Journal of Infrastructure, Policy and Development 2024, 8(1), 3014.
https://doi.org/10.24294/jipd.v8i1.3014

Article

Can participating in standards development improve enterprise performance? Evidence from China's high-tech industry

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CITATION

Xiong W, Zhao S, Liu Y, et al. (2024). Can participating in standards development improve enterprise performance? Evidence from China's high-tech industry. Journal of Infrastructure, Policy and Development. 8(1): 3014. https://doi.org/10.24294/jipd.v8i1.3014

ARTICLE INFO

Received: 12 October 2023
Accepted: 3 November 2023
Available online: 15 December 2023

ABSTRACT: As an important type of knowledge, standards are key factors in economic development and technological innovation. To analyze the impact of participation in standards development on enterprise performance, this study takes China's high-tech industry as an example. We use the operating data of listed enterprises in the industry in 2019 and conduct the propensity score matching method matching analysis on the entire sample and the classification. The conclusion shows: From an overall point of view, the participation of enterprises in the development of standards has a positive impact on the enterprise's return on total assets. Specifically, participating in the development of over three standards can also improve the return on total assets. Large enterprises can increase the return on total assets of the enterprise and the return on invested capital. The state-owned enterprises have a positive effect on the return on total assets of the enterprise. Enterprises in the western, central, and eastern region enterprises can increase their net profit, enterprise value and net profit, return on total assets and enterprise value respectively. The enterprises in Beijing-Tianjin-Hebei region, Guangdong-Hong Kong-Macao Greater Bay Area can improve their return on invested capital and enterprise value, average rate of return respectively. The participation in the development of national standards, industry standards and local standards can help increase their return on total assets, the return on total assets and enterprise value, enterprise value respectively. Finally, we suggestions are put forward to enhance enterprises' enthusiasm to take part in standards development.

Keywords: standards development; propensity score matching; enterprise performance; high-tech industry

1. Introduction

Standards are an important type of knowledge, documents that are formulated by consensus through standardization activities following prescribed procedures. Standards provide rules, guidelines, or characteristics for various activities or their results, and are used jointly or repeatedly. The purpose of formulating standards is to get the best order within a certain range and promote the best common benefits. Standardization based on standards is an activity that mainly includes planning, issuing, and implementing standards. This is a continuous cycle and spiraling movement (Tan, 2005). With the in-depth development of economic globalization, the role of standardization in facilitating economic and trade exchanges, supporting industrial development, promoting technological progress, and regulating social governance has become increasingly prominent. Standards have become the universal

language of the world (Liu et al., 2017). Research on the economic effects of standardization is a major issue in standardization work. Standardization practitioners in various countries have studied the economic benefits of standardization to varying degrees, and all believe that standards have a positive effect on the economy (Cebr, 2015; Blind and Jungmittag, 2008; Tassey, 2000; W. Xiong et al., 2023).

Enterprises' participation in standards setting is an important aspect of standardization (Toh and Miller, 2017). In developed countries and region such as the United States and Europe, most national standards are formulated by enterprises. However, in China, standards are mainly drafted by state-owned research institutes (F. Chen and Wei, 2020), with less enterprise participation, and the speed of standards formulation and revision cannot keep up with the needs of market changes and industrial development. Y. Wei et al. (2020) found that most influential drafting units are research institutes rather than enterprise. According to the results of incomplete statistics based on the data we found, before 2000, the proportion of enterprises participating in the drafting of national standards issued by China was only 12.58%. The proportion rose to 42.99% from 2000 to 2009, and after 2010, the participation rate of enterprises reached 75.39%. Among the reasons for enterprises to take part in standards formulation, internal environmental reasons include corporate resources and strategic factors and external environmental reasons include market environmental factors and institutional environmental factors (Y. Zhang and Lin, 2019). This is mainly because some Chinese enterprises began paying attention to technology research around 2010. For example, enterprises, such as Sinovac Biotech Ltd (SVA), ZTE telecommunications, and Haier, have increased their investment in technology research and development (R&D) and increased their participation in technical standards' formulation and revision (He and Fang, 2011). In recent years, with the rapid development of China's sharing economy, Chinese enterprises not only participated in the formulation of many standards in the sharing economy but also in the standardization goals formulation (Zhao et al., 2019).

In the current situation of oversupply and the increasingly fierce market competition, competition among enterprises is more represented by the standards competition. In the fourth industrial revolution, standards have become an important indicator of enterprises' international competitiveness. In the field of next generation 5G information technology, the advantages of international standards competition are shifting from developed countries and region, such as the United States, Europe, Japan, and South Korea, to China. Chinese enterprises led by Huawei are gradually gaining a higher competitive position and international market (Du and Chen, 2019). Since the innovation of complex technological systems and the development of intelligent technologies rely on technical standards, the competition of technical standards is crucial for enterprises to gain a competitive advantage. To occupy a favorable market position, standards-setting enterprises should adopt strategies in the competition of technical standards (Jiang et al., 2020). Enterprises adopting technical standards should comprehensively analyze strategic risks, choose the right development direction, and formulate policies to protect their technical standards (C. Xu et al., 2014). The essence of standards competition among enterprises is to participate in the development and formulation of standards. The survival and development of enterprises depend largely on the results of standards competition (Narayanan and

Chen, 2012). Enterprises increase their participation in standards formulation and increase their capital and human investment in standards setting, which is conducive to breaking the single and homogeneous situation of product technology, accelerating technological innovation and industrial upgrading, and gaining opportunity in a modern economy with rapid technological upgrading (F. Chen and Wei, 2020). Enterprises are the main body of the market and of standardization work; therefore, standardization activities cannot be separated from the participation of enterprises (He and Fang, 2011).

Under the new economic normal, China's economy has shifted from a stage of rapid development to high-quality development, pursuing stable and sustainable economic development. To promote the implementation of the innovation-driven strategy, various regions in China are actively creating high-tech industry innovation carriers and environments, building a good high-tech industry innovation ecosystem, and developing high-tech industries (X. Fan and Jiang, 2020). At present, owing to the in-depth R&D and application of new technologies, such as big data (Lazaroiu et al., 2022), cloud computing (E. Nica, Janoškova and Kovacova, 2020), and artificial intelligence (E. Nica, Stan et al., 2021), the high-tech industry has developed more rapidly based on its original scale and has also generated a strong impetus for economic growth.

The above discussion shows that, first, standardization formulation and standardization work promote and enhance enterprise development and enhance enterprise competitiveness, which is vital to the exploration of standards and enterprises. Second, the obtained evidence does not testify whether enterprises can generate benefits from participation in the standard development. Third, the research on standards and the high-tech industry mainly focuses on the macro level of industrial development, and few studies involve the microlevel of standards in the high-tech industry. There is no research on the impact of enterprises' participation in standards development on enterprise performance. Moreover, the participation of enterprises in standards development is very important for standardization work, which makes enterprises gradually become the main body of standards development. The motivation of enterprises to participate in standards must be to obtain benefits, otherwise, policy stimulus alone cannot ensure long-term motivation for participation. However, presently, the problem of whether participation in standards development can improve enterprise performance has not been solved. Especially in China, facing the problems of different scales, natures, and regions, and participation in different standards, the complexity of this problem has greatly increased. Thus, this study explores on this topic. It seeks ways to solve whether participation in standards development can improve enterprise performance. Specifically, this study focuses on enterprises in the high-tech industry and adopts the propensity score matching method to empirically analyze the impact of enterprises' participation in standards development on their performance.

