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6

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

The impact of industrial internet on high quality development of the manufacturing industry

Liu Jianjiang¹, Zhang Zhiyue¹ and Fidelis Ayangbah^{1*}

Abstract: Comprehensive Development Index of industrial Internet from 2009 to 2018 of 31 provinces in China was obtained by using the entropy method for the article. This paper analyzes the impact of industrial Internet on high-quality development of China's manufacturing industry by building a fixed effect model, and also studies the intermediary role of intelligence and greening on this basis. The results indicate that, Industrial Internet has significantly promoted the high-quality development of China's manufacturing industry, of which intelligence and green play an intermediary role between the Industrial Internet and the high-quality development of the manufacturing industry, and the impact of industrial Internet on the development of manufacturing industry in the Eastern region is significantly higher than that in the Central and Western regions.

Subjects: Social Sciences; Development Studies; Development Studies; Environment & amp; the Developing World; Sustainable Development; Economics, Finance, Business & Industry; Business, Management and Accounting; Industry & Industrial Studies

Keywords: Industrial Internet; manufacturing; high quality development; intelligence; greening

1. Introduction

The concept of Industrial Internet has made great progress in both academic research and industrial applications since it's inception in 2012. Liu et al. (2021) defines Industrial Internet as the Internet for industry, providing a connection between people, data and machines but most importantly, it provides important infrastructure for manufacturing (Yongkui Liu et al., 2021). This have greatly improved the world's development speed and quality, of which the impact on the high-quality development of manufacturing industry is extensive and far-reaching. Under the unprecedented changes in the 21st century, the high-quality development of China's economy relies on the high-quality development of the manufacturing industry (Sansom & Shore, 2013; Sansom & Shore, 2013).

At present, China has become the world's largest manufacturing country; however, its far from being a manufacturing power in the world. The situation of large but not strong manufacturing industry and comprehensive but not excellent manufacturing industry has not fundamentally changed. China's basic capacity is still weak, as key technologies are being controlled by others. At the same time, Sino US trade frictions and the global spread of COVID-19 have made the field of "choking" increased and the risk of "chain breaking" gradually increase. With this huge limitation, China's high-quality development of the manufacturing industry still has a long way to go. The industrial Internet formed by the integration of industry and Internet system under the digital wave has supported the new generation of industrial revolution. While lengthening the industrial chain, forming the interconnection between cross-equipment systems and plant areas, and





improving efficiency, it has also promoted the integration and development of manufacturing industry and the efficient sharing of various resource elements (Guo Chaohui, 2020; Industrial Internet research group of Wuhan University, 2020; Xu Zhengjun & Yuan Yue, 2020). As a result, the high-quality development of China's manufacturing industry cannot be separated from the technical support of industrial Internet. The Chinese government work report released in 2021 mentioned "industrial Internet" for the fourth time, pointing out that the innovation and specialization level of small, medium, and micro enterprises can be improved by building a common technology, R&D platform to develop the industrial Internet, while accelerating the integration with intelligent manufacturing. This pronouncement demonstrates the importance China attaches to the development of high-quality manufacturing through the industrial Internet (Chen et al., 2018; Wenjing et al., 2019; Yong et al., 2020). Regardless, the current state of China's industrial structure still needs an extensive development due to its accumulating problems and contradictions such as excessive resource consumption, serious environmental damage and low economic quality. However, the task of achieving high-quality development of the manufacturing industry is imminent. The most recent proposal of the China's central government on formulating the fourteenth five year plan for national economic and social development and the long-term goals for 2035 emphasizes that the real economy will be the focus of China's economic development and will use it to promote the construction of a manufacturing power.

Drawing on the recent discussion of industrial Internet in the existing literature, it can be concluded that an industrial Internet is composed of network, platform and security. It is also important to grasp the opportunities provided as a result of the integrated development of digitalization, networking and intelligence, and take informatization, intelligence and green as the lever, and rely on the increasingly rich application scenarios of the industrial Internet from the perspective of structure and environment.

The research fields of many experts and scholars at home and abroad mainly focus on the following four aspects: first, to study the development of high-end equipment manufacturing industry in some parts of China (Bin, 2021; Song Haohao & Wang Ying, 2021); Second, analyze the impact of a country or region on the global manufacturing industry or the development of China's manufacturing industry (Xuanxuan, 2021; Zhao & Lina, 2021); Third, use econometric models to empirically test the development effect of manufacturing (Buturac et al., 2019; Cunbo et al., 2019; Ping & Yiming, 2020; Wang Liping & Li slowly, 2021); Fourth, promote the development of manufacturing industry by using the promotion role between different industries (Hua, 2019; Yuhan et al., 2020).

