Unlike Li et al. (2023), who focus on the channel whereby import subsidies improve export product quality through credit supply, this paper finds that the core mechanisms of import-driven standard-setting lie in enhanced pricing power, elevated supply chain status, and the strategic lock-in of asset specificity, thereby compensating for the deficiency of existing studies that mostly focus on the credit transmission perspective. Third, in terms of extending the analysis, whereas existing literature mostly concentrates on the positive economic consequences of standard-setting, this paper goes further to reveal the resource reallocation potentially induced by import-driven standard-setting from three dimensions—labor factor structure complementarity, market competition weakening, and industry ecology polarization. Moreover, from the perspectives of collaboration network power concentration and standard fragmentation, it reveals the institutional imbalance characterized by the coexistence of the network agglomeration of standard-setting power and the fragmentation of standards at the industry level, thereby providing a new theoretical lens for understanding individual strategic behavior and collective coordination failures in standardization construction.

The remainder of this paper is organized as follows. Section II presents the literature review and theoretical hypotheses; Section III describes the research design and data; Section IV reports the empirical results; Section V conducts mechanism tests; Section VI provides heterogeneity analysis; Section VII offers further discussion; and the final section concludes with policy implications.

II. Literature Review and Theoretical Hypotheses

A. Literature Review

Two strands of literature are most closely related to this study. The first strand,

concerning advanced equipment imports, primarily focuses on identifying the macro- and micro-economic consequences of imported capital goods such as critical equipment (Parro, 2013; Raveh & Reshef, 2016). In its early stages, China's industrial system remained underdeveloped and was unable to independently produce the technical equipment required by the "world's factory." Imports thus served as a vital channel for China to acquire critical capital goods. As a key conduit for global technology diffusion, the adoption of foreign advanced technical equipment can help developing countries catch up to the technological frontier through technology spillover effects (Li et al., 2023). Encouraging the import of critical equipment has long been an important component of China's early-stage innovation strategy. Macro-level research has repeatedly confirmed that capital goods imports are a crucial pathway for introducing advanced technology and promoting both aggregate domestic productivity and firm-level micro productivity growth (Lafortune et al., 2019). The domain of innovation and R&D is likewise directly influenced by capital goods imports. Mo et al. (2021) find that the productivity-enhancing effect of capital goods imports is more pronounced than that of intermediate goods imports and is complementary to firms' own R&D investments. Xie et al. (2021) also find that import subsidy policies significantly enhance importing firms' innovation capacity and level, yet, from another perspective, significantly weaken firms' basic innovation capacity. Wu & Li(2025) shift the perspective to the labor domain, exploring how active industrial policies based on trade measures affect individual human capital accumulation, thereby enriching the research horizon of trade and industrial policy.

The second strand of literature focuses on applied fields such as the economic consequences of firm standard-setting. Firms' standardization activities include leading or participating in the development of standards, as well as implementing existing standards of various types or adjusting to standards. Existing literature has concentrated on how participation in standard-setting affects firm innovation, gradually forming two views. Scholars optimistic about standardization regard ISO standards as tools for process optimization and behavioral norms, playing a prominent role in accelerating product R&D innovation and eliminating backward production

capacity. Standards are carriers of codified knowledge, containing a large amount of intangible technical knowledge and experiential accumulation that facilitate the dissemination of product and technical information to market participants. Zhang et al. (2020) find that firms serving as drafting units for Chinese standards experience a significant improvement in patent quality. When a firm's patents are incorporated into standards, it can recover R&D investment costs through patent licensing fees and can also rely on standard-essential patents to enhance its bargaining power in cross-licensing. Critics, however, argue that the relevant intellectual property policies of ISO affect, to some extent, the monopoly rents of patents incorporated into standards and their holders, increase the hidden costs for firms implementing standards (Levine & Toffel, 2010), and may constrain employee creativity, thereby hindering firm innovation.

Although some studies have examined the microeconomic impacts of advanced equipment imports and standardization, the following gaps remain. First, the research scope is still confined to the traditional domains of firm productivity and innovation, lacking studies that integrate advanced equipment imports and firm standardization into a unified analytical framework. The existing literature on the economic consequences of imported equipment mainly focuses on production efficiency improvements and innovation output incentives (Mo et al., 2021; Lafortune et al., 2019), yet overlooks that imported equipment may reshape firms' capacity and motivation to participate in rule-making—such as national standards—by altering their market power, supply chain position, and organizational efficiency. Second, the investigation of firms' motivations for standard-setting behavior is insufficient. Only a small number of studies have paid attention to the factors influencing national standard-setting, rarely probing into the fundamental question of "why firms become standard-setters," and have not systematically examined the role that advanced technology imports play in driving the standard-setting process. Therefore, integrating advanced equipment imports and firm standard-setting into a unified analytical framework, extending from "technology introduction" to "rule-making," is not only a theoretical imperative for building a "Quality Power" under high-standard opening-up

but also a practical necessity to fill the research gap between these two strands of literature.

B. Theoretical Hypotheses

As high-tech products, imported advanced equipment embodies frontier technologies from abroad, which can facilitate knowledge and technology spillovers while complementing domestic R&D investments to fill gaps, thereby enhancing firm productivity and promoting indigenous innovation (Eaton and Kortum, 2001; Mo et al., 2021). In the early stages of economic development, encouraging the import of advanced critical equipment that the country cannot yet independently develop not only remedies market shortages but also accelerates inward technology spillovers, strengthening firms' motivation for imitative learning and innovation (Connolly, 2003). Liu (2019) further finds that industrial policies such as encouraging equipment imports affect overall economic development through production networks. Existing discussions have predominantly explored the relationship between imported advanced equipment and other capital goods on the one hand and technological innovation and firm productivity on the other (Xie et al., 2021), with some studies shifting their focus to areas such as human capital accumulation (Wu & Li, 2025). Likewise, current research on standardization remains centered on the economic consequences of standardization, such as cost elasticity and innovation lacking studies that bring advanced equipment imports and firm standardization into a unified framework. Firm participation in standard-setting is, in essence, the pioneering guidance and construction of discourse power over technical rules, a process that benefits from firms' mastery of frontier technologies and their coordination capabilities with upstream and downstream segments of the industrial chain. Thus, integrating advanced equipment imports and firm standard-setting into a unified analytical framework, extending from "technology introduction" to "rule-making," is a critical move to promote a leap in firm competitiveness under conditions of openness.

First, at the level of frontier technology embeddedness, firms can leverage imported advanced equipment to precisely insert themselves into specific segments of the global technology division of labor, thereby shortening the distance to the

technological frontier. Critical equipment embodies the quality standards and design philosophies of the exporting country—advanced embedded knowledge—which can spill over to domestic firms through the import channel, enabling the acquisition of tacit information and knowledge through learning-by-doing and reverse engineering (Keller, 2004; Xie et al., 2021). At the same time, the introduction of advanced equipment is often accompanied by complementary inputs such as technology licenses, patent specifications, and training services, which further lower firms' search costs and learning barriers for acquiring frontier technical information. It may also complement local production chains, and the "resonance" with the domestic intermediate input market (Fieler et al., 2018) helps strengthen firms' technology absorption and indigenous innovation capabilities to achieve technological catch-up (Li et al., 2023). Technology embeddedness not only enhances firms' production efficiency and product quality but, more importantly, equips them with the cognitive foundation and capability reserve needed to understand, participate in, and even influence national technical standards.