2. Hypothesis and model

2.1. Hypothesis

2.1.1. Hypothesis 1: The participation of enterprises in the development of standards is conducive to improving performance

Some studies have found that enterprises participating in or leading the development of standards can bring huge economic benefits to themselves (Shan and Yu, 2022; Wakke et al, 2016; J. Hou, Song and Zhang, 2008). Ling et al. (2017) found participating in standards development can reduce R&D expenditures, and subsequently increase the economic benefits of the enterprise in the long term. By using standards, enterprises can gain competitive advantages through the intellectual property system. Shan and Yu (2022) found that standard integration into the patent can also bring huge benefits to enterprises. Standards can also promote the further improvement of the intellectual property system (Ma, 2007). In the manufacturing industry, participation in standardization is positively correlated with enterprise performance (Wakke et al., 2016). Small enterprises in electrical engineering and mechanical industries also actively take part in the standardization alliance to acquire knowledge through other relevant stakeholders (Blind and Mangelsdorf, 2016). Participation in standards drafting is beneficial for enterprises to establish a leading brand in the industry, seize market opportunities, gain a high development platform, and enhance market core competitiveness. By obtaining these advantages, the enterprise can improve operational efficiency (Han, 2016).

Based on this, hypothesis 1 is put forward to be tested: The participation of enterprises in the development of standards is conducive to improving performance.

2.1.2. Hypothesis 2: The degree of enterprises participation has different effects on the economic benefits of the standard

Liang et al. (2010) used cointegration theory, Granger causality test, and ridge regression estimation to conduct empirical analysis and found the existence of a long-term equilibrium relationship between engineering construction standards and economic growth. Engineering construction standards play a significant role in promoting economic growth, and their role increases significantly with time. By constructing the standards development contribution index, Q. Qin et al. (2023) found that the operating income of enterprises will increase with the improvement of standard development contribution index. Wu and Huang (2012) focused on the Suzhou area and analyzed the data of Suzhou from 2007 to 2016, they found that the number of standards developments in southern Jiangsu was higher than that in central and northern Jiangsu, and the per capita gross domestic product (GDP) in southern Jiangsu is significantly higher than that in central and northern Jiangsu. The distribution trend of the number of standards revisions participation is similar to that of economic development. In the context of economic globalization, whoever has the right to set standards will have the advantage in the competition to an extent. This law also applies to the domestic economic development environment (Y. Chen and Wu, 2018). Therefore, for the microenterprise perspective, we can infer, enterprises with high participation in standards development may bring different economic benefits than enterprises with low participation and may also show that degree of participation leads to improved economic benefits.

Based on this, hypothesis 2 is proposed to be tested: The degree of corporate participation has different effects on the economic benefits of the standard.

2.1.3. Hypothesis 3: The effect of large enterprises participating in standard development is stronger

In China, there are many differences between large and small enterprises, showing the influence of various policies and external factors, as well as the operations and management methods chosen. Compared with smaller enterprises, monetary policy has little impact on large enterprises, and policy changes have little impact on investment (Gaiotti and Generale, 2002). The impact of industrial policies on enterprises of different sizes varies. Jefferson et al. (2006) found the larger the enterprise is, the more beneficial it is to increase innovation output, such as the number of patents and patents citations, and the sales revenue of new products, thereby increasing innovation performance. Compared with small enterprises, large enterprises have more transferable advantages and are more inclined toward cross-border mergers and acquisitions when making foreign investment decisions (G. Jiang and Jiang, 2017). In strategic emerging industries, the participation of large-scale enterprises in the development of standards can increase the total assets and improve the profit level, while small-scale enterprises can expand their scale (W. Xiong et al., 2022).

Based on this, hypothesis 3 is put forward to be tested: The effect of large enterprises participating in standard development is stronger.

2.1.4. Hypothesis 4: Standard development has different effects on different types of enterprises

Compared with non-state-owned enterprises, state-owned enterprises have weaker incentives to obtain private income, which is more conducive to their implementation of performance incentive contracts (G. Jiang et al., 2010). However, in state-owned enterprises, political connections will bring more government interventions, make enterprises bear more policy burdens, and lead to poor corporate governance (JP. Fan et al., 2007). However, they have a negative impact on investment efficiency (S. Chen et al., 2011), thereby affecting corporate performance. In the standard value of enterprises, the value of standard-setting proposed by non-state-owned enterprises is higher than that of state-owned enterprises (X. Zhang et al., 2019). Using the propensity score matching method, W. Xiong et al. (2022) found that the participation of non-state-owned enterprises in standard development has a positive and significant positive impact on the scale and profits of enterprises. The impact is relatively stable, while the participation of state-owned enterprises in standards development has no significant impact on performance. It can be seen from the above literature that enterprise types differ in corporate governance, cost input, and operating performance.

Based on this, hypothesis 4 is put forward to be tested: Standard development has different effects on different types of enterprises.

2.1.5. Hypothesis 5: There are regional differences in the performance of enterprises participating in the development of standards

The economic development of China's eastern, central, and western regions is uneven, and the level of infrastructure and technology varies greatly. The development status of enterprises in each region differs, and the effects of policy implementation measures also differ. The R&D performance of the western region is significantly

lower than that of the central and eastern regions (Y. Chou and Wei, 2016), and the overall economic efficiency of the central and eastern regions is higher than that of the western regions (Shen et al., 2020). W. Xiong et al. (2023) found that the influence of green standards on green development shows a decreasing trend from east, west and central regions.

Since the 18th National Congress of the Communist Party of China, China has thoroughly implemented the regional coordinated development strategy; guided by five major national strategies, and supported by four regional sectors, and has built a new pattern of regionally coordinated high-quality development during the "14th Five-Year Plan" period, according to the needs of the national development strategy, China will coordinate the development of major sectors and zones and deepen and improve the overall strategy of "4 + X" regional development. The "4" means to continue implementing the strategy of taking the lead in the east, developing the west, revitalizing the northeast, and rising in the middle, and gives it new connotations according to changes in the situation. The "X" refers to the in-depth implementation and expansion of the development strategy of key areas according to the new situation and national needs. "X" includes the coordinated development of Beijing–Tianjin–Hebei, the construction of the Yangtze River Economic Belt, the construction of the Guangdong–Hong Kong–Macao Greater Bay Area, the integrated development of the Yangtze River Delta region, and the ecological protection and high-quality development of the Yellow River Basin. (H.K. Wei et al., 2020). Thus, there are significantly different situations among different regions in China. There may be a distinction in the issue that participating in standard development differs according to region.