With reference to the existing literature, this paper adopts the intermediary effect model, on the basis of analyzing the impact of industrial Internet on the high-quality development of manufacturing industry, discusses the mechanism of industrial Internet on the high-quality development of manufacturing industry from the two dimensions of intelligent structure optimization and green environment improvement, and carries out heterogeneity analysis according to geographical division, comparing the regional differences of the role of industrial Internet in different regions in China. The researchers are using this approach a view of enhancing the ability of industrial Internet to serve the real economy and steadily promoting supply side structural reform. We will propose fundamental changes in the industrial model and enterprise form of the manufacturing industry, and pay close attention to the development differences of different regions to promote the transformation of new and old drivers of industrial development.

2. Theoretical analysis and research hypothesis

In order to seize the opportunity of the new industrial revolution, developed countries actively layout Industrial Internet, aiming to promote the innovation of production relations and production methods through the new generation of information technology. This will also help the industry to regain strong vitality and competitiveness and focus on accelerating the implementation of the industrial Internet from top-level design, innovative environment, promotion and application. With the maturity and application of intelligent technology, Internet, big data, cloud computing and 5 G new generation information technology, the manufacturing industry will become the main battlefield where the industrial Internet will play a high-quality development role in terms of intelligence and green.

2.1. Intelligent structure optimization

Intelligent structure optimization of manufacturing industry is a process to promote the development of rationalization and upgrading of manufacturing industry. It is also a state to realize the adaptation of manufacturing industry structure to resource supply structure, technology structure and demand structure (Aiying, 2022; Huadong Xiao, 2015; Wang et al., 2017). Traditional manufacturing is known as manufacturing industry that relies on a large number of labors or does not adopt and enter the traditional artificial intelligence (IM1.0) mode by adopting the non-intelligent manufacturing mode (Ligao et al., 2017; Rui & Jianwei, 2015); On the basis of the deep integration of the new generation of information technology and advanced manufacturing technology.

Intelligent manufacturing is a manufacturing industry with self-awareness, self-learning, selfdecision, self-execution, self adaptation and other functions in all aspects of manufacturing such as design, production, management and service (Jun et al., 2019; Liangyu, 2018). At present, the industrial Internet, as a product of the deep integration of the industrial system and the Internet system, promotes the intelligent development of the entire manufacturing service system by using big technology platforms, big data, cloud computing and other scientific and technological methods. It can promote the high-quality development of the manufacturing industry from the perspective of optimization of the manufacturing industry structure and develop the traditional manufacturing industry with most of the labor force and capital as the core elements into the Internet. The intelligent manufacturing industry with intelligent technologies such as big data as the core elements affects the high-quality development of the manufacturing industry through the supply structure and demand structure of the manufacturing industry. From the perspective of supply, the supply structure of the manufacturing industry promotes the optimization of the manufacturing industry structure by changing the supply structure of manufacturing elements. The original traditional manufacturing industry is dominated by low-end tangible products, supplemented by high-end intangible products, and takes the advanced manufacturing structure as the starting point. Through the industrial Internet, intelligent technologies such as computer-aided manufacturing, computer-aided design, networked collaborative design, and model knowledge base are used in intelligent design. In intelligent production, intelligent technologies such as flexible manufacturing system, distributed numerical control system and wireless sensor network are adopted, which has developed into an intelligent manufacturing industry based on large-scale, high-end and invisible. From the perspective of demand, the demand structure of the manufacturing industry promotes the optimization of the manufacturing industry structure by transforming demand consumption. The original traditional manufacturing industry mainly focuses on largescale and standardized product demand, and takes the rationalization of the manufacturing industry structure as the starting point, and adopts intelligent technologies such as production equipment performance prediction and maintenance, supply chain management, and external environment perception in intelligent management through the industrial Internet. In intelligent services, intelligent technologies such as computer networks, big data analysis and information technology are adopted, and today's intelligent manufacturing industry is dominated by personalized, small batch and diversified product needs.