Second, at the level of capability reshaping, imported equipment drives the standardized transformation and modular restructuring of production processes, enabling efficient alignment with the product manufacturing of upstream and downstream firms and substantially reducing coordination deviations caused by inconsistent production standards. Standardized production practices are not only the organizational vehicle for the internalization of technology from imported equipment but also a core source of standard-setting knowledge: the process parameters and testing methods that firms continuously accumulate during equipment operation, when systematically summarized and theoretically refined, form the experiential basis for proposing standard-setting proposals with logically consistent technical specifications and self-consistent parameter systems, thereby motivating firms to actively participate in national standard-setting. Accordingly, we propose Hypothesis 1.

Hypothesis 1: Advanced equipment imports can significantly promote firms' participation in national standard-setting.

Monopoly Power Channel.—Monopoly position is a key factor enabling firms to participate in national standard-setting. First, in the dimension of pricing power, imported advanced equipment endows firms with stronger price markup capability, reinforcing the market dominance of their products (Kugler & Verhoogen, 2012). Advanced equipment is typically used to produce high-quality, differentiated products with low demand substitution elasticity, where the price sensitivity of consumers or downstream manufacturers is relatively limited. Standard-setting usually needs to reflect the industry's frontier technological level, and firms with technological and market pricing advantages enjoy high professional authority in the standard-setting process. The technological capabilities and product quality endorsement accumulated through importing advanced equipment make the technical proposals put forward by such firms more readily accepted by other participants and government agencies in national standard-setting. Blind & Thumm (2004) also find that firm market share is a major factor influencing its participation in standard-setting; therefore, firms with high market power have greater ability and willingness to elevate their own technical standards to the status of national standards.

Second, in the dimension of cost efficiency, imported equipment enhances total factor productivity by increasing the degree of production automation and process stability (Mo et al., 2021), thereby reducing factor inputs per unit of output and lowering firms' marginal costs. The improvement in cost efficiency frees up financial funds and managerial resources previously tied up in the production process, allowing firms to redirect them toward core standard-setting activities such as refining technical proposals, drafting standard documents, and engaging in multi-party coordination and negotiation. Low production costs grant firms greater bargaining room and strategic patience in the standard-setting process, making it easier for them to substitute when facing external cost shocks in specific markets (Akerman et al., 2022), thus allowing them to calmly sustain investment in standard participation and strengthen their dominant position in standard negotiations. Accordingly, we propose Hypothesis 2.

Hypothesis 2: Advanced equipment imports promote firms' participation in

national standard-setting by strengthening their monopoly power.

Supply Chain Position Channel.—First, at the level of trade credit acquisition, advanced equipment imports significantly enhance firms' bargaining position vis-à-vis upstream suppliers by increasing their production scale and technological strength. From the perspective of relational contracts, trade credit can serve as a commitment device for suppliers' relationship-specific investments in downstream firms. When downstream firms possess strong market power, suppliers are more inclined to extend credit periods to solidify long-term cooperative relationships (Dass et al., 2015). Moreover, suppliers' willingness to provide trade credit depends not only on the bargaining power of customers but also on the degree of product differentiation—the higher the degree of product differentiation, the stronger the supplier's dependence on the customer and the more favorable the trade credit terms (Giannetti et al., 2011). The high-quality, differentiated products manufactured using imported advanced equipment significantly enhance the firm's irreplaceability within the supplier's customer portfolio. To retain high-quality customers, suppliers will more actively extend trade credit to the firm, thereby further reinforcing the firm's advantage in capital occupation and financial flexibility within the supply chain.

Second, in terms of capital reflux and industrial chain coordination, the high-quality products produced with imported critical equipment strengthen the firm's bargaining power over downstream customers, thereby reducing the occupation of accounts receivable, improving its own cash flow position, and enhancing its dominant role in the supply chain. Dominant firms in the supply chain are situated at the hub of the industrial chain, where their technical proposals and product specifications exert a significant anchoring effect on the equipment investment, process flows, and complementary product R&D of upstream and downstream firms. The hub position in the industrial chain endows firms with "architectural power"—the ability not only to coordinate their own alignment with upstream and downstream entities but also to elevate interface specifications into rules followed collectively at the industry or even national level through the formulation of technical standards (Jacobides et al., 2006). Accordingly, we propose Hypothesis 3.

Hypothesis 3: Advanced equipment imports promote firms' participation in national standard-setting by elevating their supply chain position.

Organizational Efficiency and Strategic Lock-in Channel.—Advanced equipment imports significantly reduce the transaction costs of firms' internal and external coordination by promoting the standardization and automation of production processes. Advanced equipment typically embeds a higher degree of automation and process stability, enabling efficient alignment with the production processes of upstream and downstream segments of the industrial chain and reducing coordination frictions caused by inconsistent production standards or quality specifications (Goldschmidt & Schmieder, 2017). The production standardization brought about by imported equipment is essentially a technology-driven optimization of coordination mechanisms, lowering the transaction costs of intra- and inter-firm collaboration through technological means (Acemoglu, 2009) and encouraging firms to reallocate resources toward long-term strategic planning such as standard-setting.

At the same time, the continuous operation of purchased advanced equipment depends on technical service support from external suppliers (Benmelech & Zator, 2025), and the degree of a firm's reliance on external maintenance services is an important indicator of its depth of technology absorption. During the use of purchased equipment, firms continuously accumulate operational experience and maintenance skills through learning-by-doing, and the efficiency of this knowledge internalization process depends on their existing knowledge stock. As firms systematically digest externally acquired technical knowledge and transform it into internally reusable application capabilities, their technological dependence on suppliers gradually diminishes. The autonomous technological capabilities thus accumulated lay the knowledge foundation for participating in national standard-setting.

Regarding firms' strategic investment motives, asset specificity is an intrinsic driving force for firm participation in standard-setting. Imported equipment represents highly specific assets encouraged by the state for particular product processes; once invested, these assets are difficult to redeploy for other uses, creating substantial sunk costs. Asset specificity theory posits that the investor in specific assets faces the risk

of being “held up” by trading partners. To safeguard the return on investment, the investor has a strong incentive to lock in the transactional relationship through vertical integration or long-term contracts (Acemoglu et al., 2010). In the context of standard-setting, this lock-in motive manifests as the strategic behavior of embedding the firm’s own technical solutions into national standards—once a technical solution is established as a national norm, the production value of the firm’s specific assets receives institutional safeguarding.Accordingly, we propose Hypothesis 4.

Hypothesis 4: Advanced equipment imports promote firms’ participation in national standard-setting by enhancing organizational efficiency and strengthening strategic lock-in.

III. Research Design and Data Description

A. Econometric Model Specification

To empirically analyze the causal relationship between firms’ imports of advanced equipment and their participation in national standard-setting, this section constructs the following econometric model based on the theoretical hypotheses derived above to test the impact of advanced equipment imports on standard-setting:

$$S\tan dard_{it+1} = \alpha_0 + \alpha_1 Divi_{it} + \alpha_2 X_{it} + \gamma_{jt} + \mu_i + \varepsilon_{it}$$

In the model, the dependent variable $S\tan dard_{it+1}$ is the inverse hyperbolic sine transformation of the total number of national standards that firm i participates in setting in year t+1. The key independent variable $Divi_{it}$ is the logarithm of (firm i’s import value of advanced equipment in year t plus 1). The model also includes firm-level control variables X_{it}. Industry–year fixed effects γ_{jt} are included to control for the impact of potential policy shocks at the industry level on national standard-setting. Firm fixed effects μ_i are included to control for confounding influences from time-invariant firm characteristics. Standard errors ε_{it} are clustered at the firm level to address possible heteroskedasticity and serial correlation.