Based on this, the following hypotheses are put forward: Hypothesis 5a: Participating in standard development shows different benefits in various regions in China; hypothesis 5b: Participating in standard development shows different benefits in various strategic regions.

2.1.6. Hypothesis 6: The types of standards developed by enterprises have different effects on performance

The composition of China's standard system includes national, industry, and local standards. National standards, especially mandatory standards, have a huge impact on enterprises. Implementation requires strict compliance. Therefore, enterprises often seek to take part in the formulation of national standards (J. Hou, Hou and Wang, 2020). Wakke et al. (2016) found that enterprises' participation in the formulation of national standards can enable them to take part in technology or management standardization, obtain more information sources, and have a positive impact on other enterprises. If the national standard that an enterprise participated in developing withstands the market test, the standard then becomes a powerful tool for the enterprise to expand rapidly within the market (Shapiro and Varian, 1999). The promotion depth of industry standards can help increase the enterprise's operating and strategic benefits. However, although the breadth of promotion can increase the enterprise's strategic benefits, it will reduce its operational benefits (Y. Xu et al., 2016). Compared with the national standards, the local standards for basic-level public service facilities in municipalities directly under the Central Government have obvious differences in types, grades,

items, and indicators. The local standards are of great significance for strengthening people's livelihood construction, adapting to changes in residents' needs, and improving the level of infrastructure services (Sun et al., 2017). All standards can influence the economic development and industries. We want to know whether participating in different types of standards will produce different effects on enterprises' performance.

Based on this, hypothesis 6 is put forward: The types of standards developed by enterprises have different effects on performance.

2.2. Models and methods

When random grouping is not used in experimental observation and research, the influence of confounding variables cannot be weakened and systematic bias is prone to occur in the empirical analysis. The propensity score matching method (PSM) reduces the influence of deviations and confounding variables by dividing the data into a treatment and a control group so that it can be analyzed and controlled more reasonably and stably (A. Xiong et al., 2019). The PSM method was first proposed by Rosenbaum and Rubin (1983) and is commonly used in fields, such as medicine, public health, and economics.

This study uses the PSM method to study whether the behavior of enterprises participating in the development of standards will affect their performance. It is impossible for many enterprises in the industry to have the same operating conditions. It is unrealistic to compare the profitability of the same enterprise when participating in standard development and not participating in standard development. Therefore, it is necessary to use the PSM method to divide different enterprises into treatment and control groups according to whether these enterprises have participated in standard development. The enterprises in both samples groups are matched to get the enterprises as similar as possible in addition to participating in the standard development. In this way, the impact difference and effect of different enterprise types can be more objectively evaluated. The propensity value (PS value) is the probability of the enterprise participating in standard development under the given conditions of other conditions *X* of the sample enterprise. It can be expressed as follows:

$$\mathrm{P(X) = pr(D = 1|X) = E(D|X)} \tag{1}$$

The symbol *X* is the multidimensional vector of independent variables, the covariate for PSM matching, also called the matching variable. *D* is a categorical variable that characterizes whether an enterprise participates in standards development. According to this, the samples were divided into treatment and control groups. If the enterprise participated in the standard development, $D = 1$ (treatment group), otherwise $D = 0$ (control group). *P* represents the probability value of the enterprises in the sample participating in the standard development.

If we can obtain the estimates of propensity score $p(\mathrm{X_i})$, the ATT is the average treatment effect on the treated group (Becker and Ichino, 2002). The ATT can be expressed as follows:

$$\begin{aligned}\mathrm{ATT} &= \mathrm{E(Y_{1i} - Y_{0i}|D_i = 1) = E\{E[Y_{1i} - Y_{0i}|D_i = 1, P(X_i)]\}} \\ &= \mathrm{E\{E[Y_{1i}|D_i = 1, P(X_i)] - E[Y_{0i}|D_i = 0, P(X_i)]\}}\end{aligned} \tag{2}$$

Y is the target variable, and Y_{1i} and Y_{0i} are the enterprise performance of the

treatment and control groups, respectively.

Before calculating the ATT, we also need to perform a balance testing to test whether the matching is valid, including the commonly supporting hypothesis testing and independent hypothesis testing. The commonly supporting hypothesis testing means that among the sample enterprises, enterprises that participate in standard development can find paired samples with similar propensity values (*PS* values) among enterprises that do not participate in standard development. The independent hypothesis testing tests whether the covariates (matching variables) in the two groups are no longer significantly different, that is, after we control for the characteristic variables common to the two groups, the calculated ATT is completely developed by the factor of standard development.

3. Data and descriptive statistics

3.1. Data

According to China's "Classification of National Economic Industries" (GB/T 4754-2017), high-tech industries are classified into high-tech manufacturing and high-tech service industries. The high-tech manufacturing industry includes pharmaceutical, aviation, spacecraft and equipment, electronic and communication equipment, computer and office equipment, medical equipment and instrumentation, and information chemical manufacturing. The high-tech services industry includes information, e-commerce, inspection and testing services; high-tech services for professional technical services, R&D and design services, scientific research results transformation services, intellectual property and related legal services, environmental monitoring and governance services, and other high-tech services. Based on the sample size and availability of data, this study selected pharmaceutical manufacturing, electronic and communication equipment manufacturing, medical equipment and instrumentation manufacturing, information services, and environmental monitoring and governance services as the research objects.

For the relevant data of enterprise participation standards, the data crawling software Octo parse was used to crawl the relevant data of China national, industry, and local standards as of the end of 2019 from the China standards online service network (www.spc.org.cn) and local standards information service platform (http://dbba.sacinfo.org.cn/); covering the basic information, implementation status, standard status, drafting units, and other relevant indicators, to sort them out. According to the standard numbers of different standard types (national, industry, and local standards), we used software to crawl standard data of recent decades, and then organized these scattered data into a unified table. The financial data came from the listed enterprises in the Shanghai and Shenzhen stock markets, which are obtained from the Wind and China Stock Market Accounting Research Database (CSMAR).

3.2. Variable selection

Target variable: The target variable was enterprise income (2019), which is measured by the enterprise's return on total assets (ROA), average return (AROR), return on invested capital (ROIC), net profit (NP), and enterprise value (EV).

Categorical variables: This study took whether the enterprise participates in the standard development (STAN) as a categorical variable, but owing to data limitations, only enterprises participating in standard drafting could be used as the overall representative. The data of enterprises participating in standard drafting as of the end of 2019 were used. The processing group included enterprises that participated in the development of standards, and the control group included enterprises that had not taken part in the development of standards and was treated as a dummy variable. Enterprises participating in the development of the standard were marked as 1, otherwise as 0.