Rostow, once proposed the theory of economic growth stages to study regional economic growth. He believed that a country's economic development process started from the traditional social stage, and went through the preparation stage, the take-off stage, the maturity stage, the mass consumption stage and the transcendence stage. Among them, production in the traditional social stage requires a large number of labor and capital, and the consumption level is low; In the mature stage, production depends on modern technology, and industry develops in a diversified way. The new leading sector gradually replaces the old leading sector. At present, the intelligence

of the industrial Internet has been widely used in many fields, such as intelligent manufacturing, smart home, smart city and intelligent medical care. This has become the main trend of current economic and social development (Makarova et al., 2018; Nenasheva et al., 2018). As the most representative technology of the fourth scientific and technological revolution, intelligent technology has a series of characteristics such as the extensive penetration of communication technology and the driving force of massive data. This will lead to technological progress, initiate the improvement of labor force and promote the intelligent development of manufacturing industry, and most importantly, give full play to the advantages of China's complete industrial system, and better support the construction of its manufacturing power.

To sum up, the industrial Internet can affect the high-quality development of the manufacturing industry through the supply structure and demand structure of the manufacturing industry from the perspective of the optimization of the manufacturing industry structure.

Based on the above analysis, this paper proposes hypothesis 1(H1).

H1: Industrial Internet promotes the high-quality development of China's manufacturing industry by intelligent optimization of the manufacturing industry structure.

2.2. Green environment improvement

The improvement of manufacturing environment is a process of coupling and optimizing the manufacturing system, natural system and social system in a specific region by using the organic cycle mechanism to eliminate the damage to the environment and achieve sustainable development (Donglan & Xinkuo, 2021; Xiaoguo & Tingting, 2019). Traditional manufacturing industry is a manufacturing industry that only cares about economic interests, focuses on economic development, and does not, or rarely considers environmental carrying capacity. The green manufacturing industry pays more attention to environmental protection and strives to save resources and reduce pollution with the help of science and technology (Nie Guoqing & Guo Xiaodong, 2018; Ronghui, 2017). At present, the industrial Internet is the product of the deep integration of the industrial system and the Internet system, and the Internet itself has a green attribute. Therefore, the industrial Internet promotes the high-quality development of the manufacturing industry from the perspective of the improvement of the manufacturing environment through greening, and develops the traditional manufacturing industry (which is dominated by extensive development and resource consumption), into a green manufacturing industry dominated by science and technology, and ecological protection. It also affects the high-quality development of the manufacturing industry through the manufacturing production process and the manufacturing production mode. From the perspective of production process, for the traditional manufacturing industry, its production process can be summarized as "manual analysis and decision-making-concentration of production factors -automation or semi automation"; For the green manufacturing industry, its production process can be summarized as "green analysis and decision-making—production factor network configuration-Green independent production". The traditional manufacturing industry, which used to focus on the concentration of production factors, high consumption and production costs, and relatively low resource and environmental efficiency, takes the optimal allocation of resources as the starting point, realizes the circular connection between the production system and the living system by adjusting the factor structure and energy structure through the industrial Internet, and develops it into the Internet green allocation of production factors today, reducing unnecessary factor inputs, and promotes green manufacturing with energy conservation, emission reduction and green development as the core. From the perspective of production mode, for traditional manufacturing industry, its production mode can be summarized as science and technology leading, resource saving and ecological protection. The traditional manufacturing industry, which originally focused on "developing the economy first and then governing the environment", takes sustainable development as the starting point, adheres to the requirements of ecological priority and green

development through the industrial Internet in terms of green development mode and green lifestyle, takes a new path of green civilization, and develops into a green manufacturing industry with the core of advocating economic development and environmental protection to achieve "win-win" and coordinated development.

As a discipline that studies the rational allocation of resources and the sustainable development of the environment, resource economics can be divided into gestation stage, production stage and development stage. Among them, the gestation stage includes the classicism stage and the neoclassicism stage, and its main contributions include the marginal utility theory of value and the theory of optimal allocation of resources; The development stage includes the crisis stage of resource shortage and the stage of sustainability, and the main contributions are as follows: the limit of growth and the last resource. At present, the greening of the industrial Internet has eliminated backward production capacity, resolved excess production capacity, minimized resource waste, reduced energy consumption and material consumption, and accelerated the development of low-carbon, clean and environmentally sound manufacturing. With the comprehensive green transformation of economic and social development as the guide and the low-carbon development of green energy as the key, we will accelerate the formation of the manufacturing structure, production mode, lifestyle and spatial pattern of resource conservation and environmental protection, and unswervingly follow the high-quality development path of ecological priority, green and low-carbon (Jiejun, 2021). Only by adhering to the concept of green development and forming a green development mode can we promote the high-quality development of the manufacturing industry, and achieve coordinated progress and win-win cooperation in economic and social development and ecological environment protection.