B. Variable Definitions

Standardization.—According to the stage-based division of the national

standard-setting process, the development of a national standard must pass through multiple stages—project initiation, drafting, public comment solicitation, review, approval, and publication—and completing the entire procedure objectively involves a certain institutional time lag (the average cycle for developing a national standard is three years). Among all standard types, national standards are hierarchically superior to industry standards, local standards, and enterprise standards, and using the number of applications as the core indicator to measure firms' standardization outcomes offers greater reliability. Based on the above considerations, in order to capture the overall effect of advanced equipment imports on standard-setting and to mitigate the interference of contemporaneous reverse causality, this paper identifies the timing of a firm's initial participation in standard-setting based on the publication date. At the same time, following the approach of Liu & Qiu (2016), we apply the inverse hyperbolic sine transformation to the number of national standard applications filed by the firm in the next year (i.e., period t+1) and use this as the proxy variable for the firm's standardization level $Standard$.

Advanced Equipment Imports.—Advanced equipment imports have long occupied an important position in China's strategy of technology introduction and absorption, and constitute a crucial link in safeguarding the security of China's industrial and supply chains. In September 2007, the National Development and Reform Commission, the Ministry of Finance, and the Ministry of Commerce jointly issued the Catalogue of Technologies and Products Encouraged for Import (hereinafter referred to as the "Catalogue"), aiming to expand the import of technical products such as critical equipment in short supply domestically and to promote the optimization of the trade structure (Wu & Li, 2025). The appendix to the Catalogue listed the advanced equipment encouraged for import. By 2016, the Catalogue had undergone five revisions, with its dynamic adjustments urgently requiring the updating of the technology and equipment lists to enhance the precision of policy support and the timely removal of equipment items that had already achieved import substitution or no longer fell within the key support scope. Based on the HS codes

listed in the Catalogue, this paper identifies the critical equipment encouraged for import uniformly at the 6-digit and 4-digit levels. Accordingly, following Xie et al. (2021), we use the natural logarithm of (firm import value of advanced equipment + 1) as the proxy variable for a firm's advanced equipment imports $Divi$.

Control Variables.—To minimize the influence of omitted variable bias as much as possible, this paper, drawing on major studies, selects the following control variables to account for other factors that may affect firms' standard-setting: (1) government support (Sub), measured as the ratio of subsidy income to operating revenue; (2) firm size (lnsize), proxied by the logarithm of total assets at year-end; (3) firm age (Age), measured as the logarithm of (observation year minus establishment year plus 1); (4) leverage ratio (LEV), measured as total liabilities divided by total assets; (5) return on total assets (ROTA), measured as operating profit divided by total assets at the beginning of the year; and (6) capital intensity (Cp), measured as the logarithm of (average annual assets / average annual number of employees).

Data Sources and Processing.—This paper primarily uses matched data from the following two databases: first, the National Tax Survey Database for the period 2007–2016; second, the Customs Trade Database for the period 2007–2016. To address the issues present in the Tax Survey Database, we follow the methods of Brandt et al. (2012) and Yu (2015) and carry out the following processing steps: (1) deleting observations with missing key financial indicators; (2) removing observations with an average annual number of employees fewer than 8; (3) deleting abnormal observations in accordance with general accounting standards; (4) retaining only manufacturing observations with National Economic Industry Classification codes 13–43; (5) deleting observations with obvious registration errors, such as zero fixed assets or current assets, and adjusting relevant outliers; (6) cleaning firm names for matching with the Customs Database by name, thereby obtaining a merged database; and (7) adjusting relevant information in the Customs Database. Regarding the import value of advanced equipment in the Customs Database, we convert it to the corresponding RMB price using the official exchange rates published by the World

Bank. Furthermore, the national standard data used in this paper are obtained from the National Public Service Platform for Standards Information. Entities participating in national standard-setting are identified by the names of drafting units and then matched with the Tax Survey Database, ultimately yielding the dataset used in this study. Table 1 presents the descriptive statistics.

Table 1—Descriptive Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Standard	1567797	0.00379	0.0798	0	4.883
Divi	1567797	0.508	1.946	0	17.54
Cp	1567797	5.651	1.236	-6.134	14.82
Sub	1567797	0.00346	0.0134	0	0.0933
LEV	1567797	0.634	0.314	4.00e-05	1.705
ROTA	1567797	0.0185	0.117	-0.404	0.513
lnsize	1567797	10.16	1.866	0	21.03
Age	1567797	2.091	0.699	0	4.736

IV. Empirical Results

A. Baseline Regression

Based on the econometric model specified in this paper, the baseline regression results are reported in Table 2. Column (1) of Table 2 reports the results with only firm fixed effects controlled. Subsequently, columns (2) to (4) sequentially add control variables, control for industry–year fixed effects on top of firm fixed effects, and simultaneously include both control variables and firm fixed effects as well as industry–year fixed effects. The results show that across all specifications, the coefficient on Divi is significantly positive at the 1% level. The results in column (4) indicate that advanced equipment imports increase the intensity of firms' participation in national standard-setting (a one-standard-deviation increase in Divi raises Standard by approximately 0.0098 standard deviations), consistent with the theoretical expectations of this paper, namely that advanced equipment imports drive firms' standardization efforts. The baseline regression results thus verify the validity of Hypothesis 1.

Table 2—Baseline Regression Results

Variable	(1) Standard	(2) Standard	(3) Standard	(4) Standard

Divi	0.0004***	0.0003**	0.0004***	0.0004***
	(2.63)	(2.55)	(3.22)	(3.03)
Cp		0.0003*		-0.0007***
		(1.67)		(-4.03)
Sub		-0.0151**		-0.0107
		(-2.16)		(-1.53)
LEV		-0.0021***		-0.0017***
		(-6.74)		(-5.44)
ROTA		-0.0035***		-0.0019***
		(-4.75)		(-2.65)
lnsize		0.0017***		0.0014***
		(8.52)		(6.92)
Age		0.0029***		-0.0027***
		(10.44)		(-5.64)
Control variables	No	Yes	No	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	No	No	Yes	Yes
R-squared	0.455	0.456	0.457	0.457
Observations	1,567,797	1,567,797	1,567,797	1,567,797

Note: The values in parentheses represent robust t-statistics; standard errors are clustered at the firm level; ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively. Unless otherwise specified, the same applies to the following tables.

B. Endogeneity Treatment

Instrumental Variable Approach.—Although the baseline regression has incorporated multi-dimensional fixed effects and control variables, endogeneity concerns may still arise due to omitted variables and reverse causality. Moreover, even though the dependent variable uses the number of national standard applications filed by the firm in the next period, the potential interference of reverse causality in causal identification cannot be completely ruled out. Therefore, this paper follows the approach of Goldsmith-Pinkham et al. (2020) to construct a shift-share instrumental variable. Specifically, we construct a simulated Bartik instrumental variable for firms' advanced equipment imports by multiplying the share of advanced equipment imports in the base period at the two-digit industry level (share) by the growth rate of the industry mean at the national level (shift). To further enhance the robustness of the causal identification, we also construct an alternative Bartik instrumental variable by

using the national-level mean of Divi across all other two-digit industries in the base period as an alternative share and multiplying it by the industry growth rate, thereby strengthening the robustness check. The results are reported in columns (1) to (4) of Table 3. The instrumental variables pass the under-identification test and the weak instrument test, confirming the reliability and validity of the instrument choice. The results in columns (2) and (4) show that after addressing endogeneity, the estimated coefficients of the instrumental variables remain significantly positive, indicating that a one-standard-deviation increase in Divi raises Standard by approximately 0.0317 standard deviations, thus verifying the reliability of the baseline regression[2].