Control variables. The purpose of setting control variables is to eliminate the influence of other deviations and unstable factors during data analysis, to obtain more accurate analysis results. This study selected factors, such as enterprise capital investment, labor investment, scientific research, government, and controlling shareholders. Capital investment includes the enterprise's total operating costs, sales expenses, management expenses, and financial expenses; labor input includes the total number of employees, the number of technical personnel, the number of production personnel, and the per capita salary of the enterprise; scientific research includes the enterprise's R&D expenditure and the number of R&D personnel; Government factors include corporate income tax payable by enterprises and government financial support; the influence of controlling shareholders includes the proportion and number of shares held by controlling shareholders. The control variables were all present in 2019.

Table 1. Control variables and target variables.

	Variable index	**Quantitative indicator**
Target variable	enterprise income (Y)	Return on total assets, average return, return on invested capital, net profit, enterprise value
Control variable	Input of capital (K)	Total operating costs, sales expenses, management expenses, financial expenses
	Input of labor (L)	Number of employees, per capita remuneration of employees, number of technical personnel, number of production personnel
	Innovation level (T)	R&D expenditure, number of R&D personnel
	Government factors (G)	Government subsidies, income tax payable
	Internal owner factors (S)	Proportion and number of controlling shareholders

3.3. Descriptive statistics

The descriptive statistical analysis of variables is shown in **Table 2**. The table contains information, such as the sample size, mean value, standard deviation, and minimum and maximum values of the target and control variables. The standard deviation of return on invested capital, the number of employees, per capita remuneration of employees, and the number of technical personnel and production personnel are relatively large, showing that the differences in these indicators of the sample are relatively large, while the differences in other indicators are relatively small.

Table 2. Descriptive statistics.

	Variable		Variable	Mean value	Standard deviation	Minimum value	Maximum value	Sample size
Target variable	Return on total assets (%)		ROA	521.450	1730.770	−72.608	20000	518
	Average return (%)		AROR	0.315	0.993	−4.920	4.837	518
	Return on invested capital (%)		ROIC	1759.785	7961.524	−122.739	110000	518
	Net profit (billion)		NP	26.608	77.528	−26.549	753.562	518
	Enterprise value (billion)		EV	111.128	250.107	0.376	3870.847	518
Control variable	Input of capital	Total operating costs (billion)	K1	31.069	149.383	0	2779.914	518
		Sales expenses (billion)	K2	20.167	59.501	0	623.802	518
		Management expenses (billion)	K3	3.078	12.662	−11.851	229.770	518
		Financial expenses (billion)	K4	1.547	7.898	−47.177	137.728	518
	Input of labor	Number of employees (per)	L1	6040.120	16000	17	240000	518
		Per capita remuneration of employees (10thousand)	L2	1371.293	4175.818	0	78000	518
		number of technical personnel (per)	L3	13000	45000	2.506	520000	518
		number of production personnel (per)	L4	14000	6100	0	79000	518
	Government	Government subsidies (billion)	T1	1.243	3.2580	0	38.963	518
		income tax payable (billion)	T2	341.270	827.549	−2700	9155	518
	Innovation	R&D expenditure (billion)	G1	0.468	1.638	−1.433	27.711	518
		number of R&D personnel (per)	G2	0.258	0.680	0	8.074	518
	controlling shareholders	Proportion of controlling shareholders (%)	S1	3.271	6.721	0.113	113.997	518
		number of controlling shareholders (billion)	S2	28.195	12.673	3	77.270	518

4. Results

4.1. Matching variable selection

Logit regression was performed on the selected control and categorical variables, and the variables are extracted to complete PSM matching. The regression model is shown in Equation (3):

$$\ln[\mathrm{pr}(\mathrm{STAN}=\mathrm{j}|\mathrm{X})|\mathrm{pr}(\mathrm{STAN}=\mathrm{J}|\mathrm{X})] = \alpha_0 + \alpha_1\mathrm{K1} + \alpha_2\mathrm{K2} + \alpha_3\mathrm{K3} + \alpha_4\mathrm{K4} + \alpha_5\mathrm{L1} + \alpha_6\mathrm{L2} + \alpha_7\mathrm{L3} + \alpha_8\mathrm{L4} + \alpha_9\mathrm{T1} + \alpha_{10}\mathrm{T2} + \alpha_{11}\mathrm{G1} + \alpha_{12}\mathrm{G2} + \alpha_{13}\mathrm{S1} + \alpha_{14}\mathrm{S2} \quad (3)$$

In Equation (3), STAN is whether the enterprise participates in standard drafting, *X* is the multidimensional vector of independent variables, *K1* is the total operating cost of the enterprise, *K2* is the sales cost, *K3* is the management cost, *K3* is the financial cost, *L1* is the total number of employees, *L2* is the number of technical personnel, and *L3* is Per capita salary of employees. *L4* is the per capita salary of employees, *T1* is the enterprise R&D expenditure, *T2* is the number of R&D personnel, *G1* is the income tax payable by the enterprise, *G2* is the government subsidy, *S1* is the shareholding ratio of the controlling shareholder, and *S2* is the controlling shareholder's Holdings, α_1–α_{11} are parameters. The regression results of Equation (3) are shown in **Table 3**.

Table 3. The stepwise regression results.

Explanatory variable	Predicted variable: whether the enterprise participates in the standard development					
	1–1	**1–2**	**1–3**	**1–4**	**1–5**	**1–6**
Total operating cost of the company	0.003	0.003	0.002	0.002	-	-
	(1.21)	(1.27)	(1.45)	(1.11)	-	-
Sales expenses	−0.023***	−0.022***	−0.021***	−0.021***	−0.023***	−0.018***
	(−3.35)	(−3.35)	(−3.38)	(−3.67)	(−4.05)	(−3.93)
Management expenses	0.011	0.015	-	-	-	-
	(0.26)	(0.41)	-	-	-	-
Financial expenses	0.007	-	-	-	-	-
	(0.22)	-	-	-	-	-
Total number of employees	−0.001	−0.001	−0.001	-	-	-
	(−1.24)	(−1.24)	(−1.11)	-	-	-
Number of technical personnel	0.001	0.001	0.001*	0.001	0.001	-
	(1.16)	(1.18)	(1.77)	(1.27)	(1.41)	-
Per capita salary	0.001**	0.001**	0.001**	0.001**	0.001***	0.001***
	(2.33)	(2.32)	(2.54)	(2.34)	(2.66)	(2.78)
Number of production personnel	0.001**	0.001**	0.001**	0.001***	0.001***	0.001***
	(2.05)	(2.08)	(2.47)	(2.82)	(2.97)	(2.69)
The enterprise R&D expenditure	0.057	0.56	0.046	-	-	-
	(0.97)	(0.96)	(0.81)	-	-	-
Number of R&D personnel	0.001	0.001	0.001	0.001*	0.001**	0.001***
	(1.24)	(1.25)	(1.21)	(1.94)	(2.06)	(3.99)
The income tax payable by the enterprise	−0.339*	−0.354*	−0.305	−0.279	-	-
	(−1.68)	(−1.77)	(−1.59)	(−1.58)	-	-
Government subsidy	0.254	0.264	0.331	0.311	0.161	-
	(1.07)	(1.12)	(1.51)	(1.45)	(0.92)	-
The shareholding ratio of the controlling shareholder	0.044	0.038	-	-	-	-
	(0.93)	(0.85)	-	-	-	-
The controlling shareholder's holdings	−0.003	-	-	-	-	-
	(−0.35)	-	-	-	-	-
C	−0.664	−0.736***	−0.702	−0.695***	−0.715***	−0.726***
	(−2.61)	(−5.46)	(−5.54)	(−5.52)	(−5.72)	(−6.06)

Note: ***, **, *, means passing the 1%, 5%, and 10% significance test respectively, and the values in parentheses are the t-test values. The following is the same.

