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Research on the Influence Mechanism of Enterprise Industrial Internet Standardization on Digital Innovation

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Abstract: In the era of the digital economy, with the digital and intelligent transformation of the industry, technical complexity, and higher demand for the inter-operability of Industrial Internet platforms, standardization work faces challenges of timeliness and high quality. So, enterprises must improve the quality and efficiency of their digital innovation capabilities in the dynamic process of Industrial Internet standardization. Given this condition, based on the digital innovation theory, standardization theory, and social network theory, this paper takes 387 A-share-listed enterprises in the field of Industrial Internet industry as the research object and uses the secondhand cross-sectional data to carry out the research on the influence mechanism of enterprise Industrial Internet standardization on the digital innovation capabilities of enterprises. The results show that: enterprise Industrial Internet standardization exerts a positive influence on the digital innovation capability of enterprises; a standard alliance network in the enterprise Industrial Internet standardization plays an intermediary role in the digital innovation capability of enterprises; and the scale of enterprises has a positive moderating effect on the intermediary role of a standard alliance network between the enterprise Industrial Internet standardization and the digital innovation capability of enterprises. From the perspective of the alliance network effect, the research explores the economic consequences of standardization construction and enriches the appraisal of the standardization capability of enterprises for the purpose of providing targeted empirical evidence and practical strategies for the standard-based digital innovation of Industrial Internet enterprises.

Keywords: Industrial Internet standardization; digital innovation; standard alliance network; enterprise scale

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1. Introduction

The Outline of National Standardization Development issued by the CPC Central Committee and the State Council defines the critical role of standardization in supporting industrial development, promoting scientific and technological progress, and leading high-quality development [1]. The Action Plan for Implementing the Outline, jointly issued by the State Administration for Market Regulation and other departments, further emphasized that efforts should be made to strengthen the research and development of standards for the planning of the Industrial Internet and other new infrastructure. Standards have become a necessary technical basis for accelerating the high-quality development of Industrial Internet platforms. To better practice the National Program for Standardization Development, our country is actively promoting the standardization construction of the Industrial Internet, constantly optimizing the construction of a standardization system of the Industrial Internet and deepening the reform of the mechanism of digital resource allocation in factor markets. In the process of industrial transformation to intelligent digitalization, the complexity of technology and the requirements of Industrial Internet platform interoperability continue to improve, and the standardization work faces more challenges of timeliness and high-quality standards [2].

At the same time, due to the cross-domain integration of the organizational structure of the Industrial Internet platform network, a new and complex ecosystem is taking shape, and the embedding effect of standardization promoting digital innovation is constantly at play. Many scholars have discussed the impact of enterprise standardization capability on enterprise digital innovation from different perspectives. On the one hand, the standardization capability of Industrial Internet enterprises can promote and guide the digital innovation of enterprises and enhance the research and development capability of enterprises through the social network effect of integrating into the industry-leading technology network so as to enhance the digital innovation capability of enterprises [3–5]. On the other hand, strengthening the ability to keep up with technology research and development and standards in the industry provides opportunities for enterprises to get exposed to each other's knowledge, improve learning efficiency, and enhance the enterprise's digital resource allocation ability, which is of great significance for improving the innovation efficiency of enterprises and promoting high-quality development of enterprises [6–8].

The steady development of the Industrial Internet will usher in a new era of the digital economy. Digital innovation, as a new innovation paradigm of the digital economy era, has gradually attracted the extensive attention of scholars at home and abroad and thus caused a research boom. Different scholars adopt varied perspectives on research. Generally speaking, the related research focuses on digital innovation connotation [9–16], digital innovation characteristics [17–20], digital innovation type [11,15], digital innovation elements [21–23], and digital innovation measures [24–28]. According to the literature review, there are few scholars who study digital innovation from the perspective of standardization. Standardization plays a positive supporting role in the rapid and effective transformation of digital scientific and technological achievements and the development of the digital economy, and it is essential for enterprises to accelerate digital transformation and intelligent upgrades. Further, for the emerging digital industry, especially the Industrial Internet, which has just emerged in the past two years, the academic community's targeted research on the impact mechanism between Industrial Internet standardization and digital innovation still needs to be further promoted.

Therefore, this paper focuses on the mutual influence between the standardization of the Industrial Internet by enterprises and their digital innovation capabilities. We should recognize the immediate problems and challenges faced by the standardization of the Industrial Internet by enterprises and their digital innovation capability, too. Currently, enterprises need to strengthen the dominant position of standardization in the process of promoting digital innovation, enhance their ability to formulate, implement and promote the standardization of the Industrial Internet by enterprises, integrate the Industrial Internet standard alliance with existing technology alliances, and address the disparity between the standardization of the Industrial Internet and digital innovation development. To sum up, this paper will analyze the internal mechanisms of the standardization of the Industrial Internet, which affect the digital innovation capability of enterprises, clarify the essential elements promoting the integration of the standardization of the Industrial Internet and digital innovation, and then establish a set of high-quality standards for the Industrial Internet. Through "plugging leaks and enhancing efficiency," the standardization of the Industrial Internet will play a supporting and leading role in the high-quality development of digital innovation.

Therefore, this paper focuses on the following three key issues: (1) Whether enterprise Industrial Internet standardization affects the digital innovation capability of enterprises? (2) How does the standardization of the enterprise Industrial Internet affect the enterprise's digital innovation capability through the intermediary role of the standard alliance network? (3) Does the enterprise scale play a regulatory role in the influence of Industrial Internet standardization on enterprise digital innovation through the standard alliance network? In order to seal the gap left by the above-mentioned research, this paper carries out research on the influence mechanism between enterprise Industrial Internet standardization and enterprise digital innovation, based on digital innovation theory, standardization theory, and social network theory. In order to further enrich and improve the relevant research on the relationship between standardization and digital innovation and provide targeted empirical evidence and practical strategies for Industrial Internet enterprises to promote digital innovation through standardization.