To sum up, the industrial Internet can affect the high-quality development of the manufacturing industry through the manufacturing production process and manufacturing production mode from the perspective of improving the manufacturing environment.

Based on the above analysis, this paper proposes hypothesis 2(H2).

H2: The industrial Internet uses the ecology of green and perfect manufacturing environment to promote the high-quality development of China's manufacturing industry.

Through the above theoretical analysis, the mechanism model of the Industrial Internet affecting the high-quality development of manufacturing industry is shown in Figure 1.



Figure 1. Mechanism of industrial internet affecting highquality development of the manufacturing industry.

3. Empirical test

3.1. Variable selection

3.1.1. Explained variables

With reference to Liu, et al. (2017), this paper adopts formula (3.1) to represent the development degree of the manufacturing industry, where η_i is the coefficient, and $DMI_{it}, LP_{it}, TFP_{it}, TPT_{it}, PMTA_{it}$ is the development degree of the manufacturing industry in region *i* in period *t*, labor productivity in region *i* in period *t*, total factor productivity in region *i* in period *t*, total profits and taxes in region *i* in period *t*, and profit margin on total assets in region *i* in period *t*.

$$DMI_{it} = \eta_i \begin{pmatrix} LP_{it} \\ TFP_{it} \\ TPT_{it} \\ PMTA_{it} \end{pmatrix}, \eta_i \ (i = 1, 2, 3, 4)$$

$$(3.1)$$

3.1.2. Explanatory variable

Drawing on the Industrial Internet development level indicator system of Guo Ruibing and Zhao Jun and the Internet embeddedness system of Yu hanpei (2014), this paper measures the Industrial Internet development level comprehensive index (ruibing & Jun, 2022) from the three dimensions of industrial Internet connectivity, sacrifice and matching, and selects the Industrial Internet comprehensive development index (IDI) as the explanatory variable, as shown in Table 1.

The researchers refer to the entropy weighting method used by Zhou Detian and Feng Chaocai to calculate the comprehensive development index of industrial Internet (Detian & chaocai, 2020). The steps are as follows: first, determine the attribute of the indicator and standardize the sub indicator data. See formula (3.2); Secondly, calculate the proportion of the *i*-th sample under the *j*-th index, and take it as the probability used in the calculation of relative entropy, see formula (3.3); Then, calculate the information entropy and information utility value of each indicator, see formula (3.4); Finally, the entropy weight of each index is obtained by normalization, as shown in formula (3.5). Through the above steps, the weight of each indicator in Table 1 is obtained, and the Industrial Internet comprehensive development index is obtained by weighted summation.

Table 1. Comprehensive development index of industrial Internet			
Index name	Sub index (Unit)	Weight (%)	
Contact Degree	Network News (%)	5.41	
	Search Engines (%)	4.79	
	Instant Messaging (%)	6.92	
Sacrifice	Network Music (%)	12.94	
	Network Game (%)	14.93	
	Online Shopping (%)	9.68	
	Online Payment (%)	11.52	
Matching Degree	Number of domain names (PCs.)	9.90	
	Number of Internet access ports ('0000)	8.66	
	Internet Penetration (%)	8.10	
	Total number of Internet users ('0000)	7.15	

$$\begin{cases} N: T_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} + 0.0001 \\ P: T_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})} + 0.0001 \end{cases}$$
(3.2)

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}}$$
(3.3)

$$\begin{cases} E_j = -\frac{1}{LN(n)} \sum_{i=1}^n \left[P_{ij} \times LN(P_{ij}) \right], 0 \le E_j \le 1 \\ D_j = 1 - E_j \end{cases}$$

$$(3.4)$$

$$\omega_{j} = \frac{\mathsf{D}_{j}}{\sum_{i=1}^{\mathsf{n}}\mathsf{D}_{j}} \tag{3.5}$$

3.1.3. Mediating variable

The first is Intelligence (Intel). At present, intelligence is usually measured from whether the equipment application is perfect, whether the scientific research investment is sufficient, and whether there are many patent applications. This paper refers to the practice of Huang Jianbin et al. (2022), and measures the degree of intelligence based on the number of patent applications authorized (Jianbin et al., 2022).

The second is Green. At present, greenness is usually measured from the input of treatment costs, the utilization of new energy, the emission of industrial waste gas and the application of green technology. This paper refers to the practices of Wang Mingtao and Ye Chunming (2020), and measures the degree of Greening Based on green emissions (Wang Mingtao & Ye Chunming, 2020).