Through logit stepwise regression analysis, sales expenses, per capita salary, number of production personnel, and number of R&D personnel have passed the test, and these four variables have passed the 1% level of significance test, indicating that in the next PSM matching, these four control variables can be selected as matching variables.

4.2. Matching effect analysis

The four selected variables were matched with the control variables and the target

variables for PSM matching. Before the PSM matching, we tested the sample matching effect through the balance test. The sample balance test results are shown in **Table 4**.

Table 4. The balance test unmatched and matched.

	Sample	**Ps *R2***	**LR chi2**	***P* > chi2**	**Mean bias**	**Med bias**
Unmatched	-	0.073	50.82	0	21.2	22.6
Matched	Nearest neighbor matching	0.009	5.07	0.167	7.4	8.4
	Radius matching	0.005	2.06	0.725	2.7	2.8
	Kernel matching	0.015	8.25	0.041	8.4	8.2

The balance test found that the *p*-value before matching is 0, indicating that there is a significant difference between the treatment and control groups. After the matching, the *p*-values rejected the null hypothesis under the three matching methods, indicating that after the matching, there was no significant difference between the samples of the two groups.

A joint support hypothesis testing was conducted on the sample, and the results are shown in **Table 5**. The treatment and the control groups have 205 and 313 samples, respectively, and the matching was successfully completed. Thus, the hypothesis of common support was verified. The treatment and control groups under the three matching methods all had successfully matched samples, especially the nearest neighbor matching is the result of all samples being matched.

Table 5. A joint support hypothesis testing.

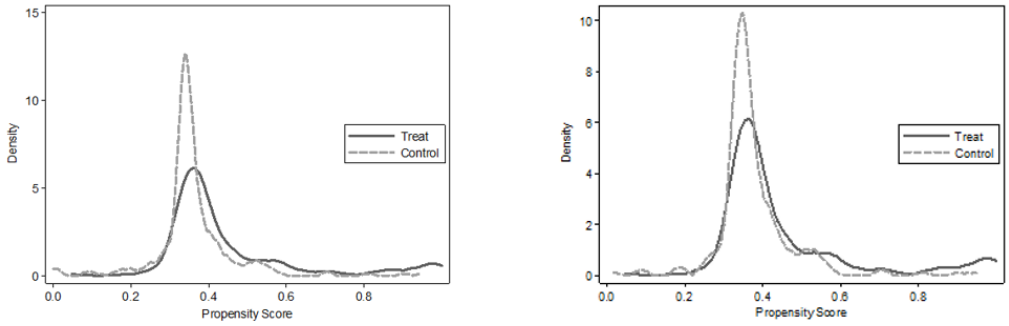
	Treatment assignment	**Common support**		**Total**
		Off support	**On support**	
Nearest neighbor matching	Untreated	0	313	313
	Treated	0	205	205
Radius matching	Untreated	0	313	313
	Treated	65	140	205
Kernel matching	Untreated	1	312	313
	Treated	0	205	205

The results of the test on the matched control variables are shown in **Table 6**. This test required that the *t*-test after the control variables have been matched has no significant difference. In the three matching methods, the three variables before matching, all passed the 1% level of significance test, but after the matching did not pass the test, showing that there was no significant difference in the variables after matching, and the independence hypothesis test was passed.

Table 6. The independence hypothesis test.

		Variable	Mean		*t*-test
			Treated	**Control**	***t***
Unmatched		K2	16.927	22.29	−1.67*
		L3	20491	8889.3	2.92***
		L4	27684	62546	3.75***
		T2	456.1	266.06	2.57***
Matched	Nearest neighbor matching	K2	16.927	22.22	−1.02
		L3	20491	14466	1.19
		L4	27008	21008	0.68
		T2	456.1	453.46	0.03
	Radius matching	K2	11.565	8.932	0.89
		L3	6529.4	6208.4	0.25
		L4	57348	45897	1.01
		T2	273.21	239.42	0.46
	Kernel matching	K2	16.927	26.473	−1.56
		L3	20491	17804	0.51
		L4	57348	26609	0.08
		T2	456.1	359.42	1.03

The results before and after matching are shown in **Figure 1**. For space reasons, only the results of the nearest neighbor matching are shown. From the **Figures 1a,b**, it can be found that there are still some differences between the treatment and control groups before matching, and the difference between the two groups after matching was reduced, indicating that, the similar samples in the two sets of samples were successfully matched.



(a) before. **(b)** after.

Figure 1. Comparison of density maps before and after propensity score matching.

4.3. Analysis of the effect of enterprises participating in the development of standards

4.3.1. The average treatment effect of the whole sample

According to Equation (2), ATT of corporate income is analyzed (**Table 7**), and the results are shown in **Table 7**. When the NP was used as the target variable, the enterprise's ATT was positive and the corresponding *t*-value passed the 5% level test,

indicating that enterprises' participation in standard development will have a negative impact on NP. This may be because firm size is an important factor affecting firm characteristics and performance (L. Fan et al, 2012; Lavie et al., 2011). Most of the enterprises involved in standard development are relatively large (64.88%). Large enterprises have more businesses, complex production and sales activities, and procedures for profit and taxation, which may lead to a lag in the acquisition of NPs. It may also be because some senior managers have a certain political connection background, including deputies to the National People's Congress and members of the Chinese People's Political Consultative Conference (CPPCC). (D. Chen, 2015). Political connections compensate for enterprises' lack of control over the allocation of economic resources, making it easier to grasp policy trends and strive for a favorable policy environment for themselves (Bartels and Brady, 2003). Therefore, when the development of the real economy is relatively difficult, enterprises are more inclined toward speculative investment when making strategic choices. However, speculative investment entails great risks, and it is easy to be excessively speculative, which makes enterprises lose motivation to conduct technological transformation and upgrading and will reduce enterprises' performance in the long term (D. Chen, 2015).

When the return on assets (ROA) was used as the target variable, the enterprise's ATT was positive and the corresponding t-value was significant at the level of 10%. The enterprise's participation in standard development can increase the ROA of the enterprise. The ROA passed the test of three methods, indicating that the result is robust, but only one target variable passed the test and the ATT was positive. This may be owing to heterogeneity, so more detailed classification matching is required.

Table 7. The average treatment effect (ATT) of corporate income.