The main contribution of this article is to explore the economic consequences of standardization capacity from the perspective of network effects. Secondly, from the perspective of standard text, we measured the whole process standardization capability of enterprises, which enriched the relevant research on standardization capability. Thirdly, we constructed a model of mesomeric effect with adjustment, which further clarified the complex relationship between enterprise scale and the standard alliance network for enterprise standardization capability and digital innovation. The remaining part of this article is arranged as follows: The second part will sort out existing literature and propose research hypotheses based on theoretical analysis; the third part introduces sample data and econometric models; the fourth part is the empirical analysis results; and the final part is the conclusion and discussion.

2. Literature Review

2.1. The Impact of Enterprise Industrial Internet Standardization on Digital Innovation

The standardization of the Industrial Internet by enterprises refers to the dynamic process by which Industrial Internet enterprises formulate, implement, and promote standards related to Industrial Internet in their respective fields according to their own needs. For the development of Internet technology, standards have been highly respected by the whole industry. Standardization is the premise and foundation of the large-scale commercialization of new technologies and applications. As an important carrier for patent sharing and application promotion, the industrial technology standard alliance has increasingly become the main organization pattern for technology standardization around the world [29]. The Internet of Things and digital platforms are sustainable digital innovations that enable enterprises to gain advantages in a fiercely competitive digital environment [30]. Today, with the acceleration and deepening of digital transformation, the standardization of the Industrial Internet has become the "connector" and "accelerator" of the digital transformation of enterprises, as well as the "vanguard" of the implementation of digital network governance. The standardization of the Industrial Internet of enterprises is essential for enterprises to accelerate the process of digital transformation and intellectual upgrading.

According to the theory of social networks and the existing literature, strengthening the construction of the Industrial Internet may promote the digital innovation ability of enterprises. First of all, the standardization capability of Industrial Internet enterprises can promote and guide the digital innovation of enterprises and enhance the research and development capability of enterprises through the social network effect embedded in the industry-leading technology network so as to enhance the digital innovation capability of enterprises. You (2021) and Qu et al. (2021) believed that the "new infrastructure" of the digital economy must meet international standards on the supply side [31], By realizing the transition from the parallel development of the digital economy and standardization to the mode of standardization leading the digital economy, enterprises can seize the "commanding heights" of standardization on the supply side and empower the new development driving force of the digital economy on the supply side [32].

Secondly, through standardization construction, Industrial Internet enterprises can strengthen their ability to combine technology R&D with standardization within the industry, providing opportunities for enterprises to contact each other's knowledge and effectively improving learning efficiency. Li (2021) studied and pointed out barriers and blocking points in the standardization construction process of the Industrial Internet, such as delayed updating of the standard system, gaps in key technical standards, and imperfect standard systems [33,34]. When enterprises establish standard alliances with strategic partners and participate in the formulation of formal standards, it can help enterprises obtain more external resources, reduce the risk caused by standard competition locking [35,36], and improve the output level of digital innovation. Based on the above, this paper believes that the standardization of the construction of the enterprise Industrial Internet can promote the improvement of enterprise resource allocation efficiency and the realization of the innovation network effect so as to improve the overall digital innovation capability of enterprises. Based on this, this paper proposes the main research hypothesis H1.

H1: *Enterprise Industrial Internet standardization has a positive impact on enterprise digital innovation.*

2.2. The Intermediary Role of the Standard Alliance Network

A standard alliance network refers to the collection of enterprises establishing formal cooperation relations based on a common goal for the purpose of realizing resource sharing, technological breakthroughs, intellectual property, and benefit distribution in the process of standard research and development, formulation, implementation, and diffusion [37]. Wang et al. (2020) pointed out that the emergence of the standard alliance shows the power of voluntary technical standards in the market. Still, in fact, it is an important change in the globally standardized governance system [38]. Zhang et al. (2018) proposed that the technical standard alliance should promote the improvement of industrial economic benefits by promoting the formulation, revision, promotion, and industrialization of technical standards [39]. Technical standards constructed by technical standard alliances can promote industrial innovation. As an important technical carrier of technical standardization and the driving force of industrial innovation, the technical standard alliance strengthens the mutually promoting relationship between technological standardization and industrial innovation and ultimately promotes the overall improvement of industrial economic benefits. Manders et al. (2016) and Wakke et al. (2016) pointed out that technical standards have a positive effect on the innovation performance of enterprises, and they are able to carry out standardization activities more smoothly by using the alliance network through research [40,41]. Gao (2020) believed that cooperation between enterprises and alliances could continuously improve standardization and innovation abilities through the standard alliance network and ultimately promote the accelerated improvement of innovation performance [37]. The research by Rice and Galvin (2006) showed that the standard alliance plays a role in the whole process of standardization [42]. At present, there are few academic papers on how the standard alliance network affects innovation performance. Zheng's research (2016) showed that the structure and relationship of innovation networks would promote the improvement of innovation performance [43]. Dai et al. (2017) proved that enterprises could improve their innovation performance through standard alliances [44]. BLIND (2013) showed that enterprises in the standard alliance could achieve higher performance than those outside the standard alliance [45]; Baum and others (2000) believed that the alliance has a strong positive effect on the innovation performance of enterprises and helps technology-based enterprises obtain the necessary resources for their development [46]; Anderson et al. (2002) and Hoffmann (2007) claimed that the rational use of the alliance network is not only conducive to the growth of enterprises but also plays a decisive role in the innovation performance of enterprises [47,48].