Table 3—Instrumental Variables Results

	(1)	(2)	(3)	(4)
Variable	Divi	Standard	Divi	Standard
Divi		0.0013***		0.0031**
		(4.95)		(2.48)
BartikIV	-2.3545***		-7.1754***	
	(-41.26)		(-4.39)	
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM Statistics		12146.55		1592.489
Kleibergen-Paap rk Wald F Statistics		1702.423		19.303
Observations	1,567,797	1,567,797	1,567,797	1,567,797

C. Robustness Checks

Alternative Measures of the Dependent and Independent Variables.—To address potential measurement bias, this paper conducts robustness checks by replacing both the dependent variable and the core independent variable. First, we replace the core independent variable. Firms' advanced equipment imports may be influenced by firm size and the industry in which they operate—that is, larger firms tend to have higher

[2] In addition, this paper also follows the method of Lewbel (1997) and uses the higher-order moments of the deviation between the explanatory variable and the industry mean within the same province excluding the firm itself as an instrumental variable. The results remain consistent with the baseline findings, further strengthening the reliability of the causal identification in this paper.

equipment import values. To eliminate the scale effect, we use the ratio of equipment import value to year-end total assets as an alternative measure of import intensity, applying a logarithmic transformation with offset values equal to 1/10 and 1/100 of the smallest positive value in the sample, respectively. Second, we replace the dependent variable.We apply the inverse hyperbolic sine transformation to the sum of the number of national standard applications filed by the firm in the current year and the following two years to capture the longer-term effect of standard-setting activities. The results, reported in columns (1) to (3) of Table 4, show that the findings remain robust after substituting both the independent and dependent variables.

Double Machine Learning Method.—To avoid estimation bias arising from functional form misspecification and arbitrary alterations to the data distribution, this paper follows Chernozhukov et al. (2025) and employs a partially linear model based on double machine learning for more robust causal estimation. The regression results are presented in column (4) of Table 4. In addition, we also use the Lasso regression model for estimation, and the results consistently corroborate the baseline conclusion.

Adjusting Standard Error Clustering and Fixed Effects.—Advanced equipment imports within the same industry may generate demonstration effects. To rule out interference from correlations among firms within the same industry, we adjust the clustering of standard errors to the two-digit industry level to address cross-sectional dependence. Moreover, on top of controlling for firm and industry–year fixed effects, we further include province–year fixed effects to control for more granular macroeconomic regional and temporal characteristics. The results, reported in columns (5) and (6) of Table 4, show that the coefficient of the core independent variable remains positive, further verifying the robustness of the core conclusion.

Controlling for Omitted Variable Bias.—To test for potential interference from omitted variables and to verify the robustness of the baseline conclusion, this paper conducts a coefficient stability analysis following the method of Oster (2019). Testing under the given conditions of $\beta = 0$ and $R_{\max}$, we find that $\delta > 1$; moreover, the coefficient interval does not contain zero when $\delta = 1$ is given, suggesting that

unobserved variables have a relatively small impact on the core effect. We further perform a sensitivity analysis regarding the omitted variable problem following the approach of Altonji et al. (2005). The results indicate that the omitted unobservable factors would need to be at least 16.18 times as large as the included control variables to produce a serious bias in the regression results, thereby confirming the robustness of the baseline conclusion.

Alternative Regression Models.—Since the original dependent variable is non-negative count data, applying a logarithmic-like transformation to count data may, according to Chen and Roth (2024), introduce certain biases into the estimates. Therefore, we replace the regression model. Following Liang et al. (2024), we employ the Poisson pseudo-maximum-likelihood (PPML) model and fixed-effects negative binomial regression on the original number of applications to relax the assumptions on the dependent variable. The results are reported in columns (7) and (8) of Table 4, and the baseline conclusion remains robust.

Table 4— Robustness Tests

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	Standard	Standard	Std	Standard	Standard	Standard	future_1yr	future_1yr
lnDivi1	0.0001***							
	(3.03)							
lnDivi2		0.0001***						
		(3.12)						
Divi			0.0009***	0.0019***	0.0004***	0.0004***	0.0310***	0.0295***
			(4.03)	(12.04)	(2.77)	(3.07)	(3.47)	(4.73)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No	No	No	No	Yes
Industry fixed effects	No	No	No	No	No	No	No	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Province-year fixed effects	No	No	No	No	No	Yes	No	No
R-squared	0.457	0.457	0.609		0.457	0.458		

Observations	1,567,797	1,567,797	1,567,797	1,567,797	1,567,797	1,567,794	1,567,797	15,678

V. Mechanism Tests

A. Monopoly Power Channel

Standard-setting is, in essence, the extension and institutionalization of a firm's market power in the domain of technical rules. Imported advanced equipment endows firms with technological advantages and cost efficiency, enabling them to gain stronger pricing power and market dominance in product markets. In the cost efficiency dimension, advanced equipment increases the degree of production automation and process stability, reduces factor inputs per unit of output, thereby raising total factor productivity and lowering marginal costs. In the pricing power dimension, imported equipment is typically used to produce high-quality, differentiated products for which market demand is relatively inelastic, granting firms substantial room for price markups. At the same time, the substantial equipment investment constitutes huge sunk costs, creating barriers for potential entrants and further consolidating the dominant market position of incumbent firms. First, in the market power dimension, this paper follows the approach of Peress (2010) to construct the Lerner index to characterize a firm's monopoly power. Meanwhile, we use the markup to measure a firm's pricing power in the market. In the cost efficiency aspect, drawing on the method of Lu & Yu (2015), we use total factor productivity calculated by the LP method to indirectly gauge a firm's marginal cost; higher total factor productivity indicates lower marginal costs. To further capture cost changes more directly, we use the ratio of main business cost to main business revenue as a proxy for cost control capability. The regression results are reported in columns (1) to (4) of Table 5, indicating that advanced equipment imports enhance firms' pricing power and monopoly power in the market. Standards inherently exhibit network effects and path dependence (Katz & Shapiro, 1985). Once a particular technical solution is established as an industry standard, upstream and downstream firms will be compelled to converge toward that standard to maintain product compatibility and market competitiveness, making it easier for standards promoted by dominant firms to gain widespread industry recognition. Based on this expectation, firms with high

market power have stronger motivation and practical capability to embed their own technical solutions into national standards to lock in the existing technological trajectory; at the same time, by raising the industry's technological threshold, they force competitors to bear higher compliance costs, thereby expanding their own market share and securing first-mover advantages.