3.1.4. Control variable

With reference to the research results of relevant literature on financial development, industrial transformation and upgrading, and high-quality development of manufacturing industry, in order to avoid endogenous errors caused by missing variables as far as possible, this paper refers to the practice of Long Haiming et al. (2021), and combines government intervention (GI) Investment in fixed assets (IFA) and foreign direct investment (FDI) are included in the model as control variables (Haiming et al., 2021).

3.1.5. Data description

According to the development history of China's manufacturing industry and the availability of data, this study selects the provincial panel data of 34 provinces, cities and autonomous regions from 2009 to 2018 to analyze the impact of Industrial Internet on the high-quality development of China's manufacturing industry. Among them, the data was derived from the statistical yearbook (2010–2019), the statistical bulletin of national economic and social development (2009–2018), the statistical report on the development of China's Internet network issued by the China Internet Network Center, the Guotai'an CSMAR Series Research Library and the forward-looking database published by the National Bureau of Statistics and various provinces, cities and autonomous regions, and the variables missing from the key indicators in the middle years are eliminated, To ensure data continuity. Finally, the data of 31 provinces, municipalities and autonomous regions are sorted out, with a total of 280 balanced panel data. The selection of variables is shown in Table 2.

The descriptive statistical results of each variable are shown in Table 3.

Table 2. Variable definition and description			
Variable type	Variable name	Variable symbols	Variable definition
Explained variable	Development degree of Manufacturing Industry	DMI	$\textit{DMI}_{it} = \eta_i egin{pmatrix} \textit{LP}_{it} \ \textit{TFP}_{it} \ \textit{TPT}_{it} \ \textit{PMTA}_{it} \end{pmatrix}$
Explanatory variable	Industrial Internet comprehensive Development Index	IDI	Synthesis by entropy weighting method
Mediating variable	Intellectualization	Intel	Number of patent applications authorized
	Greening	Green	Green Emission
Control Variable	Government Intervention	GI	Expenditure/GDP
	Fixed Assets Investment	IFA	Fixed Assets Investment/ GDP
	Foreign Direct Investment	FDI	Actual Utilization of Foreign Investment/GDP

Table 3. Data descriptive statistics					
Variable	Symbol	Average value	Standard deviation	Minimum value	Maximum
High quality Development of Manufacturing Industry	DMI	5.7841	0.2874	5.2694	6.2008
Industrial Internet comprehensive Development index	IDI	0.8059	0.0521	0.7400	0.8819
Intellectualization	Intel	1,398,400	553,449	581,992	2,447,460
Greening	Green	6,000,310	1,942,789	2,343,857	7,353,227
Government Intervention	GI	0.2358	0.0127	0.2181	0.2553
Fixed Assets Investment	IFA	0.5458	0.0321	0.4894	0.5893
Foreign Direct Investment	FDI	0.0141	0.0029	0.0102	0.0184

First, from the perspective of high-quality development of manufacturing industry (DMI), the average value is 5.7841, and the minimum value and maximum value are 5.2694 and 6.2008 respectively, indicating that the quality level of manufacturing industry development in some regions of China is high, but the quality level of development in most regions is low, and there are certain differences among regions.

Second, from the perspective of the industrial Internet comprehensive development index (IDI), the average value is 0.8059, the minimum value and the maximum value are 0.7400 and 0.8819 respectively, and the standard deviation is 0.0521, indicating that the development level of industrial Internet in various regions of China is relatively small.

Third, from the perspective of mediating variables, there are significant regional differences between intelligence (*Intel*) and green in China, and the development level of intelligence and green in some regions needs to be further improved.

Fourth, from the perspective of control variables, there are large differences in fixed asset investment (*IFA*) among various regions in China, and small differences in government intervention (*GI*) and foreign direct investment (*FDI*).

3.1.6. Model building

In order to analyze the impact of industrial Internet on the high-quality development of manufacturing industry, the following model is established:

$$\ln DMI_{it} = \lambda_0 + \lambda_1 \ln IDI_{it} + \lambda_2 \ln GI_{it} + \lambda_3 \ln IFA_{it} + \lambda_4 \ln FDI_{it} + \mu_i + e_{it}$$
(3.6)

where *i* is each province and *t* is the year, DMI_{it} and IDI_{it} they respectively represent the development degree of manufacturing industry in region *i* in the *t*-th year and the comprehensive development index of industrial Internet in region *i* in the *t*-th year; $GI_{it}IFA_{it}$ as well as FDI_{it} They represent the degree of government intervention, fixed assets investment and foreign direct investment of region *i* in year *t*: λ_0 , η_0 , γ_0 , ζ_0 as well as ξ_0 are constant terms, μ_i , individual effect, e_{it} , ν_{it} , ε_{it} , σ_{it} , σ_{it} , as well as ω_{it} is a random error term.