In the process of technology standardization, due to a lack of resources entailed in setting standards and spreading them, most enterprises seek strategic partners who can provide key resources through the establishment of cooperative relations. When enterprises establish standard alliances with strategic partners and participate in the formulation of official standards, it can help enterprises obtain more external resources and reduce the risks caused by standard competition locks. Combined with the above analysis, this paper believes that enterprises, through the collaboration between enterprises and alliances, obtain benefits for their own development of rich resources, and by enhancing their learning ability and improving their innovation ability, they constantly adapt to the dynamic environment change, thus expanding the scale of the standard alliance network. On the basis of the standard alliance network's optimization, standardization, and innovation abilities, enterprises improve their innovation performance to a large extent. In conclusion, this paper proposes the hypothesis that:

H2: *The standard alliance network plays a partial intermediary role between Industrial Internet standardization and enterprise digital innovation.*

H2a: *Enterprise Industrial Internet standardization has a positive impact on the standard alliance network.*

H2b: *Standard alliance networks will have a positive impact on the performance of enterprise digital innovation.*

2.3. The Regulating Effect of the Enterprise Scale

Through a literature review, it is found that although some scholars have studied enterprise scale as a moderating variable, only some scholars have incorporated enterprise scale into the research framework of standard alliance networks and the digital innovation abilities of enterprises. In addition, when enterprise scale is used as a moderating variable, domestic and foreign scholars have yet to reach an agreement on its effect. Domestic scholars tend to believe it has a negative moderating effect, while foreign scholars are more likely to think it exerts a positive moderating effect. Cui (2022) studied enterprise size as a regulatory variable, and they believed that it could have a positive regulatory effect on the relationship between high-value patents and enterprise technology standardization ability [49]. This paper also believes that enterprise scale can have a positive regulatory effect on the relationship between the standard alliance network and the digital innovation capability of enterprises. First of all, in 1912, Schumpeter proposed that the innovation advantages of larger enterprises were more prominent, which was the first time that the relationship between enterprise size and innovation was mentioned in the "Schumpeter hypothesis". Additionally, from the previous research, large-scale enterprises are in a favorable position [50–52]. In terms of their visualization degree and market control power, it is easy for them to generate resource benefits and improve market benefits, and they have the ability to carry out innovative activities in many fields [53]. Sun (2014) showed that most enterprises could improve their input-output ratio by expanding their scale [54]. Zhang (2016) pointed out that the enterprise scale has a significant positive correlation with the economic performance of the enterprise [55]. Ling (2012) proposed that expanding their own scale would be beneficial to strategic emerging industries to improve their operating performance [56]. Secondly, the foreign scholar Blind et al. (2013) showed that the fixed cost of investment would affect standardization. In general, larger enterprises tend to be more competitive [45] because, compared with smaller enterprises, large enterprises have rich resources in all aspects and have access to information more quickly and timely, thus making them more likely to participate in standardization and get a dominant position in the process of standardization. At the same time, Lv Tie (2005) pointed out in his research that technology standards are a crucial strategic tool in the competition of the high-tech industry, and the establishment of a technology standard alliance is the core issue of the standardization strategy of the Chinese high-tech industry [57]. Standard alliances are an important way for enterprises to participate in the competition of industry standards. Leading enterprises in the industry often form alliances around core technologies to establish industry standards jointly, namely, the establishment of standard alliances to disperse standardization risks, create "first mover" advantages, restrict the development of competitors, and enjoy other advantages.

The larger the enterprise scale is, the more resources it will be able to procure to some extent, and it tends to have substantial social relations of high quality. Such enterprises usually have technology research and development institutions as well as special standardization organizations, all of which contribute to strong comprehensive strength, so they have a stronger willingness to join the standard alliance and share within the alliance the development of technology standards and paradigms, in order to get more benefits [53].

Keil (2002) also mentioned in the research that enterprises with strong comprehensive strength usually dominate the technical standard alliance in the direction of standard development [54]. Through cooperation with other enterprises, they will gain a foothold in the market and gradually develop a competitive advantage within the field. Afterward, they continue to attract more members into the standard alliance, and while stabilizing standard alliance operation and development, they improve their comprehensive strength. In summary, this article proposes the following assumptions:

H3: *Enterprise scale plays a regulating role between Industrial Internet standardization and enterprise digital innovation.*

H4: *Enterprise scale has a positive regulatory effect on the intermediary role of standard alliance network between Industrial Internet standardization and enterprise digital innovation.*

Based on the above theoretical derivation, the theoretical hypothesis of this study can be integrated into a moderated mediation model, as shown in Figure 1.

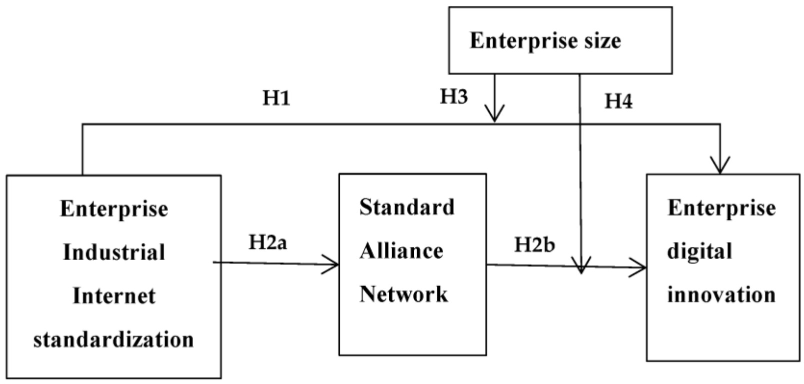

Figure 1. Research theoretical model.

3. Data and Methodology

3.1. Data Source

This paper takes 438 A-share listed companies that have participated in the formulation of China's Industrial Internet standards by 2021 as the research objects. The empirical data comes from Guotai'an Database, the annual report of listed companies, the national standard information public service platform, the national group standard information platform, the standard global search, the China Standard Service network, etc. Follow the following logic to check and delete the data for listed companies: (1) excluding ST and *ST enterprise samples; (2) excluding enterprise samples with incomplete or missing information; (3) excluding enterprise samples with evident abnormal values; (4) supplementing the missing main financial indicators with the company's annual report, 1% of the censored samples were tailed, and all of the censored samples went through Z-Score normalization prior to hierarchical regression. Finally, this study involves 387 Industrial Internet listed companies' standardization capability observation data.