B. Supply Chain Position Channel

Supply chain position is an important indicator reflecting a firm's discourse power and capital allocation capability within the industrial chain. Advanced equipment imports significantly enhance a firm's bargaining position in the supply chain through two aspects—trade credit acquisition and capital reflux—by increasing its production scale and technological strength. On the one hand, imported advanced equipment makes the firm a premium key customer for upstream suppliers; to sustain long-term cooperative relationships, suppliers are willing to offer more favorable trade credit terms. On the other hand, the high-quality products produced with advanced equipment give the firm stronger bargaining power over downstream customers. Therefore, advanced equipment imports substantively improve the firm's position in the trade credit network. Regarding trade credit acquisition, the firm, as a financing entity, can obtain trade credit in the form of accounts payable from its upstream input suppliers (Burkart & Ellingsen, 2004). If upstream suppliers have relatively low bargaining power, they tend to extend trade credit periods, thereby increasing the share of trade credit payments in product sales (Fabbri & Klapper, 2016). Accordingly, this paper uses the inverse hyperbolic sine transformation of (accounts payable / total assets) to represent the firm's supply chain position, denoted as DV. Moreover We use accounts receivable / total assets to measure the trade credit provided by the firm (AR_TA), and we also use the ratio of accounts payable after subtracting accounts receivable to total assets to represent the net trade credit obtained by the firm (Net_TC). The regression results are reported in columns (5) to (7) of Table 5, showing that advanced equipment imports enhance firms' supply chain position and capital reflux capability. Standards, as the definition of technical interfaces and division-of-labor rules along the industrial chain, are deeply

intertwined with a firm's dominant position in the supply chain. From a resource-capability perspective, accounts payable and net trade credit mean that the firm obtains low-cost implicit financing from upstream, effectively alleviating the pressure on working capital turnover and enabling it to allocate more financial resources to long-term, strategic, and high-cost investments such as the technical validation and multi-party coordination required for standard-setting. Viewed from the strategic willingness perspective, a supply chain-dominant firm occupies a hub position in the industrial chain, exerting a demonstration effect on the process flows and complementary product R&D of upstream and downstream firms. To consolidate its core dominant position, the firm has a strong incentive to elevate its own technical solutions to the status of national standards, thereby reducing product coordination and compliance costs across the industrial chain, decreasing transaction frictions arising from incompatible technical standards, and further expanding its supply chain influence and synergistic returns through the network effects of standards, ultimately driving the firm's participation in national standard-setting.

C. Organizational Efficiency and Strategic Lock-in Channel

Advanced equipment imports also lay the foundation for firms' participation in standard-setting by reshaping their internal organizational efficiency and asset structure through the dual pathways of empowerment and efficiency improvement and motivation optimization. First, in the organizational efficiency dimension, advanced equipment imports can effectively reduce firms' coordination costs through standardized production processes, enabling firms to shoulder the complex multi-party coordination work involved in the standard-setting process. Transaction cost theory posits that the deepening of the market division of labor is constrained by various transaction costs such as information search, negotiation, and monitoring (Acemoglu et al., 2009). Thus, this paper uses the inverse hyperbolic sine transformation of the sum of selling expenses and administrative expenses as a share of operating revenue to represent the firm's external coordination cost (collaborate). The results in column (8) indicate that advanced equipment imports significantly reduce external coordination costs. Advanced equipment typically possesses a higher

degree of automation and process stability, enabling efficient alignment with the product manufacturing of upstream and downstream firms and substantially reducing coordination deviations and rework losses caused by inconsistent production standards (Goldschmidt & Schmieder, 2017). At the same time, the operation and maintenance of advanced equipment often require continuous external technical service support, and the degree of a firm's reliance on external maintenance services reflects whether it has truly absorbed and mastered the technical knowledge embodied in the equipment. This paper uses the inverse hyperbolic sine transformation of (outsourced equipment repair and maintenance expenses / net fixed assets) to represent the firm's dependence on external maintenance services (rep)[3]. Similarly, the results in column (9) demonstrate that external maintenance costs per unit of fixed assets decrease, indicating that the firm has gradually internalized equipment maintenance capabilities through learning-by-doing, reduced technological dependence on suppliers, and formed proprietary intellectual property, thereby laying the knowledge foundation for participation in standard-setting. Furthermore, asset specificity constitutes an intrinsic driving force for firms' participation in standard-setting. This paper also uses the ratio of intangible assets to total assets (IA) to measure asset specificity. The results in column (10) support the conclusion that firms' adoption of advanced imported equipment increases asset specificity. Imported equipment is often highly specific assets tailored to particular products and processes, constituting potentially high sunk costs. The higher the asset specificity, the stronger the firm's strategic motivation to lock in the existing technological trajectory and safeguard the long-term returns on specific assets by participating in standard-setting. Therefore, from the multi-faceted perspective of "external coordination—internal technology assimilation—deepening asset specificity," advanced equipment imports enhance firms' organizational efficiency and autonomous technological capabilities, resolving the capability question of "whether they can participate"; simultaneously, by increasing asset specificity, they strengthen firms' strategic motivation to lock in the

[3] Outsourced equipment repair and maintenance expenses have been recorded in the Tax Survey Database since 2009; therefore, the regression period is chosen to start from 2009. The same applies to intangible assets.

technological trajectory through standard-setting, answering the willingness question of "why they participate," and jointly drive firms' participation in national standard-setting.

Table 5—Mechanism Tests

Variable	(1) Lerner	(2) Markup	(3) LP	(4) MC	(5) DV	(6) AR_TA	(7) Net_TC	(8) collaborate	(9) rep	(10) IA
Divi	0.0015***	0.0058*	0.0095***	-0.0003***	0.0007***	-0.0008***	0.0015***	-0.0017***	-0.0002*	0.0002***
	(6.36)	(1.86)	(9.83)	(-4.30)	(7.47)	(-8.87)	(12.84)	(-4.42)	(-1.89)	(8.54)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.551	0.360	0.738	0.795	0.708	0.754	0.701	0.456	0.435	0.458
Observations	1,461,898	1,566,626	1,567,692	1,564,221	1,567,797	1,567,797	1,567,797	1,461,898	1,263,576	1,280,207

VI. Heterogeneity Analysis

A. Heterogeneity by Supply Chain Risk

The degree of external dependence on intermediate inputs in the production process determines a firm's potential risk exposure to supply chain shocks. Accordingly, this paper uses a firm's exposure to intermediate input risk to measure the supply chain risk it faces, specifically employing the ratio of intermediate inputs to output value, and groups firms based on the industry–year mean (High_risk = 1 for high-risk firms). The results are reported in column (1) of Table 6. The coefficient of the interaction term is significantly positive, indicating that the marginal gains from advanced equipment imports are more pronounced for firms with high supply chain risk, demonstrating that advanced equipment imports can promote firms' participation in national standard-setting by reducing supply chain risk. A possible reason is that for firms with high supply chain risk, advanced equipment imports not only reduce excessive dependence on specific inputs by enhancing production automation and process stability but also strengthen bargaining power vis-à-vis upstream suppliers

through the technological advantages conferred by the advanced equipment, thereby securing more stable trade credit and supply guarantees amid supply chain fluctuations, and thus mitigating supply chain risk.

B. Heterogeneity by Industry Concentration

Market structure characteristics and a firm's own industry position are important boundary conditions affecting its ability to convert the advantages of imported equipment into standard-setting capabilities. This paper calculates the Herfindahl-Hirschman index at the four-digit industry level to measure the degree of industry concentration, and divides industries into high-concentration and low-concentration groups based on the mean. The results, shown in column (2) of Table 6, indicate that the coefficient of the interaction term is significantly positive, suggesting that the gains from advanced equipment imports are significantly greater for firms in highly concentrated industries than for those in low-concentration industries. A possible reason is that the division of labor along the industrial chain in highly concentrated industries is typically structured around a small number of large firms, making the technical proposals of dominant firms more readily eliciting coordinated responses from upstream and downstream entities, thereby significantly reducing the coordination costs of standard diffusion. Moreover, to further identify the heterogeneous impact of leading firms within an industry, this paper, following the definition of Stiebale et al. (2024), classifies firms with sales in the top 10% of their four-digit industry as superstar firms (top10). The results are reported in column (3) of Table 6, and the coefficient of the interaction term is significantly positive, indicating that the gains from advanced equipment are more pronounced for superstar firms. These firms possess dual advantages: first, abundant innovation resources and financial capacity, enabling them to sustain the long-term strategic resource investments required for standard-setting; second, the institutional influence forged through deep embeddedness in industry technical governance networks, granting them a much greater voice than ordinary firms in the standard-setting process. These dual advantages allow superstar firms to more efficiently convert the technological advantages conferred by imported equipment into standard-setting outcomes.

