



The Impact of Standardization on Industrial Innovation Performance

--Empirical Study based on Data from High Technology Industry

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Abstract

Theories suggest that standards promote industrial innovation through compatibility features, variety of simplification functions, and accelerated knowledge dissemination mechanisms, but there is a lack of robust empirical evidence. Given this, this paper selects the data of 13 industries in China's high-tech industries from 2010 to 2019 as the sample for analysis, uses econometric modeling to establish a multiple linear regression model for empirical testing, and analyzes the heterogeneity of standardization on innovation performance in different industries. It is found that standardization has a significant positive impact on the innovation performance of high-tech industries. In terms of sub-industries, the electronics and communication equipment manufacturing industry and medical equipment and instrumentation manufacturing industry standardization significantly impact their innovation performance. Accordingly, the policy recommendations of adjusting government input based on actual performance, strengthening government support according to industry characteristics, and optimizing support methods for R&D needs are proposed.

Keywords: Standard development; high-tech industry; multiple linear regression model; industry heterogeneity

1. INTRODUCTION

The 21st century is a new era of "knowledge economy", in which industrial development is shifting from labour, capital and other production factor inputs to advanced forms of standard inputs^[1]. High-tech industries are knowledge-intensive industries with solid innovation capability, which are the key to industrial restructuring and transforming economic growth momentum in China. Therefore, how to scientifically evaluate the influencing factors of an industry's innovation performance and the magnitude of its role has become one of the hot issues in economics research.

Standardization is a critical technical base for economic and social development, an essential guarantee for modernization, standardization and specialization of industrial systems, and a critical link for maintaining market order and promoting scientific and technological

progress^[2]. As an essential basis for industrial innovation, standardization can enhance industrial innovation performance directly by improving industrial production efficiency, gaining the first-mover advantage, and winning intellectual property rights, but indirectly by reducing transaction costs, achieving economies of scale, and promoting resource and energy conservation. With its unique attributes, standards help the innovation performance of high-tech enterprises. Chinese regions and enterprises have also used technology, standards, patents and other resources to accelerate industrial layout and seize the innovation high ground. Therefore, it is crucial to study the impact of standardization on the innovation performance of high-tech industries.

There are more studies on the factors influencing the innovation performance of high-tech industries, mainly including labour and capital input. However, with the development of information technology, many scholars gradually realize that standardization also plays a non-

negligible role in the innovation process of high-tech industries^[3]. The compatibility of standards and the nature of storing and disseminating innovative knowledge accelerate the process of innovation in high-tech industries. Because of this, this study intends to study the factors influencing standardization on the innovation performance of high-tech industries based on the relevant literature and to clarify the mechanism of the influence of standardization on the innovation performance of high-tech industries.

2. LITERATURE REVIEW AND HYPOTHESIS

The formulation of a standard often leads to adopting the same standard by different enterprises in the market. Therefore, the impact of product standards on market competition is determined by the formation of different participants in a network of many competitors^[4]. Standardization can improve the management level of enterprises, enable enterprises to learn, develop and innovate new technologies, form unified standards globally, achieve economies of scale, and reduce costs. Standardization has played a great role in the diffusion of technology, which can make technology spread and applications faster^[5]. Therefore, technical standards are the result of cooperation between government and business. In international economic cooperation, enterprises are the main producers of technical standards. The formation of technical standards requires the joint participation of the government, enterprises and other social subjects. Through policy incentives and regulations, enterprises can actively take standard technical actions to reduce costs and enhance competitiveness^[6]. According to the current market conditions, it is necessary to sort out the industry standards. Industry standards may include product design standards, product performance requirements and testing methods, after-sales service specifications, etc^[7].

Standardization promotes economies of scale in production, and when it becomes more standardized, companies make greater use of labor, land, and other natural resources to improve economic efficiency^[8]. In this process, enterprises can further reduce costs and gain more profits by simplifying standards. It is understood that after the implementation of the standards, there will be more enterprises through independent research and development and market feedback to continuously improve the production process, quality and other technical indicators so that it can meet consumer needs and customer requirements, promote enterprises to continue to improve the core competitiveness.

If standardization can promote industrial innovation, how should we analyze and understand this problem? Based on this, this paper puts forward the following hypothesis: standardization level has a positive impact on high-tech industry innovation performance.

