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The Measurement and Influencing Factors of China's Industrial High-quality Development from the Perspective of Industrial Intelligence

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Abstract: *With the rapid speed of technical and economic reforms, vast amounts of money have been invested in modern machinery and cutting-edge technology. In certain areas, "machine replacement" has been the primary tool of technical change. Furthermore, the convergence between Internet technologies and enterprise has raised the amount of industrial intelligence significantly. Promote yourself. Industrial intelligence is critical in fostering industry's productive growth. This term was included in this article. In this paper, the super-efficiency SBM model of unexpected output is used to measure the high-quality development efficiency of China's industry, analyze the spatio-temporal evolution and heterogeneity of high-quality development efficiency of industry, and build a panel multiple regression model to analyze the driving effect of its influencing factors on high-quality development of China's industry. The findings indicate that, among its influencing factors, industrial intelligence, economic growth, environmental regulations, and technical advancement have a substantial positive effect on China's industrial high-quality development, The level of opening to the outside world and marketization reform are negatively correlated with it.*

Keywords: *High-quality industrial development, Efficiency measurement, Undesired output super-efficiency SBM model, Influencing factors*

1. Introduction

With a new round of industrial revolution characterized by digitalization, networking and intelligence booming, the United States, Germany and other western industrialized countries have successively launched "Industrial Internet" and "Industry 4.0" strategic plans, trying to reshape the global industrial division of labor with the help of industrial upgrading and intelligent transformation. As the biggest developing country, to fully grasp the new round of the historic opportunity of the industrial revolution, China's national strategy, to speed up the science and technology and in a new round of industrial revolution, the Chinese intelligent manufacturing equipment and core support software became widespread in various fields, and the production process for industry transformation, promote the real economy and the depth of the artificial intelligence fusion, Large-scale investment in advanced equipment with cutting-edge technology. Due to the long-term policy of favoring capital deepening and the shortening of technology upgrading cycle, the labor cost of enterprises keeps rising. "Machine replacement" has become an significant method for Chinese firm to improve capacity and competitiveness in the new era. In this context, China's industrial intelligence began to enter a full speed development stage, China's industrial development level will be far-reaching influence. Take Guangdong province as an example. From 2015 to 2017, the total investment in industrial technological transformation in Guangdong reached 1.15 trillion yuan, supporting 20,000 industrial enterprises to upgrade equipment and nearly 2,000 enterprises to implement "machine replacement". With the adhibition of big data and AI, China has turn into the world's second largest marketplace for sweeping robots after the United States, but the penetration rate of household robots in coastal cities is more than ten times that of inland cities, making China's labor force employment structure with obvious regional characteristics. Starting from the reality of unbalanced regional development in China in the new stage, this paper fully considers the regional characteristics of industrial intelligentization and industrial upgrading, and accurately reveals that industrial intelligentization is of great significance for China's economy to achieve high-quality development.

2. Literature Review

From the perspective of high quality industry development, different scholars use different methods to measure. In measuring high-quality economic development, some scholars equate economic efficiency with the quality of economic growth, and believe that high economic efficiency means good quality. For example, the super-efficiency SBM model was used to calculate the workpiece ratio of high-quality economic progress in China and analyze its of the day and spatial evolution by Sun Yixuan (2021) . Characteristics, through the spatial panel data regression pattern to probe the driving mechanism of technological innovation on high-quality economic progress[1]. In the measurement of high-quality industrial progress, some scholars have also followed the method of measuring high-quality economic progress.Green total factor productivity was used by Li Wenhong (2021) as an alternative indicator of high-quality progress, and conducted a three-system coupling scheduling of high-quality progress, technical innovation, and Opening up the economy in the three provinces of Beijing, Tianjin and Hebei. Related analysis research [2]. Ju hong(2020) used Egtfp as a measure standard, and used super-efficiency DEA and Malmquist index models to measure the industrial high-quality progress level of major regions and urban agglomerations in the Yellow River Basin from 2006 to 2016 [3]; Wang Yan et al. (2020) measured the industrial total factor productivity of 30 provinces in mainland China from 2009 to 2016 based on the ML index pattern of data envelopment analysis, and used the ruling breath estimation method to analyze the factors affecting the quality of industrial growth [4]. Some scholars have conducted a series of related studies on the interpretation of a high-quality progress index system based on the connotation of high-quality progress or China's national conditions. Gao Wenju (2020) is based on the overall layout of "five in one", and builds EMI high-quality progress from six magnitude including renovation progress, transformational advancement, integrated advancement, and high-end advancement. The evaluation index system studies the mechanism and path of influence of scientific and technological talents on the high-quality advancement of the equipment manufacturing industry [5]. Du Yu(2020) integrated the scientific connotation of high-quality industrial advancement in the new era, and constructed a comprehensive index system from the five magnitude of innovation-driven, green transformation, coordinated advancement, open advancement, and quality benefits to study the time and space of the industrial high-quality advancement index in the Yangtze River Economic Zone Evolution characteristics [6]; Li Zhenye(2020) believe that high-quality industrial advancement is mainly reflected in three aspects: scale efficiency, research and advancement efficiency, and environmental protection effects. The impact of quality advancement [7]. Wang Xiang (2019)[8], Yang Renfa, etc. (2020)[9] conducted an empirical analysis on the impact of ambient regulation and technical innovation on the high-quality advancement of industry and found that the impact of ambient regulation on the high-quality advancement of industry is "U"-shaped, while technical innovation It presents a significant mediating effect in the impact of environmental regulations on the high-quality advancement of industries.