C. Heterogeneity by Management Control Costs

On the other hand, the proportion of administrative expenses intuitively reflects a firm's internal organizational management and control efficiency and operational cost burden. Therefore, this paper uses the administrative expense ratio to measure the organizational control costs of a firm's internal process management, and divides firms into high-control-cost and low-control-cost groups based on the industry–year median. The coefficient of the interaction term in column (4) of Table 6 is significantly positive, indicating that when firms face higher internal coordination costs, the standardization and automation of production processes induced by advanced equipment imports can reduce non-production administrative expenditures and streamline redundant management and control links, thereby reallocating the saved organizational resources toward long-term strategic investments such as standard-setting, and enhancing the efficiency of firms' participation in national standard-setting.

D. Heterogeneity by Ownership Type

Firm ownership profoundly affects resource allocation efficiency and the initial endowment of market power, and thus the promoting effect of advanced equipment imports on standard-setting may exhibit systematic differences across firms of different ownership types. Accordingly, this paper classifies firms into state-owned enterprises (SOEs), private enterprises, and foreign-invested enterprises, using SOEs as the reference group to investigate the heterogeneous effects of ownership on the promoting effect of advanced equipment. The regression results are reported in column (5) of Table 6. The coefficient of the interaction term for private enterprises is significantly positive, whereas that for foreign-invested enterprises is not significant. The results indicate that compared to SOEs, the gains from advanced equipment imports are more pronounced for private enterprises. A possible economic explanation for this result is that SOEs, owing to their ownership privileges, inherently possess higher market power and standard-setting discourse power, with a higher initial level of monopoly capability (Brandt et al., 2017); thus, the marginal improvement in pricing power and cost efficiency from imported equipment is relatively limited. In

contrast, private enterprises face stronger market competition pressure and resource constraints, with a lower initial level of monopoly. The technological advantages and cost efficiency improvements brought by advanced equipment imports can more substantially intensify market competition and enhance their market power, thereby driving their participation in national standard-setting. The non-significant interaction term for foreign-invested enterprises may stem from the fact that their technology sources mainly rely on intra-firm transfers from parent companies, making the marginal contribution of imported equipment to standard-setting discourse power relatively limited. Therefore, ownership is an important boundary condition affecting the potential of imported equipment to be unleashed.

E. Heterogeneity by Industry Entry Barriers

The level of industry entry barriers determines the difficulty for potential competitors to enter the market, shapes the fundamental characteristics of rule-based games in different industries, and thereby influences the strategic space for incumbent firms to consolidate their market position through standard-setting. Therefore, this paper follows the definition of Lu & Yu (2015) and measures industry entry barriers by industry average fixed assets. That is, the larger the initial investment scale required for new firms to enter, the higher the corresponding entry barriers. Industries are divided into high-entry-barrier and low-entry-barrier industries based on the industry–year mean. The results, reported in column (6) of Table 6, show that the coefficient of the interaction term is significantly positive, indicating that the marginal gains are most prominent in high-entry-barrier industries. High entry barriers imply, on the one hand, that firms in the industry possess stronger technological capabilities and more resources and industry discourse power to participate in standard-setting; on the other hand, they also mean that firms need to invest in more specific assets and face greater risk of technical standard changes. If industry technical standards change in a direction unfavorable to the firm, the huge sunk costs face the risk of devaluation. Therefore, advanced equipment further strengthens firms' strategic motivation to safeguard the long-term returns on specific assets by participating in standard-setting.

F. Heterogeneity by Market Promotion Intensity

Market promotion intensity reflects firms' strategic investment in building differentiation barriers on the market side through brand reputation and customer stickiness. The persistence of brand reputation depends on continuous advertising efforts on the customer side. Accordingly, this paper uses the ratio of advertising expenditure to operating revenue to measure market promotion intensity, and divides firms into high-market-promotion-intensity and low-market-promotion-intensity groups based on the industry–year median. The results of the interaction regression are reported in column (7) of Table 6. The significantly positive coefficient indicates that in firms with high market promotion intensity, the promoting effect of advanced equipment imports on standard-setting is more pronounced. Brand premiums are, in essence, a form of "collateral" provided by firms to the market to assure product quality (Klein & Leffler, 1981). The precondition for consumers to pay a premium is the reputation constraint formed by the firm's sustained investment in brand equity. Firms with high market promotion intensity have already formed significant sunk investments in brand premiums and production and sales channel networks, and their market reputation faces potential devaluation risk. Therefore, firms with high market promotion intensity have a stronger strategic motivation to participate in standard-setting to reinforce their technological trajectory and safeguard the long-term returns on their assets.

Table 6—Heterogeneity Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variable	Standard	Standard	Standard	Standard	Standard	Standard	Standard
Divi	0.0003**	0.0002	0.0003**	0.0003*	0.0001	0.0002	0.0003**
	(2.02)	(1.42)	(2.38)	(1.87)	(0.33)	(1.43)	(2.00)
High_risk	-0.0004**						
	(-2.30)						
Divi×High_risk	0.0004**						
	(2.22)						
High_HHI		0.0000					
		(0.04)					
Divi×High_HHI		0.0008***					
		(3.66)					
top10			-0.0008				
			(-1.41)				

top10×Divi			0.0004*				
			(1.83)				
High_CR				-0.0003			
				(-1.58)			
High_CR×Divi				0.0005***			
				(2.62)			
Private					0.0001		
					(0.58)		
Foreign					0.0004		
					(0.48)		
Private×Divi					0.0014**		
					(2.52)		
Foreign×Divi					0.0001		
					(0.15)		
High_gdzc						-0.0001	
						(-0.49)	
High_gdzc×Divi						0.0004**	
						(2.35)	
High_jd							0.0002
							(0.77)
High_jd×Divi							0.0006**
							(2.27)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.457	0.457	0.457	0.457	0.457	0.457	0.457
Observations	1,567,797	1,567,797	1,567,797	1,567,797	1,567,797	1,567,797	1,567,797

VII. Further Discussion

A. Resource Factor Flows and Reallocation

In the preceding sections, this paper has established that advanced equipment imports significantly promote firms' participation in national standard-setting, and that this effect operates through three channels: enhanced monopoly power, elevated supply chain position, and the reshaping of organizational efficiency and asset structure. However, standards are, by nature, public goods characterized by non-rivalry and non-excludability. Yet, when the power to set them is strategically exploited by individual firms, they can be transformed from coordination tools that

facilitate technology diffusion into exclusive barriers that consolidate private advantages. Accordingly, this section systematically examines the resource factor flows and reallocations potentially triggered by import-driven standard-setting from three dimensions—labor factor structure complementarity, market competition distortion, and industry ecology polarization and resource misallocation—thereby revealing the economic costs and long-term consequences behind the game of rules. The analysis proceeds in the following three parts.