3. STANDARDIZATION LEVEL MEASUREMENT

3.1. Measurement method

The degree of standardization should be measured in two dimensions: normal development and application. However, since it is difficult to quantify the degree of application of standards, this paper adopts the number of standards development to measure the degree of standardization. Therefore, this paper adopts the annual stock of standards in each industry of the high-tech industries to refer to the level of standardization., and the calculation formula should be:

$$\text{Current year standard stock} = \text{Prior Year Inventory} + \text{Release volume this year} - \text{Abandoned volume this year}$$

Since there are differences between the Chinese Standard Classification of Documents (CCS), Industry Standard Classification and High Technology Industry Classification, it is necessary to establish a mapping relationship between them to make the statistical caliber converge. See the table 1.

TABLE 1. MAPPING OF CHINESE HIGH TECHNOLOGY INDUSTRIES TO CHINESE STANDARD CLASSIFICATION

Industry Classification	China Standard Classification
Pharmaceutical Manufacturing(C1)	C05/C10、C11、C12、C13、C14、C15、C16、C17、C18、C19、C20、C21、C23、C24/C25、C27
Electronic and communication equipment manufacturing(C2)	M00/09、M10/29、M30/49、M90/99、M50/59、M60/69、M70/79、L00/09、L10/34、L35/39、L55/59、L40/49、L50/54
Electronic computer and office equipment manufacturing(C3)	L60/69、L90/94、L95/99
Medical equipment and instrumentation manufacturing(C4)	N30/39、N40/49、N50/59、N60/69、N70/79、N00/09、N10/19、N20/29、N90/99

3.2. Measurement method

The types of standards were selected as national standards, industry standards and local standards according to the mapping relationship between industry classification and Chinese standards classification, and the data were collected through the Chinese standards service website (<http://www.cssn.net.cn>). Table 2 shows the stock of standards in each industry as of 2019 and their changes during the study period.

From Table 2, the annual stock of standards in the sample industries of China's high-tech industries from 2010 to 2019 continued to increase, from 5,511 initially to 14,720 in 2019, an increase of 167%. This indicates that although standard documents are released and repealed every year, the number of releases is much larger than the number of repeals, and the growth trend of the standard stock remains unabated. It can be seen that the overall standardization of high-tech industries is in the growth stage

TABLE 2. HIGH-TECH INDUSTRY 2019 STANDARD STOCK AND INCREASE

Industry Code	Standardized stock in 2010	Standardized stock in 2019	Increase from 2010 to 2019
C1	143	1133	692%
C2	1910	4814	152%
C3	2095	5898	182%
C4	1363	2875	111%
Total	5511	14720	167%

4. EMPIRICAL ANALYSIS

4.1. Variable Selection

The model's explanatory variables are the innovation performance of high-tech industries, and the explanatory variables are the level of standardization. The control variables are enterprise size, R&D human capital, market competition, and fixed asset investment in high-tech industries. The specific variables are described as follows:

The revenue from the central business measures the scale of enterprises in high-tech industries (Scale). In the innovation process of the high technology industry, the larger the scale, the more likely the scale effect of innovation will occur, resulting in higher profits^[9].^②In this paper, R&D human capital (Researcher) is selected to represent the then amount of researchers in high technology industries. The creativity of R&D personnel and the characteristic of chasing the frontier of knowledge determine that they are an essential resource for innovation^[10].^③Market competition (Market), in this paper, is represented by the number of enterprises with R&D activities in high-tech industries. In the context of a market economy, the degree of competition in the market directly affects the innovation consciousness of enterprises and the allocation of innovation resources,

which has an impact on innovation performance^[11].^④Fixed asset investment (Fixed) innovation requires human and financial resources and material resources, including the purchase of various instruments and equipment that require financial expenditure; this paper measures the fixed asset investment in high-tech industries by the expenditure on technological transformation^[9].

4.2. Model Setting

This paper adopts multiple regression analysis to analyze the innovation performance of high-tech industries to measure the impact of standardization on the innovation performance of high-tech industries. The baseline regression model is:

$$\ln Innovation_{it} = \alpha + \beta \ln STA + \theta control + \varepsilon_{it}$$

where the explanatory variable Innovation is the innovation performance of high-tech industries; STA is the industry standardization level; control is the control variable; α , β , and θ are the coefficients to be estimated; and ε_{it} is the residual term.