3.2. Variable Measurement

3.2.1. Dependent Variables

This paper uses the entropy value of enterprise digital transformation and enterprise innovation performance as the measurement index of enterprise digital innovation. First of all, for the measurement of the degree of digital transformation, we studied and learned from Wu Fei's (2021) [58] and Yuan Chun's (2021) [59] practices, and with the help of the annual reports of listed companies, we used text analysis methods to summarize the sum of the frequency of the five corresponding segmentation indicators in the annual reports of enterprises, such as artificial intelligence technology, blockchain technology, cloud computing technology, big data technology, and digital technology applications, to grade the digital transformation. Secondly, considering the time lag in patent authorization, most scholars currently use the number of patent applications to measure the performance of enterprise technology innovation. Therefore, this article will also use the number of patent applications as an indicator to measure the performance of enterprise technology innovation. Finally, the entropy method is used to calculate the degree of digital transformation and the number of patent applications for non-negative standardization and calculate the weight of the two indicators. Enterprise digital innovation (EDI) is the weighted sum of the non-negative standardization value Tij and its corresponding weight of two indicators, including the degree of digital transformation and the number of patent applications, and the final value is treated logarithmically.

3.2.2. Independent Variables

Enterprise standardization capacity building is a systematic process, and it is highly challenging to accurately characterize the level of standardization capacity building throughout the entire lifecycle. Zeng et al. (2015) characterized the enterprise's technology standardization ability as a qualitative and quantitative indicator system that combines technical advantages, standard formulation ability, and standard promotion ability [60]. Some scholars proposed their own standardization lifecycle model, which includes stages such as standard preparation, development, product development, execution, use, and feedback. However, due to the difficulty in obtaining many indicators, the vast majority of existing empirical research is conducted from the perspective of the achievements of enterprise standardization capacity construction, only measuring the technical standardization ability of enterprises based on the number of technical standards the companies drafted, edited, or participated in [5,61–64]. Therefore, it significantly affects the accuracy and completeness of enterprise standardization capability measurement and cannot accurately reflect the overall picture of enterprise standardization.

In the few pieces of literature that measure the standardization ability of enterprises with a full process approach, most of them divide the measurement indicators of enterprise technology standardization into two aspects: the work process of enterprise technology standardization and the output of technology standardization through questionnaire surveys and set items for measurement separately [39,65–67]. It has a certain degree of scientificity, but the questionnaire survey data itself has a limited sample size and low representativeness. Another group of scholars conducted research from a qualitative perspective, such as Jiang et al. (2018), who defined the characteristics of the development, implementation, and promotion periods of enterprise technology standardization from the perspective of knowledge management in different stages of knowledge innovation [8]. They also used Huawei's case study to reveal the synergistic mechanisms between enterprise technology standardization and knowledge management. Unlike the previous research literature, this paper decomposes the standardization ability of enterprises into standard setting ability, standard implementation ability, and standard promotion ability. Additionally, with the help of Industrial Internet related text analysis and the characteristics of standards formulated by enterprises, we hope to build a more comprehensive indicator system that reflects the whole process standardization capability of Industrial Internet enterprises and, in the meantime, has high operability.

Firstly, the measurement of standard-setting ability is widely believed in existing research that the number of formal standards drafted by enterprises is a measure of ability to influence the behavior of other enterprises and promote their own technology into industrial standards, which can effectively reflect their technical standardization ability. At the same time, if a company gets involved in standard setting longer, its technical influence in the industry continues to increase as the established standards continue to spread. Therefore, we use three aspects, namely, the number of standards drafted by enterprises as the central unit, the number of standards drafted by enterprises as participants, and the duration of participation in the standard formulation, as measurement indicators of the standardization capability of Industrial Internet enterprises.

Secondly, the measurement of standard implementation capability, because of their complexity, dynamics, and speed of technological progress, Industrial Internet enterprises have posed multiple challenges to traditional standardization. Moreover, they need to provide standards in a timely manner, their agility is crucial for the smooth implementation of standards [6]. The implementation of standards generally refers to the whole process in which enterprises develop corresponding standard commercial products to participate in market competition after the initial formation of technical standard text to promote the process of rapid implementation of technological standardization [8]. The more other leading standards are referenced in a standard and the higher the level of standard formulation, the higher the correlation between the newly formulated standard and the current standard, and it will be more compatible with the original complementary assets of enterprises. At the same time, it saves the time and cost of improving technology, equipment, and manpower. Therefore, the detailed degree of the standard text also improves the operability of the standard application. The speed at which enterprises produce standard commercial products will also be correspondingly increased so that it is easier to shorten the implementation cycle of standards and help enterprises better obtain the initiative in market competition. Therefore, this paper uses the number of other standards adopted or quoted in the standards developed by enterprises, the standard type, the detailed degree of standard text catalog and the detailed degree of standard text as the measurement indicators of the standardization implementation ability of Industrial Internet enterprises.

Thirdly, measurement of the promotion of standards. With the realization of enterprise technology standardization, product, and service market competition is becoming increasingly fierce. Standards need "democratic legitimacy" to help other businesses accept and spread their application because standards are not only based on technical considerations but also always involve issues such as "commercial interests, political preferences, and ethical evaluation" [6]. Therefore, the diversified types and coverage width of the participants involved in the formulation of a technical standard directly affect the legitimacy of the standard and the realization of the commercial interests of the standard-making subject to ensure the better diffusion and promotion of a bar in the industry. Therefore, this paper uses the number of enterprises participating, the number of industry associations involved, and the richness of multiple subjects as measurement indicators of the standardization promotion ability of Industrial Internet enterprises.