In order to further test the path mechanism of the industrial Internet affecting the high-quality development of the manufacturing industry, the intermediary variables (Intel, Green) are introduced on the basis of the above model, and referring to the practices of Wen Zhonglin et al. (2004) and Zheng wanteng et al. (2021), the intermediary effect model constructed in this study is as follows (wanteng et al., 2021; Zhonglin et al., 2004):

$$\ln Intel_{it} = \eta_0 + \eta_1 \ln IDI_{it} + \eta_2 \ln GI_{it} + \eta_3 \ln IFA_{it} + \eta_4 \ln FDI_{it} + \mu_i + \nu_{it}$$
(3.7)

$$\ln Green_{it} = \gamma_0 + \gamma \ln IDI_{it} + \gamma \ln GI_{it} + \gamma_3 \ln IFA_{it} + \gamma_4 \ln FDI_{it} + \mu_i + \varepsilon_{it}$$
(3.8)

$$\ln DMI_{it} = \zeta_0 + \zeta_1 \ln IDI_{it} + \zeta_2 \ln Intel_{it} + \zeta_3 \ln GI_{it} + \zeta_4 \ln IFA_{it} + \zeta_5 \ln FDI_{it} + \mu_i + o_{it}$$
(3.9)

$$\ln DMI_{it} = \xi_0 + \xi_1 \ln IDI_{it} + \xi_2 \ln Green_{it} + \xi_3 \ln GI_{it} + \xi_4 \ln IFA_{it} + \xi_5 \ln FDI_{it} + \mu_i + \omega_{it}$$
(3.10)

4. Empirical results

4.1. Basic regression analysis

First, Hausman test is conducted, and the results are shown in Table 4. Table 4 shows that the results of models (1) and (2) reject the original hypothesis, and (2) the random effect model is not satisfied, so it is necessary to use the fixed effect model for regression. The results are shown in Table 5. The results of model (1) in Table 5 show that the impact coefficient of industrial Internet on the high-quality development of manufacturing industry is 4.1919; On the premise of controlling other variables, the results of model (2) in Table 5 show that the total effect of industrial Internet on the high-quality development of manufacturing industry is significantly 5.3671. This shows that the industrial Internet really has a positive role in promoting the high-quality development of the manufacturing industry.

From the results of the control variables, fixed asset investment has a significant negative effect on the high-quality development of manufacturing industry. The possible reason is that China's economic system is not mature, and the relevant laws and policies are not perfect, which makes it difficult to guide correct investment, which makes the development gap between industries gradually widen, which is not conducive to the high-quality development of manufacturing industry; Foreign direct investment has a positive effect on the high-quality development of

Table 4. Hausman test			
Variable		Model (1) InIDI	Model (2) InIDI
Coe.	(b) FE	-2.4192	0.5107
	(B) RE	-2.6027	-1.2990
(b-B) Difference		0.1835	1.8096
Sqrt(diag(V_b-V_B)) S.E.		0.0331	0.1076
chi2(1)		30.69	235.72
Prob>chi2		0.0000	0.0000 (V_b-V_B is not positive definite)
Ind		No	Yes

Table 5. Analysis of total effects of industrial internet		
Variable	Model (1) InDMI	Model (2) InDMI
lnIDI	4.1919*** (0.2104)	5.3671*** (1.4386)
lnGI		8.0222* (6.8620)
lnIFA		-1.0848* (1.9157)
lnFI		15.0966 (11.4142)
Ind	No	Yes
Obs	280	280
R ²	0.8437	0.9957

Note: The standard error of the robust cluster is in parentheses, * * *, * * and * are significant at 1%, 5% and 10%, respectively, the same below.

manufacturing industry. The possible reason is that China's economy continues to develop, the structure of foreign investment introduced continues to optimize, and the efficiency of investment continues to improve, thus contributing to the high-quality development of manufacturing industry.