Target variable	Nearest neighbor matching		Radius matching		Kernel matching	
	ATT	***t***	**ATT**	***t***	**ATT**	***t***
ROA	332.456	1.804*	96.925	1.720*	322.568	1.685*
AROR	0.103	0.917	0.092	0.829	0.045	0.399
ROIC	132.867	0.189	28.275	0.181	209.594	0.245
NP	−12.167	−1.345	3.15	0.889	−17.166	−1.976**
EV	31.435	1.026	13.91	0.702	29.215	1.036

4.3.2. The impact of different degrees of enterprises participating in the development of standards on revenue

Next, this study divided the sample into two groups according to the number of enterprises participating and the proportion of different numbers of enterprises in the total sample. The number of enterprises participating is less than or equal to 3 and the number of enterprises participating is greater than 3. Then, this study analyzed the difference in the impact of enterprises' participation in standard development on their income when the degree of participation of enterprises differs (**Table 8**).

As shown in the **Table 8**, among the enterprises with over 3 participations, the ATT of the ROA is greater than zero, and the *t*-value has passed the 1% level significance test, showing that participating in the development of more than 3 standards can improve the enterprise's ROA. Simultaneously, the ATT value of NP is

less than zero, and the *t*-value is significant at the level of 10%, indicating that the number of enterprises participating in standards development is greater than 3 will significantly reduce the level of NP. This may be because firm size is an important factor affecting firm characteristics and performance (Lavie et al., 2011). Most enterprises involved in standards development are relatively large (73.74%). Large enterprises have more businesses, complex production and sales activities, and procedures for profit and taxation, which may lead to a lag in the acquisition of NP. This result is consistent with that of the full sample. However, both results only passed the *t*-test in one match, indicating that the results are not sufficiently robust. In the enterprises with participation numbers less than or equal to 3, the ATT values of all target variables failed the significance test, indicating that participation in standard development has no significant impact on performance. So, the H2 has been verified.

In summary, enterprises with over 3 enterprises participating in standard development have a significant positive impact on their ROA.

Table 8. The average treatment effect (ATT) of different degree of participation.

		Nearest neighbor matching		**Radius matching**		**Kernel matching**	
		ATT	***t***	**ATT**	***t***	**ATT**	***t***
More than 3	ROA	661.199	2.051***	−14.181	−0.197	580.24	1.734
	AROR	0.061	0.364	−0.004	−0.021	0.004	0.023
	ROIC	963.907	1.306	−29.507	−0.134	259.822	0.283
	NP	−4.792	−0.454	−1.675	−0.346	−23.061	−1.828*
	EV	59.28	1.273	−49.064	−1.358	49.571	1.315
Less than or equal to 3	ROA	92.848	0.859	96.124	1.287	83.992	0.844
	AROR	0.101	0.784	0.116	0.939	0.098	0.931
	ROIC	−102.841	−0.201	73.649	0.489	−292.581	−0.516
	NP	−6.055	−1.103	0.009	0.003	−1.082	−0.185

4.3.3. The impact of participation in standard development on revenue by enterprises of different sizes

This study divided enterprises into large and small enterprises according to their scale and analyzed whether the participation of two differently sized enterprises in the standard development will affect their revenue. The samples of large and small enterprises participating and not participating in the standard development were compared through PSM matching. The results are shown in **Table 9**.

The following conclusions can be drawn from **Table 9**: In large enterprises, when the ROA and the return on invested capital (ROIC) are the target variables, the ATT value is greater than zero, and the *t*-value has passed the 5% level of significance test. The participation of large enterprises in drafting standards can improve their ROA and ROIC. The two target variables passed only one method of testing, showing that the results were not sufficiently robust. In the small enterprises, the ATT value of the target variable did not pass the t-value test, indicating that the participation of the small enterprises in the development of standards has no significant impact on the corporate income. This conclusion is consistent with H3.

In summary, the participation of large enterprises in the development of standards

can increase their ROA and ROIC, while the participation of small enterprises has no significant impact on corporate earnings.

Table 9. The average treatment effect (ATT) of different sizes of corporate income.

		Nearest neighbor matching		Radius matching		Kernel matching	
		ATT	***t***	**ATT**	***t***	**ATT**	***t***
	ROA	1055.917	2.340**	75.918	1.017	150.265	1.065
	AROR	−0.049	−0.269	−0.223	−0.914	−0.032	−0.173
Large enterprises	ROIC	2334.685	2.331**	288.227	1.555	855.445	1.492
	NP	14.033	1.032	0.602	0.195	7.968	0.92
	EV	76.42	1.198	−79.186	−0.973	5.277	0.127
	ROA	39.131	0.334	34.979	0.983	85.672	0.667
	AROR	0.168	1.354	0.162	1.174	0.147	1.338
Small enterprises	ROIC	−398.426	−0.7	131.643	1.073	−409.155	−0.539
	NP	−9.329	−1.492	0.842	0.255	−3.139	−0.418
	EV	3.712	0.117	−9.418	−0.266	0.935	0.04

4.3.4. The impact of different types of enterprises participating in the development of standards on revenue

According to the organizational form, enterprises are divided into state-owned and non-state-owned enterprises. Owing to the amount of data, private enterprises, Sino-foreign joint ventures, and collective enterprises are classified as non-state-owned enterprises. The subsequent matching process is similar to the previous step. Comparing the samples of state-owned and non-state-owned enterprises that participate and do not participate in the development of standards, we analyzed the difference in the impact of participation in the development of standards on enterprises income when the organizational form is different (**Table 10**).

Table 10 shows the ATT and *t*-values of all enterprises, state-owned and non-state-owned enterprises, under the three matching methods. According to the data in the table, in state-owned enterprises, the ATT value of the ROA of the enterprise is positive. It has passed the 5% level of significance test, indicating that the participation of state-owned enterprises in standard development has a significant effect on the return on total assets of the enterprise. However, the result only passes the nearest neighbor matching method test, indicating that the result is not robust enough. For state-owned enterprises, the target variables all did not pass the test of any matching method, showing that the participation of state-owned enterprises in the development of standards does not promote their performance. So, the H4 has been verified.

In summary, the participation of state-owned enterprises in the development of standards is conducive to improving the ROA of enterprises.

Table 10. The average treatment effect (ATT) of different types of corporate income.

		Nearest neighbor matching		Radius matching		Kernel matching	
		ATT	***t***	**ATT**	***t***	**ATT**	***t***
State−owned enterprises	ROA	587.753	2.172 **	176.722	1.51	282.978	1.332
	AROR	0.069	0.54	0.082	0.541	0.082	0.657
	ROIC	905.322	1.189	187.784	0.679	61.521	0.046
	NP	−11.962	−1.131	6.39	0.981	−6.872	−0.604
	EV	−3.89	−0.076	6.622	0.1	−3.563	−0.089
Non−state−owned enterprises	ROA	21.867	0.493	−37.654	−0.929	6.04	0.158
	AROR	0.164	0.909	0.281	1.037	0.171	1.011
	ROIC	−7.728	−0.086	4.495	0.038	−0.758	−0.008
	NP	1.002	0.423	−3.606	−1.573	1.537	0.643
	EV	−7.219	−0.596	−4.622	−0.229	−9.137	−0.95

4.3.5. The impact of participation of enterprises in different regions in the development of standards on revenue

According to the development strategy plan during the "14th Five-Year Plan" period and data availability, when analyzing regional heterogeneity, this study analyzed the eastern, central, and western regions, as well as the Beijing–Tianjin–Hebei, Yangtze River Economic Belt, Guangdong–Hong Kong–Macao Greater Bay Area, Yangtze River Delta, and several regions including the Yellow River Basin (H.K. Wei et al., 2020).