Lastly, after the dates of the formulation, implementation, and promotion of Industrial Internet standards are obtained by the above steps, the weighted sum of the non-negative standardized value Tij of the three indicators of Industrial Internet standardization, namely the formulation, implementation, and promotion of standards, and the corresponding weights of each indicator are obtained by using the entropy value method. The final value is processed by a logarithm (see Table 1).

Table 1. Enterprise Industrial Internet standardization indicators.

Measure the Item	Measurement Index	Subdivision Index	Measuring Method
Enterprise and Industrial Internet standardization	Standard-setting capability	Main drafting	Enterprises as the main unit drafting standard number
		Participate in drafting	The number of standards drafted by enterprises as the participating units
		Duration of participation in standard development	2022-The earliest participation in setting the standard time
	Standard implementation capability	Number of bids/references	The average of the number of bids/references for all standards participated by the enterprise
		Standard type of bidding	(National standards, group standards, local standards, international standards, industry standards, and others)
		Standard text directory detail degree	Standard text directory list page number average
		Standard text detail degree four	The standard is the average value of this page number
	Standard promotion capability	Number of participating standard enterprises	Average value of the number of participating standard enterprises
		The number of participating industry associations	Average number of participating industry associations
		Multi-subject richness	Number of multivariate subject types + 1 (Enterprises, scientific research institutes, industry associations)

3.2.3. Control Variables

Drawing on previous research literature [62,63], this article includes a series of control variables in the model: the government support (GOVS), enterprise age (AGE), business performance (BP), the number of employees (EMPLOY), and four other variables identified as control variables. The government supports the measurement by using two indicators, such as capital subsidy and tax preference, and the comprehensive score is obtained by the entropy method, which then takes the logarithm. The age of the company is the total number of years until 2022. The operating performance is the logarithmic processing of the company's operating income at the end of 2021. The number of employees is measured by the number of employees insured by the enterprise.

3.2.4. Other Variables

The mediation variable is the standard alliance network (SAN). The standard alliance network includes two measurement indicators, including degree centrality and structural hole. The measurement method is to find the comprehensive score of degree centrality and structural hole by the entropy method to represent the standard alliance network.

The adjustment variable is enterprise scale (SIZE). According to Meng et al. (2019) [55], Gu et al. (2018) [56], Cui et al. (2022) [43], and others studies, the total assets of the company at the end of 2021 are processed logarithmically to measure the size of the enterprise (SIZE).

3.3. Model Design

To test the impact of enterprise Industrial Internet standardization on enterprise digital innovation and the path and adjustment of its role, the regression model of this paper is set as follows:

$$EDI_{it} = \alpha_0 + \alpha_1 EIIS_{it} + \alpha_2 C_{it} + \varepsilon_{it} \quad (1)$$

$$SAN_{it} = \alpha_0 + \alpha_1 EIIS_{it} + \alpha_2 C_{it} + \varepsilon_{it} \quad (2)$$

$$EDI_{it} = \alpha_0 + \alpha_1 SAN_{it} + \alpha_2 C_{it} + \varepsilon_{it} \quad (3)$$

$$EDI_{it} = \alpha_0 + \alpha_1 EIIS_{it} + \alpha_2 SAN_{it} + \alpha_2 C_{it} + \varepsilon_{it} \quad (4)$$

$$EDI_{it} = \alpha_0 + \alpha_1 EIIS_{it} + \alpha_2 SIZE_{it} + \alpha_3 (EIIS * SIZE)_{it} + \varepsilon_{it} \quad (5)$$

$$EDI_{it} = \alpha_0 + \alpha_1 EIIS_{it} + \alpha_2 SAN_{it} + \alpha_3 SIZE_{it} + \alpha_4 (EIIS * SIZE)_{it} + \varepsilon_{it} \quad (6)$$

In these: α represents the parameter values to be estimated for independent variables and control variables; C shows each control variable; ε_{it} represents the model error term; t is the year; and i is the sample enterprise. Formula (1) tests the impact of enterprise Industrial Internet standardization on enterprise digital innovation; Formula (2) tests the impact of enterprise Industrial Internet standardization on the standard alliance network; Formula (3) tests the impact of the standard alliance network on enterprise digital innovation; Formula (4) tests the intermediary role of the standard alliance network; Formula (5) tests the adjustment effect of enterprise scale; and Formula (6) tests the mediation effect of regulation.

4. Results and Discussions

4.1. Descriptive Statistical Analysis and Correlation Analysis

This paper uses SPSS 25.0 software to analyze the descriptive statistics and Pearson correlation of related variables. From the VIF results, the VIF values for all variables were distributed in the range of 1.085–5.367, significantly below the judgment criteria of 5 or 10. In general, the correlation coefficient and VIF values between EDI, EIIS, SAN, SIZE, G OVS, AGE, E MPLOY, BP are all at reasonable levels. The analysis of the included model will not cause serious collinearity problems. Due to the limited space, it needs to be more detailed here; see Table 2 for details.

Table 2. Descriptive statistics and correlation coefficients table.