Labor Factor Structure Complementarity.—Standard-setting relies heavily on the technical knowledge and highly skilled talent that firms accumulate through practice. The technological advantages conferred by imported advanced equipment necessitate the recruitment of matching high-quality technical personnel to undertake activities such as equipment debugging and process optimization, thereby fostering firms' urgent demand for high-skilled labor. Therefore, this paper measures firms' human capital level using the inverse hyperbolic sine transformation of average wages and per-worker training expenditures. The results, reported in columns (1) and (2) of Table 7, show that the coefficients of the interaction terms are positive, indicating that standard-setting significantly strengthens the facilitating effect of advanced equipment on human capital. Possible reasons are as follows. First, unleashing the technological potential of imported equipment requires firms to coordinate compensation premiums and training investments with human capital stock cultivation. When firms' expandable knowledge and proprietary knowledge serve as substitutable investments, standardization raises their marginal returns (Argente et al., 2025). Second, standard-setting establishes firms' technical solutions as national norms, subjecting them to technical scrutiny and competitive pressure from other participants. This compels firms to systematically allocate more resources to upgrading human capital in order to solidify their technological advantage in standard competition, thereby driving the optimization of labor factor allocation within firms.

Market Competition Distortion.—While standard-setting grants firms discourse power over technical rules, it may simultaneously weaken the incentive effect of market competition on firm innovation. Most existing studies focus on the direct

incentive effects of standard-setting on innovation. Theoretically, however, the advanced equipment import behavior of other firms in the same industry represents intensified competitive pressure and potential technology spillovers, which should prompt a given firm to increase R&D in order to maintain its competitive advantage. Yet, if the firm has already deeply participated in standard-setting, it may be able to build technical barriers by virtue of its standard-setting discourse power, thereby reducing its sensitivity to competitors' actions. To test this logic, we construct the average advanced equipment import intensity of other firms in the same industry (rival_Divi) and introduce its interaction term with standard participation. R&D intensity (RD) is proxied by the ratio of "three new" expenditures (i.e., expenses incurred for research on new products, new technologies, and new processes) in the Tax Survey Database to total assets. The regression results, reported in column (3) of Table 7, show that the coefficient of the interaction term is significantly negative, indicating that standard participation significantly weakens the promoting effect of competitive pressure on firm R&D. A possible reason lies in an implicit "competitive buffering effect": standard-setting power serves, to some extent, as a shelter for firms to evade market competition, and standards can partly shift from being coordination tools that promote technological progress to becoming monopoly barriers that suppress competitive incentives.

Industry Ecology Polarization and Resource Misallocation.—First, regarding industry ecology polarization, this paper follows the definition of Leary & Roberts (2014) and defines leading firms as those whose main business revenue ranks in the top 30% within a two-digit industry. We measure the import gap (firm_Divi_gap_abs) as the difference between a firm's advanced equipment imports and the average level of leading firms in the industry. Column (4) of Table 7 shows a significantly positive coefficient, indicating that the further a firm lags behind the industry frontier in imports, the more difficult it is for the firm to participate in standard-setting. This confirms the existence of implicit entry barriers to standard-setting with advanced equipment as the threshold, marginalizing small and medium-sized firms in standard competition. Furthermore, this paper identifies a positive feedback mechanism

between market share growth and standard-setting, which reinforces the polarization trend. We use the growth rate of market share (Dshare) within the two-digit industry to capture a firm's ability to expand its market share. Column (5) reports a significantly positive interaction term, indicating a synergistic effect between advanced equipment imports and market share growth: market share expansion strengthens the positive effect of imports on standard-setting, helping fast-growing firms obtain standard-setting power and enlarge their advantages, while small and medium-sized firms with shrinking market shares are excluded. Taken together, these findings suggest that import-driven standard-setting may become a tool for leading firms to reinforce their market dominance, exacerbating industry dual polarization. This confirms that the implicit entry barriers with advanced equipment as the threshold marginalize small and medium-sized firms in standard competition.

Additionally, it is worth noting that this paper draws on Hsieh & Klenow (2009) to measure the degree of resource misallocation by the dispersion of TFP within a four-digit industry (sd_LP) in order to examine the consequences of resource misallocation. Column (6) shows that the interaction term is significantly negative, indicating that standard-setting does not exacerbate intra-industry productivity divergence but instead narrows the efficiency gap among firms to some extent. When high-efficiency firms participate in standard-setting through imported equipment, their technical knowledge is made public in the form of standard documents. Low-efficiency firms can access this publicly available technical information at very low marginal cost, reducing their technology trial-and-error costs. To some extent, this prompts them to achieve free-rider productivity catch-up through standard implementation, thereby narrowing the efficiency gap with frontier firms and reducing the overall TFP dispersion of the industry.

Table 7 —Further Discussion 1

Variable	(1) labwage	(2) labcap	(3) RD	(4) Standard	(5) Standard	(6) sd_LP
Divi×Standard	0.1277**	0.0030*				
	(1.99)	(1.78)				
Standard	1.5518***	0.0184***	0.0008***			0.0003

	(4.96)	(2.81)	(2.58)			(0.15)
Divi	0.0827***	0.0013***			0.0003*	0.0004***
	(4.93)	(4.56)			(1.65)	(3.66)
rival_Divi			-0.0415**			
			(-2.30)			
Standard×rival_Divi			-0.0009**			
			(-2.07)			
firm_Divi_gap_abs				0.0004***		
				(3.23)		
Dshare					-0.0002**	
					(-2.32)	
Divi×Dshare					0.0002***	
					(2.64)	
Standard×Divi						-0.0016**
						(-2.51)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.717	0.468	0.598	0.457	0.472	0.804
Observations	1,567,797	1,280,207	1,567,797	1,567,797	920,802	1,567,568

B.Collaboration Network Power Concentration and Standard Fragmentation

Standard-setting is not an isolated activity undertaken by firms in isolation; rather, it is a collaborative process that requires extensive technical coordination with other firms and government agencies. A firm's position in the standard collaboration network reflects its capacity to acquire external technical information and to influence the direction of standard documents. Based on data on firms' joint participation in drafting national standards, this paper constructs firm-level degree centrality measures in the standard collaboration network. Degree centrality (degree) measures the number of distinct firms or institutions with which a firm co-drafted national standards in a given year, reflecting the breadth of its collaboration in the standard network. Weighted degree centrality (wdegree) is calculated as the cumulative number of co-drafting instances between the firm and other firms or institutions, reflecting the depth of its collaboration. The regression results reported in columns (1) and (2) of Table 8 show that the coefficients of Divi on both degree centrality and weighted degree centrality are significantly positive, indicating that firms with higher advanced equipment import intensity possess more extensive and more frequent collaborative

ties in the standard collaboration network. In short, leading importers not only participate in a greater number of standard-setting activities themselves but also become core nodes in the standard collaboration network—other firms coalesce around them to carry out standard drafting work, and standard-setting discourse power exhibits a pronounced feature of "network agglomeration." Leading firms, leveraging the technological advantages forged through imported equipment, attract other firms to collaborate with them and thus occupy hub positions in the network; in contrast, small and medium-sized firms, lacking technological attractiveness, remain at the periphery of the network. Even if they participate in standard-setting, they can only attach themselves to leading firms and find it difficult to establish extensive connections within the network. The concentration of network power solidifies the collaborative landscape of standard-setting power at the relational structural level.