4.3. Empirical studies

This paper uses Driscoll and Kraay robustness tests to correct for bias in serial correlation, heteroskedasticity, and cross-sectional correlation problems, and applies stepwise regression, as shown in Table 3. the econometric analyses in this paper were all implemented using Stata 16.0.

The regression results show that the impact coefficient of the level of standardization is significant in both the total sample and multiple types of industries, indicating to some extent that the level of standardization in high-tech industries has an essential impact on their innovation performance, and there is heterogeneity in different types of industries. In terms of the overall significance characteristics of the model, the R2 of the regression results by industry type lies between 0.762 and 0.951, indicating that both the full sample and the regression model by industry have good explanatory power. From the regression results, the impact of standardization on innovation performance of high-tech industries cannot be judged in a one-size-fits-all manner, but the heterogeneity of different types of industries should be fully considered.

TABLE 3. EMPIRICAL REGRESSION RESULTS

	Full sample	Pharmaceutical Manufacturing	Electronic and communication equipment manufacturing	Electronic computer and office equipment manufacturing	Medical equipment and instrumentation manufacturing
lnSTA	0.272*** (6.73)	0.234*** (7.63)	0.850** (2.31)	0.048 (0.32)	1.429*** (4.90)

InScale	1.086*** (12.64)	1.152*** (10.66)	0.810*** (3.53)	0.813** (2.80)	0.865*** (4.25)
InMarket	0.035 (0.29)	-0.591 (-1.52)	-0.303 (-0.79)	0.735** (2.22)	0.184 (0.83)
InResearcher	0.068** (2.11)	-0.017 (-0.24)	0.048 (0.94)	-0.033 (-0.54)	-0.007 (-0.10)
InFixed	0.012 (0.39)	0.044 (0.66)	-0.091 (-1.53)	0.080 (1.50)	0.360** (2.33)
Constant	1.967*** (7.57)	4.072*** (3.52)	3.200*** (3.40)	1.863** (2.77)	-2.957* (-2.06)
R²	0.844	0.970	0.806	0.860	0.966

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.3.1. Pharmaceutical Manufacturing

Compared to developed countries, China's overall level of medical development is still a gap; most of the primary drug manufacturing and the overall research and development capabilities are relatively weak. Moreover, its main innovative output is new pharmaceutical products, which require a significant initial investment and long R&D time, and the willingness of enterprises to innovate is relatively low. However, the development of standards will promote innovation performance to a certain extent; due to the industry's high risk of R&D and intellectual property regulation to be improved, standardization may make the overall R&D threshold of the industry higher. Hence, the promotion of innovation by standardization in the pharmaceutical industry is less than the total sample.

4.3.2. Electronic and communication equipment manufacturing.

The electronics and communication equipment manufacturing industry is the leading industry in China's high technology field, which is relatively mature and can lead to the further development of the high technology industry. Since standardization does not interfere with the business activities outside of R&D, it can reduce the risk perception of enterprises and increase their willingness to invest in R&D activities while compensating for the lack of R&D capital investment. Therefore, the coefficient of standardization is significantly positive in the results of this industry data.

4.3.3. Electronic computer and office equipment manufacturing

Market factors greatly influence the development of the electronic computer and office equipment manufacturing industry, and the demand for technological leadership is significantly differentiated. Compared to the other three industries, the industry has an intense product penetration and a strong differentiation of R&D thresholds for different positioning products. Influenced by product characteristics, although standardization similarly signals to society that the industry has strong R&D capabilities,

the effect of the signal is limited relative to the impact of an unsaturated competitive market environment. Therefore, the effect of standardization on the positive impact of innovation performance in this industry is not significant.

4.3.4. medical equipment and instrumentation manufacturing

The medical equipment and instrumentation manufacturing industry has a high technical threshold. Although the domestic development cycle is relatively short, based on a large number of absorption and digestion of foreign technology, the industry has been developing rapidly. The industry is dependent on innovation and has a strong willingness for R&D activities guided by the motivation to pursue market dominance and does not inhibit its innovation by setting standards, which is a direct positive effect of standardization on innovation performance. Concerning indirect effects, standardization is, to some extent, a symbol of an industry's innovative capacity, and a high degree of standardization sends a signal to the outside world that the industry has a high level of innovative activities and good development prospects and is, therefore, able to attract more social capital. Due to the combination of both direct and indirect positive effects, the standardized coefficients in the results of this industry data are positive and highly significant.