Variable	Average Value	Standard Deviation	EDI	EIIS	SAN	SIZE	GOVS	AGE	EMPLOEY	BP	VIF
EDI	3.652	1.224	1								-
EIIS	1.889	0.556	0.151 ***	1							1.234
SAN	4.584	4.077	0.314 ***	0.344 ***	1						1.213
SIZE	22.58	1.508	0.144 ***	−0.050	0.158 ***	1					5.367
GOVS	17.578	1.744	0.231 ***	0.019	0.121 **	0.745 ***	1				2.493
AGE	3.002	0.29	−0.044	0.083	0.015	0.215 ***	0.126 **	1			1.085
EMPLOY	6.533	1.46	0.289 ***	−0.054	0.136 ***	0.342 ***	0.284 ***	0.164 ***	1		1.185
BP	21.894	1.549	0.248 ***	−0.106 **	0.138 ***	0.886 ***	0.735 ***	0.204 ***	0.360 ***	1	5.261

** $p < 0.05$ *** $p < 0.01$.

4.2. Multiple Linear Regression Analysis

According to the research hypothesis, six regression models are listed to verify the influence of enterprise Industrial Internet standardization on digital innovation, and the empirical data are detailed in Table 3. Model 1 tested the impact of enterprise Industrial Internet standardization on digital innovation. The regression coefficient value of EIIS was

0.194 (t = 4.032, p = 0.000 < 0.01), which meant that EIIS would have a significant positive impact on EDI. Model 2 tested the influence of enterprise Industrial Internet standardization on the standard alliance network, and the regression coefficient value of EIIS was 0.376 (t = 7.836, p = 0.000 < 0.01), which means that EIIS will have a significant positive effect on SAN. Model 3 tested the impact of the standard alliance network on digital innovation, and the regression coefficient value of SAN was 0.264 (t = 5.664, p = 0.000 < 0.01), meaning that SAN would have a significant positive impact on EDI. This result assumes that H1, H2, and H3 are verified. Model 4 incorporated the SAN variables on the basis of Model 1, showing the regression results of the effects of EIIS and SAN on EDI, The results showed significantly positive regression coefficients for EIIS, The regression results of the EIIS were significantly positive (β = 0.110) and 0.084 as compared with the EIIS regression coefficient in Model 1 (β = 0.194); therefore, after controlling for the SAN variables and the diminished influence of EIIS on EDI, it shows that the standard alliance network plays an intermediary role between enterprise Industrial Internet standardization and digital innovation. The hypothesis that H4 is verified.

Table 3. Model regression results of enterprise Industrial Internet standardization and digital innovation.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
GOVS	0.047 (0.688)	−0.044 (−0.635)	0.079 (1.163)	0.057 (0.828)	0.123 * (1.743)	0.121 * (1.742)
AGE	−0.142 *** (−2.924)	−0.067 (−1.383)	−0.113 ** (−2.391)	−0.127 *** (−2.673)	−0.124 *** (−2.650)	−0.116 ** (−2.533)
EMPLOY	0.247 *** (4.882)	0.114 ** (2.253)	0.214 *** (4.288)	0.222 *** (4.457)	0.254 *** (5.202)	0.235 *** (4.933)
BP	0.175 ** (2.389)	0.184 ** (2.516)	0.100 (1.417)	0.134 * (1.858)	0.492 *** (4.777)	0.515 *** (5.155)
EIIS	0.194 *** (4.032)	0.376 *** (7.836)		0.110 ** (2.174)	0.222 *** (4.749)	0.123 ** (2.543)
EDI						
SAN			0.264 *** (5.664)	0.223 *** (4.452)		0.188 *** (3.765)
SIZE					−0.421 *** (−4.062)	−0.514 *** (−5.136)
SAN × SIZE					0.149 *** (3.232)	0.147 *** (3.508)
R^2	0.161	0.164	0.193	0.203	0.224	0.273
adj-R^2	0.150	0.153	0.182	0.190	0.210	0.256
F	14.633	14.910	18.198	16.101	15.642	17.750

* p < 0.1 ** p < 0.05 *** p < 0.01 Table values are normalized coefficient, significance and (t value).

The Bootstrap test of the mediation effect of the standard alliance network was performed using the SPSS 25.0 software process plugin. At the level of a 95% confidence interval, the study sample was sampled 5000 times to obtain the confidence interval for the value of the product of the coefficients. See Table 4, and the confidence interval range does not include 0, so there is a mediation effect. To sum up, the standard alliance network plays a partial intermediary role in the impact of Industrial Internet standardization on enterprise digital innovation. Thus, confirming the hypothesis that the H4. Further, a confirmatory analysis of the above models using the Amos structural equation, $\chi^2/Df = 3.239$; GFI = 0.974; RMSEA = 0.076; RMR = 0.003; CFI = 0.970; NFI = 0.958; NNFI = 0.943; TLI = 0.943; AGFI = 0.933; IFI = 0.970; SRMR = 0.07, shows that all indicators meet the critical value for good model fit, and AIC, CAIC, and BIC, so that the hypothesis model is less than the independent model and less than the saturation model. This indicates that the model fit is good and acceptable.

Table 4. Results of Bootstrap mediation test for standard alliance networks.

Argument	Gross Effect c	a	b	a × b The Mediation Effect Value	Direct Effect c′	The 95% Confidence Interval a × b	Inspect the Conclusion
EIIS	0.194 ***	0.376 ***	0.223 ***	0.084	0.110 **	0.043~0.127	Part of the intermediary

** p < 0.05 *** p < 0.01.

Based on Model 3, Model 5 added SIZE, and the interaction term of SAN and SIZE, the results show that the regression coefficient of SAN × SIZE is significantly positive, indicating that enterprise size plays a positive role between standard alliance networks and digital innovation. According to Table 5, when the enterprise size is low, the impact of enterprise Industrial Internet standardization on enterprise digital innovation through the network mediation of standard alliances, the indirect effect was 0.016, and the lower and upper limits of the 95% confidence intervals are −0.052 and 0.071, respectively. The conditional indirect effect is significant; if the size level of the enterprise is high, The indirect impact of enterprise Industrial Internet standardization on enterprise digital innovation through the intermediary effect of the standard alliance network is 0.126. And 95% confidence intervals, with lower and upper limits of 0.072 and 0.198, respectively, This indicates that it has a mediating regulatory effect. At the same time, the influence of enterprise scale on enterprise digital innovation through the standard alliance network the adjustment index INDEX value of 0.055, the lower limit of the confidence interval of 95% is 0.018, and the upper limit is 0.113, so it has an intermediary regulation effect. Thus, assuming that both H5 and H6 are verified.