Beyond this, when too many firms simultaneously acquire the capability for standard-setting yet effective coordination mechanisms are absent, excessive fragmentation of standard-setting power may emerge at the industry level. This paper measures the degree of standard fragmentation (frag_ah) using the inverse hyperbolic sine transformation of the reciprocal of the Herfindahl-Hirschman Index of firms' standard applications within a two-digit industry in a given year, and examines the effect of advanced equipment imports on standard fragmentation from the industry level. Divi is weighted by the share of main business revenue at the two-digit industry level to obtain ind_Divi. The regression results, shown in column (3) of Table 8, indicate that the coefficient of ind_Divi is significantly positive, suggesting that the more active advanced equipment imports are in an industry, the more standard-setting activities tend to become fragmented. Under an institutional environment lacking effective coordination, although advanced equipment imports endow more firms with the capacity to participate in standard-setting, the mutual compatibility of standards within the industry simultaneously declines, exhibiting a trend toward fragmentation. Moreover, consistent with expectations, in column (4) we define firms within a two-digit industry that have ever participated in setting national standards as industry leaders and calculate the share of their advanced equipment import value in the total

industry import value (excluding the firm itself). The results reveal that this share significantly reduces the market share of follower firms, which is consistent with the market power channel.

C.Import Source Diversification

This paper further explores the issue from the perspective of import source structure. We measure import concentration using the Herfindahl-Hirschman Index of firms' shares of advanced equipment imports across source countries (Divi_HHI). A larger value of this index indicates that import sources are more concentrated in a small number of countries and that the firm is more deeply embedded in the technological systems of those source countries. The regression results reported in columns (5) to (7) of Table 8 show that the coefficients of Divi_HHI on Standard, degree, and wdegree are all significantly positive, indicating that firms with more concentrated import sources exhibit higher participation in standard-setting and greater network centrality.

From the perspective of deep technological embeddedness, overly dispersed import sources may expose firms to diverse technological systems, but confronting mutually incompatible multi-country technical standards incurs high internal technology integration costs, making it difficult to form unified and standardized technical proposals to compete in national standard-setting. Firms that diversify their imports across multiple markets must pay higher import fixed costs than those that concentrate imports from a single market (Barrot & Sauvagnat, 2016). Conversely, an import strategy concentrated on a small number of technologically leading countries helps firms deeply embed themselves in specific technological systems and systematically accumulate process knowledge matched to those systems, enabling them to put forward professional proposals with logically consistent technical specifications in standard-setting, thereby seizing the technological high ground in standard competition.

Analyzed from the perspective of network coordination, firms with high technological specificity in their import sources possess a distinctive coordination advantage: the long-term consistency and predictability of their technological

trajectory sends clear technical signals to other participants in the network, reducing the technology alignment costs and uncertainty for other firms when collaborating with them, and enhancing their capacity to become coordination hubs in the network. Import intensity and source diversification jointly determine firms' standard-setting participation and collaboration network construction.

Table 8 —Further Discussion 2

Variable	(1) degree	(2) wdegree	(3) frag_ah	(4) follower_total_share	(5) Standard	(6) degree	(7) wdegree
Divi	0.0003***	0.0004***					
	(2.62)	(2.69)					
ind_Divi			0.1657**				
			(2.57)				
ind_leader_share				-0.1347***			
				(-3.87)			
Divi_HHI					0.0023***	0.0021***	0.0021**
					(2.97)	(2.72)	(2.55)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	No	No	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	No	No	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No	No
Year fixed effects	No	No	Yes	Yes	No	No	No
R-squared	0.353	0.356	0.765	0.737	0.457	0.353	0.356
Observations	1,567,797	1,567,797	300	300	1,567,797	1,567,797	1,567,797

VIII. Research Conclusions and Implications

The proposals for the 15th Five-Year Plan emphasize "expanding high-standard opening-up and creating new prospects for win-win cooperation" and call for "strengthening the guiding role of standards and raising the level of internationalization," elevating standardization to the height of a national strategy. In this critical period when technology introduction and indigenous innovation advance in tandem, how advanced equipment imports can propel firms to make the leap from "technology follower" to "rule-maker" is not only a strategic imperative for

expanding high-standard opening-up but also a key move for enhancing the independent and self-reliant capacity of industrial chains. Based on a matched dataset constructed from the National Tax Survey Data, Customs Data, and the National Public Service Platform for Standards Information for the period 2007–2016, this paper verifies that advanced equipment imports significantly promote firms' participation in national standard-setting. The findings are as follows. First, in terms of heterogeneity, the marginal effect of advanced equipment imports on standard-setting is more pronounced among firms with high supply chain risk, in industries with high concentration, superstar firms, firms with high management control costs, private firms, firms in industries with high entry barriers, and firms with high market promotion intensity. Second, regarding transmission mechanisms, advanced equipment imports drive firms' participation in national standard-setting through channels such as enhanced monopoly power, elevated supply chain position, and improved organizational efficiency and strategic lock-in. Third, while generating positive effects, import-driven standard-setting may trigger a triple impact—labor factor structure complementarity, market competition weakening, and industry ecology polarization—accompanied by the structural consequence of the coexistence of power concentration in standard collaboration networks and standard fragmentation at the industry level. This paper also conducts an exploratory study on the relationship between import source structure and firms' network hub position, revealing that an import strategy concentrated on a small number of technologically leading countries helps firms occupy a coordination hub position in a fragmented standard ecosystem. Based on these findings, we propose the following policy recommendations.

First, implement differentiated support policies for advanced equipment imports to precisely meet the standardization development needs of different types of firms. Policy design should avoid a one-size-fits-all universal subsidy model. On the one hand, for leading firms that possess technological absorptive capacity and market power, they should be encouraged to deeply participate in the setting of international and national standards through the import of advanced equipment, transforming their technological advantages into rule-making discourse power and playing a leading role

in global industrial chain competition. On the other hand, for small and medium-sized firms with a weak technological foundation, targeted equipment import support strategies can be formulated. Import subsidies, financing guarantees, and equipment leasing can lower the financial threshold for importing advanced equipment. When combined with technical training and standardization guidance, these measures help firms overcome the capability threshold for standard-setting, ensuring that import-driven standardization dividends benefit market entities of all sizes.

Second, improve the linkage mechanism between R&D incentives and standardization, and rely on advanced equipment imports to build industry-chain standard communities. Support leading firms in using imported advanced equipment as a technological anchor, joining forces with upstream and downstream supporting firms to form industrial standard innovation consortia, and systematically transforming the generic technologies—such as process parameters accumulated during equipment operation—into national institutional standards to be followed by the entire industrial chain. Through standard coordination, achieve technological alignment between upstream and downstream segments of the industrial chain and enhance overall industrial competitiveness. Establish special funds for standardization innovation, using imported advanced equipment to drive technological iteration and integrated R&D. This will shift industrial development from imitation to original innovation, reduce external technological dependence, and guard against the risk of low-end lock-in.

Third, construct a collaborative and open standardization governance system. Standardization administration departments should further improve the coordination mechanisms for standard-setting. Standard drafting committees should include diverse participants to prevent monopolization by leading firms and ensure fair, public-good national standards. Meanwhile, standard system planning should prioritize compatibility to avoid rising compliance costs from a proliferation of incompatible standards. Furthermore, China should actively participate in international standardization governance, promote the mutual recognition and alignment of Chinese standards with international standards, and provide a rule-based shield for firms

“going global.”

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