5. SUMMARY AND INSIGHTS

This paper examines the impact of the level of standardization on innovation performance in high-tech industries and the heterogeneity of the impact across 13 sub-industries, using sample data from 2010 to 2019 in China's high-tech industries. The study can draw the following conclusions:

There are industry differences in the impact of standardization on the innovation performance of high-tech industries, and it has an enhancing effect on the innovation performance of medical equipment, instrumentation manufacturing and electronic and communication equipment manufacturing; The positive contribution of standardization to the innovation performance of pharmaceutical manufacturing and

electronic computer and office equipment manufacturing was not significant.

Based on the above research findings, under the goal of building a world power in science and technology, this paper proposes three policy insights.

(1) Strengthen standardization according to industry characteristics to enhance the overall innovation performance level. The innovation performance of high-tech industries is an essential manifestation of the country's technological competitiveness. According to the data results, the impact of standardization on innovation performance varies according to industry characteristics, and standardization can effectively improve the innovation performance of industries such as pharmaceutical manufacturing. In contrast, the current standardization level of such industries is relatively low. Therefore, government departments must strengthen standardization according to industry characteristics.

(2) Government should adjust the level of standardization based on actual performance. Standards are not only an essential guarantee of competitive advantage for the industry but also have the property of public goods. Under the condition of limited economic resources, government departments need to readjust the financial support for some industries according to the actual effect of standardization to improve the efficiency of public funds. They have reduced interest rates on loans for companies with high innovation performance, cash incentives for companies with significant innovation contributions, and increased no-cost subsidies for investment in the industry.

(3) Optimize support methods for innovation performance and stimulate social capital to invest in R&D. The specific approaches are: ① Select the appropriate support method and intensity according to the actual needs of basic R&D. ② Pay attention to the problems of raising the price of R&D factors and constraining the allocation of enterprise resources caused by the involvement of government funds. ③ Improve relevant supporting mechanisms with demand orientation to ensure that market mechanisms can play a fundamental role in allocating R&D factors.

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REFERENCES

- [1] BELOBRAGIN V Y, BURIY A S, GERASIMOV B I, et al. Harmonization of standardization documents as a key element of the innovation process [J]. *Svarochnoe proizvodstvo*, 2020, 4): 48-54.
- [2] BUDKIN Y V, DOKUKIN A V, KVASNITSKIY V N, et al. Current state and prospects of the new production technologies standardization in machine building [J]. *Svarochnoe proizvodstvo*, 2020, 2): 46-50.
- [3] HOON C S. Recent Trend of International Standardization for MEMS Devices and Technology [J]. *Journal of Standards, Certification and Safety*, 2020, 10(3): 1-15.
- [4] KIM J, NOH Y. A Study on the Need for Standardization of Beauty Industry [J]. *Journal of The Korean Society of cosmetology*, 2020, 26(4): 941-51.
- [5] LEE J-W. Assessment of Standardization Capability of ICT [J]. *Journal of Korean Institute of Information Technology*, 2016, 14(2): 135-42.
- [6] NOVICHENKO I. Standards and Society: to the Question of the History of Standardization [J]. *Novaya i noveishaya istoriya*, 2018, 5): 171-80.
- [7] PUGACHEV S. THE WORK OF TECHNICAL COMMITTEES FOR STANDARDIZATION: PROBLEMS AND SOLUTIONS [J]. *Standarty i kachestvo*, 2020, 10): 26-31.
- [8] SHALAEV A P, VELMOZHINA E S, KALASHNIKOVA M A. THE NATIONAL STANDARDIZATION PROGRAM AS A KEY TOOL FOR SHORT- AND MID-TERM PLANNING OF STANDARDIZATION WORKS [J]. *Standarty i kachestvo*, 2020, 12): 10-5.
- [9] TAE-KYUNG S, KEUN P S. The Determinants of Standardization Activity at the Industry Level in Korea [J]. *Journal of Standards, Certification and Safety*, 2020, 10(3): 39-57.
- [10] TSARICHENKO S G, ANTOKHIN E A, CHERNOVA P D, et al. The state and problems of standardization and unification of military ground robot systems [J]. *Robotics and Technical Cybernetics*, 2020, 8(1): 18-23.
- [11] 임현경. A best practice study and suggestions for the standardization of public-sector terminology in Korea [J]. *Interpretation and Translation*, 2015, 17(2): 27-49.

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