According to the analysis results of three different regions (**Table 11**), the ATT value of the NP of enterprises in the western region is greater than zero and the *t*-value has passed the test, indicating that participation of enterprises in the western region in standard development can increase the NP of enterprises. However, the result only passes the nuclear matching test, indicating that it is not robust enough. The NP and EV ATT of central enterprises are both positive, and the corresponding *t*-value has passed the significance test at the 5% or 10% level. Therefore, the participation of central enterprises in the standard formulation has a significant positive effect on the enterprise's NP and EV. However, both results pass only one *t*-test, indicating that although the samples are different, the results are not sufficiently robust. When the ROA and EV of eastern enterprises are the target variables, their t-values have passed the significance test, and are significantly different from 0 at the statistical level of 10% or 5%. While the ATT values are positive, showing that the participation of eastern enterprises in standard development is conducive to improving their ROA and EV. Among them, the ROA passed the nearest neighbor and core matching tests, showing that the results have a certain degree of robustness. However, the EV only passed one method test, showing that it is not sufficiently robust. So, the H5a has been verified.

In the Beijing–Tianjin–Hebei region, when the target variables are ROIC and EV, the ATT value is positive and the *t*-value has passed the significance test at the level of at least 5%, indicating that the participation of enterprises in standards development in the Beijing–Tianjin–Hebei region has a significant positive impact on the return on ROIC and EV. However, both results only pass the test of one method, indicating that the results are not sufficiently robust. In the Guangdong–Hong Kong–Macao Greater

Bay Area, when the target variable is the average rate of return, the ATT value is greater than zero and the t-value has passed the significance test. This indicates that the participation of enterprises in the Guangdong–Hong Kong–Macao Greater Bay Area in the development of standards is conducive to improving the average rate of return (AROR). The ATT passes two matching methods, showing that the result has a certain degree of robustness. However, when the target variable is NP, the ATT value is less than zero and the t-value is significant at the 5% level. This shows that the participation of enterprises in the Guangdong–Hong Kong–Macao Greater Bay Area in the development of standards has a negative impact on NP. This may be because most of them (61.91%) are relatively large in scale, and their complex business and processes lead to a lag in the acquisition of net profit (Lavie et al, 2011). At the same time, some corporate executives have a political connection background, which leads to high speculative investment and poor technological transformation and upgrading capabilities (D. Chen, 2015). However, in the Yangtze River Delta region, the Yangtze River Economic Belt, and the Yellow River Basin, participation in standards development has no significant impact on corporate performance. So, the H5b has been verified.

In summary, the participation of western enterprises in the development of standards can increase their NP; the participation of central enterprises has a positive impact on their NP and EV, while the participation of eastern enterprises has a positive impact on their ROA and EV. The participation of enterprises in the Beijing–Tianjin–Hebei region in the development of standards can improve their ROIC and EV, and the participation of enterprises in the Guangdong–Hong Kong–Macao Greater Bay Area can improve their AROR.

Table 11. The average treatment effect (ATT) of corporate income in different regions.

		Nearest neighbor matching		**Radius matching**		**Kernel matching**	
		ATT	***t***	**ATT**	***t***	**ATT**	***t***
	ROA	25.642	0.128	−2.552	−0.396	45.387	1.071
	AROR	0.317	1.102	0.586	0.689	0.393	1.098
Western	ROIC	−304.467	−0.311	−4.3	−0.556	14.586	1.323
	NP	7.91	0.655	−1.305	−0.586	12.115	1.663*
	EV	65.844	0.639	−21.273	−0.597	189.405	1.203
	ROA	385.883	1.185	21.365	0.132	49.94	0.352
	AROR	0.068	0.43	−0.011	−0.072	0.106	0.808
Central	ROIC	−343.115	−0.199	−888.961	−0.899	−633.254	−0.753
	NP	−23.584	-1.892*	−0.552	−0.073	−8.085	−0.832
	EV	56.822	2.017**	−3.023	−0.261	33.784	1.412
	ROA	279.802	1.861*	27.544	0.463	307.422	2.084**
	AROR	−0.049	−0.272	0.146	0.526	0.008	0.045
Eastern	ROIC	456.793	1.407	28.098	0.1	471.329	1.501
	NP	14.473	1.252	3.905	0.868	14.843	1.262
	EV	43.789	2.161**	18.465	0.603	26.172	0.447

Table 11. (*Continued*).

		Nearest neighbor matching		Radius matching		Kernel matching	
		ATT	***t***	**ATT**	***t***	**ATT**	***t***
	ROA	518.802	1.524	−48.623	−0.592	−68.13	−0.721
	AROR	−0.032	−0.201	−0.179	−1.044	−0.181	−1.221
Beijing–Tianjin–Hebei	ROIC	−103.437	−0.122	1400	2.781***	−1200	−2.104
	NP	5.938	0.467	18.996	1.037	8.604	0.651
	EV	17.597	0.38	77.811	2.323**	−17.016	−0.568
	ROA	5.021	0.037	103.981	1.521	36.449	0.342
	AROR	0.108	0.824	0.057	0.429	0.127	1.134
Yangtze River Delta	ROIC	−406.094	−0.489	178.516	0.818	−302.164	−0.531
	NP	2.032	0.206	1.133	0.346	−0.745	−0.107
	EV	26.665	0.877	−0.435	−0.032	36.216	1.226
	ROA	23.269	0.187	49.806	0.964	49.231	0.449
	AROR	0.025	0.209	0.021	0.172	−0.007	−0.061
Yangtze River Economic Belt	ROIC	−28.538	−0.039	35.783	0.201	151.165	0.238
	NP	−2.629	−0.26	0.168	0.064	−2.575	−0.331
	EV	28.271	1.237	0.825	0.057	28.366	1.291
	ROA	213.303	0.921	132.843	0.574	274.057	1.209
	AROR	−0.12	−0.638	−0.024	−0.133	−0.021	−0.125
Yellow River Basin	ROIC	644.219	0.701	691.037	0.727	814.832	0.804
	NP	1.966	0.201	3.698	0.383	0.737	0.072
	EV	14.511	0.545	0.044	0.002	22.398	0.822
	ROA	93.006	0.491	28.622	0.558	115.161	0.721
	AROR	0.338	2.291**	0.209	1.388	0.337	2.924***
Guangdong–Hong Kong–Macao Greater Bay Area	ROIC	800.267	0.584	−91.511	−0.431	720.969	0.601
	NP	−25.824	−2.111**	1.382	0.347	−17.192	−2.016**
	EV	−0.147	−0.004	−55.501	−1.569	−6.67	−0.301

4.3.6. The impact on revenue of enterprises of different types participating in the development of standards

Enterprises are classified according to the types of standards (national, industry, and local standards) the enterprises participate in to discuss heterogeneity.