4.2. Intermediary effect test

4.2.1. Intermediary effect test of intelligence

This part examines the intermediary effect of intelligence. According to the results of model (1) in Table 6, under the premise of controlling other variables, the total effect of Industrial Internet on the high-quality development of manufacturing industry is significantly 5.3671; According to model (2), the significant effect of industrial Internet on intelligence is 0.7472; Model (3) is the joint effect of industrial Internet and intelligence on the high-quality development of manufacturing industry. The results show that the coefficient of industrial Internet is significantly 3.7770 (direct effect), which is lower than 5.3671 in model (1). In addition, the coefficient of intelligence is significantly 2.1279 (indirect effect), that is, intelligence can optimize its structure through the supply and demand of manufacturing industry to promote the high-quality development of

Table 6. Intelligent mediation effect test			
Variable	Model (1)	Model (2)	Model (3)
	InDMI	InIntel	InDMI
lnIDI	5.3671***	0.7472**	3.7770**
	(1.4386)	(0.5148)	(1.0989)
lnIntel			2.1279* (0.6405)
lnGI	8.0222*	3.9429**	-0.3678
	(6.8620)	(2.4554)	(5.3517)
lnIFA	-1.0848*	-0.3577*	-0.3236
	(1.9157)	(0.6855)	(1.3370)
InFDI	15.0966	7.1300	0.0754
	(11.4142)	(4.0843)	(9.0803)
Ind	Yes	Yes	Yes
Obs	280	280	280
R ²	0.9957	0.9908	0.9982

manufacturing industry. Combined with the results of model (2), according to the mediation effect test principle, the industrial Internet promotes the high-quality development of manufacturing industry through intelligence. Part of the mediation effect played by intelligence in this process is: $\frac{0.7472 \times 2.1279}{5.3671} = 0.2962$, that is, 29.62% of the industrial Internet improves its role in the high-quality development of the manufacturing industry through intelligence. H1 verification is completed.

4.2.2. Intermediary effect test of greening

This part examines the intermediary effect of greening. According to the results of model (1) in Table 7, under the premise of controlling other variables, the total effect of industrial Internet on the high-quality development of manufacturing industry is significantly 5.3671; According to model (2), the significant effect of industrial Internet on greening is 1.0551; Model (3) is the joint effect of industrial Internet and greening on the high-quality development of manufacturing industry. The results show that the coefficient of industrial Internet is significantly 5.4562 (direct effect), which is higher than that of model (1) of 5.3671. In addition, the coefficient of greening is significantly 1.6184 (indirect effect), that is, greening can improve the environment of manufacturing industry through its production process and mode to promote the high-quality development of manufacturing industry. Combined with the results of model (2), according to the mediation effect

Table 7. Test of intermediary effect of greening			
Variable	Model (1)	Model (2)	Model (3)
	InDMI	InGreen	InDMI
InIDI	5.3671***	1.0551***	5.4562***
	(1.4386)	(0.7643)	(0.7795)
InGreen			1.6184*** (0.3399)
lnGI	8.0222*	7.8038**	-4.6076
	(6.8620)	(3.6454)	(4.5663)
lnIFA	-1.0848*	-0.6089*	0.0994*
	(1.9157)	(1.0177)	(1.0581)
lnFDI	15.0966	7.4580	3.0264
	(11.4142)	(6.0637)	(6.6822)
Ind	Yes	Yes	Yes
Obs	280	280	280
R^2	0.9957	0.9834	0.9989

test principle, the industrial Internet promotes the high-quality development of manufacturing industry through greening. Part of the mediation effect of greening in this process is: $\frac{1.0551 \times 1.6184}{5.3671} = 0.3182$, That is, 31.82% of the industrial Internet improves its role in the high-quality development of the manufacturing industry through greening, and H2 has verified it.

4.3. Heterogeneity test

In order to specifically explore the differences in the impact of the industrial Internet on the highquality development of China's manufacturing industry, this paper divides 31 provinces and autonomous regions into three parts: the East, the middle and the West¹ conduct empirical test. According to the results in Table 8, the influence coefficients of industrial Internet on the highauality development of manufacturing industry in the East, middle and west regions are 7.1046, 6.1823 and 5.2728 respectively, from which it can be concluded that the influence of industrial Internet on the high-quality development of manufacturing industry in different regions is different. The impact of industrial Internet on the development of manufacturing industry in the eastern region is significantly higher than that in the central and western regions. On the whole, the development of China's industrial Internet in terms of manufacturing has formed an intelligent manufacturing cluster area dominated by the Bohai Rim region, the Yangtze River Delta region and the Pearl River Delta region. It has strong economic strength, rich financial resources and advanced science and technology, which provide power and lay a foundation for the highquality development of the manufacturing industry; However, the central and western regions are still in the stage of automation, and the research and development of the financial system and high-tech is relatively lagging, which is not conducive to the high-guality development of the manufacturing industry.