Table 5. Test of the mediation effect of enterprise size.

Condirect Effect of Condition					There is a Mediating Mediating Effect		
Metavariable	Regulated Variable	Mesomeric Effect	And the 95% Confidence Interval		INDEX	And the 95% Confidence Interval	
			Lower Limit	Superior Limit		Lower Limit	Superior Limit
Entrepreneurship performance	Low value High value	0.016 0.126	−0.052 0.072	0.071 0.198	0.055	0.018	0.113

4.3. Robustness Test

4.3.1. Replace Variables

Replace the moderating variable with government support, and the results are shown in Table 6. The regression coefficient value of EIIS in Model 1 was 0.215 (t = 4.613, $p = 0.000 < 0.01$), indicating that EIIS would have a significant positive influence on EDI.that is, hypothesis H1 was proved. In Model 2, the regression coefficient value of EIIS is 0.367 (t = 7.721, $p = 0.000 < 0.01$), indicating that EIIS will have a significant positive influence on SAN, which is proved by hypothesis H2. In Model 3, the regression coefficient value of SAN was 0.279 (t = 6.090, $p = 0.000 < 0.01$), indicating that SAN would have a significant positive influence on EDI; that is, H3 was proved. After the standard alliance network variable is added to Model 4, the regression coefficient of Industrial Internet standardization on enterprise digital innovation decreases. According to the regression results, the standard alliance network plays a partial mediating role between Industrial Internet standardization and enterprise digital innovation, and the hypothesis H4 in this paper is confirmed. When it comes to the influence of Industrial Internet standardization on enterprise digital innovation, the influence amplitude of the regulating variable enterprise size is significantly different at different levels, and the mediating effect is inconsistent at different levels, indicating that it has a mediating effect. H5 and H6 are assumed to be proven.

4.3.2. Sub-Sample Regression

Three hundred eighty-seven enterprises were divided into two subsamples: 152 manufacturing enterprises were classified as sample 1, and in addition, 235 enterprises in other industries were classified as sample 2. Then the two subsamples were tested by hierarchical regression and robustness testing. The regression results are shown in Tables 7 and 8. The direction and significance level of the coefficients in the two samples are basically the same as the original hypothesis, so the original hypothesis is still valid in the sub-sample regression.

Table 6. Results of replacement variable regression (adjustment variables were government support).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
EIIS	0.215 *** (4.613)	0.367 *** (7.721)		0.131 *** (2.669)	0.159 *** (3.219)	0.120 ** (2.498)
EDI						
SAN			0.279 *** (6.090)	0.231 *** (4.726)		0.189 *** (3.858)
GOVS					0.229 *** (4.669)	0.158 ** (2.318)
EIIS × GOVS					0.087 * (1.759)	0.179 *** (4.240)
R^2	0.195	0.164	0.225	0.239	0.082	0.283
adj-R^2	0.184	0.154	0.215	0.227	0.075	0.266
F	18.424	15.000	22.142	19.936	11.435	18.694

* $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$ Table values are normalized coefficient, significance and (t value).

Table 7. Results of subsample-model regression.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
GOVS	0.047 (0.668)	−0.044 (−0.635)	0.079 (1.163)	0.057 (0.828)	0.123 * (1.743)	0.121 * (1.742)
AGE	−0.142 *** (−2.924)	−0.067 (−1.383)	−0.113 ** (−2.391)	−0.127 *** (−2.673)	−0.124 *** (−2.650)	−0.116 ** (−2.533)
EMPLOY	0.247 *** (4.882)	0.114 ** (2.253)	0.214 *** (4.288)	0.222 *** (4.457)	0.254 *** (5.202)	0.235 *** (4.933)
BP	0.175 ** (2.389)	0.184 ** (2.516)	0.100 (1.417)	0.134 * (1.858)	0.492 *** (4.777)	0.515 *** (5.155)
EIIS	0.194 *** (4.032)	0.376 *** (7.836)		0.110 ** (2.174)	0.222 *** (4.749)	0.123 ** (2.543)
EDI						
SAN			0.264 *** (5.643)	0.223 *** (4.452)		0.188 *** (3.765)
SIZE					−0.421 *** (−4.062)	−0.514 *** (5.136)
SAN × SIZE					0.149 *** (3.232)	0.147 *** (3.508)
R^2	0.161	0.164	0.193	0.203	0.224	0.273
adj-R^2	0.150	0.153	0.182	0.190	0.210	0.256
F	14.633	14.910	18.198	16.101	15.642	17.750

* $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$ Table values are normalized coefficient, significance and (t value).

Table 8. Results of subsample two-model regression.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
GOVS	−0.010 (−0.113)	0.022 (0.265)	0.007 (0.086)	−0.016 (−0.185)	0.097 (1.012)	0.086 (0.937)
AGE	−0.197 *** (−3.010)	−0.122 (−1.963)	−0.144 ** (−2.273)	−0.165 ** (−2.573)	−0.170 *** (−2.671)	−0.146 ** (−2.365)
EMPLOY	0.124 * (1.842)	0.095 ** (1.487)	0.088 (1.337)	0.099 (1.506)	0.170 ** (2.585)	0.145 ** (2.292)
BP	0.113 (1.219)	0.146 ** (1.663)	0.034 (0.386)	0.074 (0.821)	0.460 *** (3.405)	0.469 *** (3.596)
EIIS	0.229 *** (3.489)	0.409 *** (8.582)		0.120 * (1.735)	0.288 *** (4.380)	0.138 ** (2.077)
EDI						
SAN			0.312 *** (5.008)	0.265 *** (3.921)		0.215 *** (3.204)
SIZE					−0.466 *** (−3.083)	−0.568 *** (−3.926)
SAN × SIZE					0.180 *** (2.787)	0.189 *** (3.155)
R^2	0.088	0.181	0.135	0.146	0.162	0.228
adj-R^2	0.068	0.163	0.116	0.123	0.136	0.197
F	4.437	10.142	7.126	6.492	6.265	8.321

* $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$ Table values are normalized coefficient, significance and (t value).