Table 12 shows the ATT and *t*-values of enterprises participating in the development of three different types of standards under the three matching methods. The following conclusions can be drawn. When the ROA and AROR on enterprises participating in the development of national standards are used as target variables, the ATT value is positive and *t*-value has passed the significance test. Participating in the development of national standards has a significant positive impact on the enterprise's ROA and AROR. The ATT value of the ROA passes the significance test issued by the two matching methods, indicating that there is a certain degree of robustness. However, the ROA and AROR only passed a matching t-test, showing that the sample results are not sufficiently robust. For enterprises taking part in the development of industry standards, the ATT values of the ROA and EV are positive and significant at least at

the level of 10%, indicating that participation in the development of industry standards is beneficial to increase the ROA and EV. However, both only passed the significance test of one method, indicating that the results are not sufficiently robust. For enterprises participating in the development of local standards, the ATT values of the AROR and EV are greater than zero and the *t*-values have passed the test, that is, participation in the development of local standards can increase the AROR and EV. The ATT value of the AROR has passed the *t*-test of the three matching methods, which shows that the results are robust, while only the nearest neighbor matching is passed when the EV is the target variable, indicating that the result is not sufficiently robust. So, the H6 has been verified.

In summary, the participation of enterprises in the development of national standards is conducive to improving the ROA and AROR; participating in the development of industry standards is conducive to improving the ROA and EV and participating in the development of local standards can increase the AROR and EV.

Table 12. The average treatment effect (ATT) of enterprises of different types participating in the development of standards income.

		Nearest neighbor matching		**Radius matching**		**Kernel matching**	
		ATT	***t***	**ATT**	***t***	**ATT**	***t***
National standards	ROA	421.177	1.838*	148.89	1.826*	184.348	1.261
	AROR	0.196	1.529	0.359	2.570**	0.09	0.806
	ROIC	226.551	0.264	274.071	1.341	−292.661	−0.369
	NP	−9.174	−0.925	5.171	1.166	−9.679	−1.067
	EV	14.39	0.371	−0.889	−0.052	9.724	0.35
Industry standards	ROA	628.96	1.904*	96.363	0.874	243.945	1.329
	AROR	−0.071	−0.456	−0.098	−0.673	−0.096	−0.722
	ROIC	652.504	0.882	59.857	0.219	−152.54	−0.199
	NP	−1.988	−0.148	−1.604	−0.269	−2.678	−0.187
	EV	64.487	2.299**	18.685	0.748	25.876	0.87
Local standards	ROA	354.348	1.246	237.251	1.593	203.605	1.237
	AROR	0.415	2.085**	0.338	1.695*	0.429	2.593***
	ROIC	97.238	0.077	488.455	1.445	−127.964	−0.259
	NP	10.753	0.537	10.194	1.125	5.205	0.59
	EV	62.345	1.980**	−0.528	−0.032	17.689	0.557

5. Conclusion and discussion

This study takes China's high-tech industry as an example (2019) to analyze the impact of participating in the development of standards on corporate performance. Conclusions and suggestions are as follows.

It is found that the participation of enterprises in the development of standards has a positive, robust impact on their ROA, and participating in the development of over 3 standards can also improve an enterprise's ROA, but it is not sufficiently robust. Participating in the development of less than 3 standards has no impact on performance. The participation of large enterprises in the development of standards can increase

their ROA and ROIC, but it is not sufficiently robust, while the participation of small-scale enterprises cannot affect the performance. For the state-owned enterprises, participation in the development of standards has a positive but less robust effect on their ROA. For non-state-owned enterprises, participation in the development of standards has no effect on their performance. Regarding participation in the development of standards, enterprises in the western region can increase their NP (not sufficiently robust), central enterprises can increase their NP and EV (not sufficiently robust), eastern enterprises can increase their ROA (a degree of robustness) and EV (not sufficiently robust), while enterprises in the Beijing–Tianjin–Hebei region can improve their ROIC and EV (not sufficiently robust), and the enterprises in the Guangdong–Hong Kong–Macao Greater Bay Area can improve their AROR (a degree of robustness). However, in the Yangtze River Delta region, the Yangtze River Economic Belt and the Yellow River Basin, participation in standard development has no significant impact on corporate performance. At the same time, the participation of enterprises in the development of national standards has a positive, robust impact on their ROA, as well as a positive but less robust impact on their AROR. Participation in industry standards has a less robust positive impact on their AROR and EV. Participation in local standards has a positive, robust impact on enterprises' AROR and a less robust positive impact on their EV.

Accordingly, several suggestions based on the above conclusions are put forward. First, participation in the formulation of standards has a positive impact on corporate performance. Enterprises should take a proactive attitude paying attention to the drafting and development of standards to enhance their competitiveness, especially large-scale and state-owned enterprises. Also, the participating in more than 3 standard developments is beneficial. Second, participating in the development of local standards has a more stable positive effect on the AROR of enterprises. Therefore, enterprises should focus on formulating local standards and increase their capital and manpower investment to increase returns. Third, the government should support and encourage enterprises to take part in the development of standards, enhance their awareness of standard formulation, and introduce implementation policies to promote the participation of enterprises in standard formulation. Fourth, the government should strengthen the financial and technical support for enterprises to take part in the development of standards. For enterprises that participate in the formulation of high-quality and representative standards, the government can appropriately implement tax reductions or preferential treatment policies to create a good external environment for standards development. In sum, to further promote standardization reform and innovation, the construction of a new standards system that meets high-quality development and increases the income of enterprises and the entire industry should be accelerated; enterprises need to pay attention and change accordingly. The state and government also need to develop relative policies to promote the participation of enterprises in the standards development.

Author contributions: Conceptualization, WX, SZ and YS; methodology, WX and SZ; formal analysis, WX and SZ; investigation, SZ and XW; resources, SZ, YL and XW; software, WX and SZ; writing—original draft, SZ; writing—review and editing,

WX, SZ, YL and YS; funding acquisition, WX and YS. All authors have read and agreed to the published version of the manuscript.

Acknowledgments: The authors acknowledged Chinese Academy of Sciences, Beijing Technology and Business University, the National Natural Science Foundation of China "Benefits and Contributions of Standardization in China's Economic Development: Research on Computable Ensemble Drive Model" (71871211), the National Key Research and Development Project of China "Research on the Commonality and Comprehensive Evaluation Technology of New Urbanization for Sustainable Development" (2018YFF0215801) and the Fund Project of Institute of Science and Department of Chinese Academy of Sciences (Y8X1061Q01) for supporting this article until it is published.

Conflict of interest: The authors declare no conflict of interest.

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