4.4. Robustness test

Robustness test is to test whether the regression result is reliable through the selection of explanatory variables and changes in regression methods. Therefore, this paper will re-test the influence effect by changing the selection of the explained variable. Referring to the practices of Ren Zhuanzhuan and Deng Feng (2022), the high-quality development level of the manufacturing industry is reflected in the optimization and upgrading of the internal structure of the manufacturing industry and the climbing of the external value chain (Zhuanzhuan & Feng, 2022). It can be seen from the data in Table 9 that the influence coefficients of the industrial Internet on the high-quality development of the manufacturing industry are significantly, which indicates that the industrial Internet indeed has a positive role in promoting the high-quality development of the manufacturing industry. The results obtained by using different measurement indicators are consistent with the previous ones, indicating that the empirical results of this paper are relatively robust.

Table 8. Heterogeneity test			
	Eastern region	Central region	Western region
	Model (1)	Model (2)	Model (3)
Variable	lnDMI	lnDMI	lnDMI
InIDI	7.1046*** (0.365)	6.1823** (0.991)	5.2728*** (0.395)
lnGI	8.6480*** (2.170)	6.0945*** (1.874)	7.0492*** (4.527)
InIFA	7.4722* (5.8492)	6.8278** (3.4854)	4.4959** (2.3754)
InFDI	-3.0958* (2.9628)	-0.3789* (1.9376)	-0.6477* (0.6915)
Ind	Yes	Yes	Yes
Obs	110	90	80
R ²	0.7282	0.8086	0.7075

Table 9. Robustness test		
Variable	Model (1) InDMI	
InIDI	4.5936*** (1.5827)	
InGI	6.0269* (3.8268)	
InIFA	-5.9302* (2.3864)	
InFDI	8.9048 (9.0277)	
Ind	Yes	
Obs	280	
R ²	0.9548	

5. Conclusions and suggestions

This paper selected the data of 31 provinces, cities and autonomous regions from 2009 to 2018 to analyze the impact of the industrial Internet on the high-quality development of China's manufacturing industry. The research results show that the development of the industrial Internet promotes the high-quality development of China's manufacturing industry. From the national perspective, the industrial Internet has significantly promoted the high-quality development of China's manufacturing industry, of which intelligence and green play an intermediary role between the industrial Internet and the high-quality development of manufacturing industry; From a regional perspective, the impact of industrial Internet in the eastern region on the development of manufacturing industry is significantly higher than that in the central and western regions, which may be related to the concentration of most of China's leading-edge manufacturing industries in the East; From the perspective of control variables, fixed assets investment plays a significant negative role in promoting the high-quality development of manufacturing industry. The possible reason is that China's economic system is not mature, and it is difficult to guide correct investment, which is not conducive to the high-guality development of manufacturing industry. Foreign direct investment can help the high-quality development of manufacturing industry through the continuous optimization of investment structure and the continuous improvement of investment efficiency. To sum up, the following suggestions are put forward in this paper:

First, strengthen the research of intelligence theory and breakthrough of core technology. As the most representative technology of the industrial Internet, the development of intelligent technology depends on the foundation of key technology and equipment, which cannot be separated from the breakthrough of intelligent theory; We will strengthen the research and development of core technologies, break the "bottleneck" technology, and solve the lagging development of high-end hardware equipment and industrial Internet.

Second, speed up the establishment of industrial platforms and the improvement of systems and mechanisms. We will build an industrial Internet service platform, actively develop green and ecological manufacturing, strive to improve an efficient, clean, low-carbon and circular green manufacturing system, and promote the application of pollution and carbon reduction technologies; Build a "green pattern" led by green planning, build a "green barrier" based on green ecology, and enhance "green strength" driven by green transformation.

Third, increase investment in scientific research and the training of professionals. Give full play to the financing function of the multi-level capital market, improve China's economic system and relevant policies, guide correct investment, and narrow the gap between industries. In addition, the only way to innovate lies in people. Pay attention to converting scientific research achievements into investment, firmly establish the strategic position of talents leading development, focus on independent innovation, comprehensively gather talents, and lay a solid foundation for innovative development of talents; Promote industrial Internet with talents, stimulate scientific research with industrial Internet, encourage innovation with scientific research, promote high-quality development of manufacturing industry with innovation, and enhance the voice and rule making power of China's manufacturing industry in the global value chain in the future.

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Notes

1. The East includes 11 provinces (cities) including Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan);

The central region includes 10 provinces (autonomous regions) including Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan and Guangxi;

The western region will include a total of 10 provinces (cities, autonomous regions) including Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Chongqing and Xinjiang.]

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