In this paper, sub-sample regression and alternative variables are used to test robustness, which makes the research results more convincing. The study finds that the standardization of enterprise Industrial Internet has a positive impact on enterprise digital innovation; the standardization of enterprise Industrial Internet has a positive effect on the standard alliance network; the standard alliance network will have a positive impact on enterprise digital innovation performance; and the standard alliance network plays a partial intermediary role between the standardization of enterprise Industrial Internet and enterprise digital innovation. Enterprise size plays a moderating role between the standard alliance network and enterprise Industrial Internet standardization, and enterprise size has a positive moderating effect on the mediating role of the standard alliance network between enterprise Industrial Internet standardization and enterprise digital innovation. All the hypotheses proposed in this paper have been verified.

5. Conclusions and Discussion

5.1. Research Conclusions

In recent years, with the rapid development of the digital economy and Industrial Internet worldwide, the standardization of enterprise Industrial Internet has followed the changes in the era of the digital economy, gradually improved the standard system, and analyzed and implemented the standardization needs. This paper takes 387 A-share listed companies in the field of Industrial Internet as the research object. Based on the analysis of the standard texts of the listed companies in the field of Industrial Internet, this paper uses secondary cross-sectional data and an empirical regression analysis method to explore the influence mechanism of enterprise Industrial Internet standardization on enterprise digital innovation. The main research conclusions are as follows:

Firstly, the research finds that the standardization of the enterprise Industrial Internet is helpful to promote enterprise digital innovation. From the perspective of social network theory, the data of the Industrial Internet industry is used to respond to Wang et al. (2022) [68]. A discussion on the mechanism and path of digital industry innovation promoted by standards and intellectual property. The rapid and steady development of the Industrial Internet is the crucial driving force for the digital innovation of enterprises, and standards are increasingly becoming a necessary technical basis for accelerating the high-quality development of the Industrial Internet. Standards determine the quality, and high-quality development needs correspondingly high standards of support.

Secondly, it is found that the standard alliance network plays a partial mediating role between enterprise Industrial Internet standardization and enterprise digital innovation. This paper responds to Blind's (2021) [69] discussion on the social network effect of Industrial Internet enterprise standardization ability embedding into industry-leading technology networks, further analyzes its economic consequences and finds that the construction of Industrial Internet standardization ability promotes the establishment of inter-enterprise standard alliance cooperation networks and enterprises' own innovation ability constantly adapts to environmental changes [56]. At the same time, the flow of knowledge and resources between network nodes is increased [70], breaking through the limitation of enterprises' own resources [71] so as to promote the development of enterprises' digital innovation.

Finally, it is found that enterprise size plays a positive moderating role in the influence of standard alliance networks and enterprise digital innovation. In response to Sun et al.'s (2014) study on the impact of firm size on productivity and its differences [42], it was found that with the increase of enterprise scale, there is a stronger internal willingness to set up a specialized standardization organization and join the standard alliance to share the technical standards and paradigms of their own research and development. Through the establishment of cooperative relations with other enterprises and the gradual development of core competitive advantages in the industry, comprehensive strength can be improved while the operation and development of standard alliances are stabilized [45].

5.2. Management Enlightenment

This paper puts forward the following suggestions on how to promote enterprise digital innovation and development through enterprise Industrial Internet standardization:

First, speed up the standardization of the Industrial Internet and enable the development of digital innovation in enterprises on a large scale. First, we will accelerate the introduction of standards and paths for the construction of fully connected factories under the 5G+ Industrial Internet initiative and promote digital innovation and the development of enterprises through Industrial Internet standardization. Second, accelerate the formulation, implementation, and promotion of key technical standards for "5G+ Industrial Internet", and expand the integration and expansion of technical scenarios. Third, we will strengthen the competitiveness of international standards for "5G+ Industrial Internet" and promote digital innovation and the development of enterprises on a large scale.

Secondly, explore a new model of Industrial Internet standard alliance to accurately promote enterprise digital innovation. The first is to explore standard alliance co-construction and sharing, reduce the cost of enterprise network construction and network use, and provide small and medium-sized enterprises with a new mode of cooperation of "use first, build later", or even "only use but not build." Second, organizations such as the Standard Alliance are encouraged to promote the docking of enterprise resources, promote standard certification and recognition, and facilitate SMES to access the Internet platform. Third, explore the establishment of a standard integration pilot demonstration, deepen the Industrial Internet standardization platform innovation, promote Industrial Internet standardization service industry cluster innovation, and precisely promote enterprise digital innovation development.

Finally, create an Industrial Internet standard innovation network ecology, and continue to promote enterprise digital innovation. First, establish a sound policy system to support Industrial Internet standardization. The second is to build an Industrial Internet standard innovation network combining intellectual property rights and standards to promote the connection and interaction of multiple subjects in the standardization process. Third, enterprises are encouraged to make full use of standardized process mechanisms to integrate vertical industry resources and promote solid and complementary industrial chains.

5.3. Limitations and Future Scope

Although this paper analyzes and verifies the enterprise Industrial Internet standardization and digital innovation relationship and mechanism, there are certain limitations: First, the standard text is not comprehensive, but if you want to try to find all the standard text related to Industrial Internet standardization, the workload is vast, so the research needs to solve this problem in order to make the analysis more convincing. Secondly, the index system constructed in this paper involves only some of the factors, and the way adopted will inevitably have some subjectivity and incomprehensibility. In the future, the relevant evaluation indicators should be improved. Finally, there are few sample enterprises in this paper, and the data and time span need to be expanded and extended. Therefore, the conclusion of the study will inevitably have some limitations.

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