In summary, the research on high-quality industrial advancement mainly focuses on the comparison of trend changes and regional distribution; and for its mechanism of action, some scholars conduct net impact research on possible influencing factors through regression analysis after constructing an indicator system. However, the improvement of high-quality industrial advancement is the result of the mutual influence of many influential factors, and it is a complex process of synergistic influence. Based on the above-mentioned literature research, this paper adopts green total factor productivity as a measure of high-quality industrial advancement. Based on the Unexpected Output Super-SBM model, calculate and analyze the industrial green total factor productivity of 30 provinces in China from 2005 to 2018 (Tibet was eliminated due to missing data); and use the economic patternto analyze and study its influencing factors.

3. Research Method

3.1 Super-SBM Model Considering Undesired Output

Data Envelopment Analysis (DEA) is an efficiency evaluation method proposed by Charnes, a famous American operational researcher. After more than 30 years of advancement, it has become a common and important analysis tool and research means in the fields of management science, systems engineering and decision analysis, evaluation technology, etc. It is a quantitative programming model to analyze and calculate the relative effectiveness of multi-input-output decision making units. However, the traditional DEA method assumes output maximization and does not apply to the situation where waste water, waste gas and other unexpected outputs are generated in the production process.

Therefore, this paper adopts the Super-SBM model considering the unexpected output, assumes that there are n provinces, and constructs the production frontier with each province as a decision unit. Each decision unit uses m inputs $X \in R^m$ to obtain S1 expected outputs $Y^g \in R^{s1}$ and S2 non-expected outputs $Y^b \in R^{s2}$. Define the matrices X,Y^g and Y^b as:

$$X = \left[x_1, x_2, \dots x_n\right] \in R^{m\times n}$$
$$Y^g = \left[y_1^\beta z_2^g, \dots v_n^\beta\right] \in R^{s_1\times n}$$
$$Y^b = \left[y_1^b y_2^b, \dots y_n^b\right] \in R^{s_2\times n}$$

Assuming X>0, Y^g>0, Y^b>0, the production capacity set can be defined as:

$$\mathrm{P} = \left\{(\mathrm{x}, y^g, y^b)\middle| x \geq X_\lambda, y^g \leq Y_\lambda^g, y^b \geq Y_\lambda^b, \lambda \geq 0\right\}$$

λ is the weight vector. The three inequalities in the production possibility function indicates that the actual level of input is not less than the input level of the border, the output level expected real is not greater than the output level expected for the boundary and the actual unexpected output level is not less than the unexpected output boundary output level. In formula (1), is the super efficiency value of the test unit K with constant returns to scale (CCS), namely, the high quality advancement efficiency value of the KTH province S^-,S^g and S^b are the relaxation variables of input, expected output and unexpected output. When ρ*⩾1, the evaluated DMU is relatively effective, and when ρ*<1; DMU is relatively invalid.

$$\rho^* = \min \frac{1 - \frac{1}{m}\sum_{i=1}^m \frac{S_i}{x_{ik}}}{1 + \frac{1}{s_1 + s_2}\left(\sum_{r=1}^{s_1} \frac{S_r^g}{y_{rk}^g} + \sum_{r=1}^{s_2} \frac{S_r^b}{y_{rk}^b}\right)}$$

$$\mathrm{s.t.}\,\mathrm{x}_k = X_\lambda + S^-$$
$$y_k^g = Y_\lambda^g - S^g$$
$$y_k^b = Y_\lambda^b + S^b$$
$$\lambda \geq 0, S^- \geq 0, S^g \geq 0, S^b \geq 0$$

3.2 Measurement Model Setting

Based on the theoretical model and existing research, the panel regression model is constructed by taking the high quality advancement efficiency of industry as the explained variable, and industrial intelligence, economic openness, economic advancement level, technical innovation, environmental regulation and market-oriented reform as the explained variable.

$$\ln Gtfp_{it} = \beta_0 + \beta_1 \ln INT_{it} + \beta_2 \ln TRA_{it} + \beta_3 \ln Development_{it}$$
$$+\beta_4 \ln MOR_{it} + \beta_5 \ln ENR_{it} + \beta_6 \ln RD_{it} + \varepsilon_{it}$$

Where, I represents region, t represents time; INT stands for industrial intelligence; TRA stands for open economy; advancement represents the level of economic advancement; The Ministry of Railways represents market reform; RD stands for technical innovation; ε represents random disturbance. Economic openness (TRA), level of economic advancement (Development), technical innovation (RD), environmental regulation (ENR) and market reform (MOR) were selected as control variables. Per capita GDP is used for the level of economic development, R&D investment is used for technical innovation, and the operating cost of waste water and waste gas equipment is used for environmental regulation, which represents the proportion of main business income of the industry. In the market-oriented reform, non-state-owned fixed assets account for the total fixed assets. Represents the total proportion of assets. Industrial intelligence (INT) is calculated using sun Zao's measurement standard. Due to space constraints, this article is not listed [10].

3.3 Measurement of Industrial High-Quality Development Efficiency

The high-quality development of industry requires a relatively small input of production factors, a low cost of resource and environmental governance, and high production efficiency and social benefits. Taking into account the availability of data, this paper selects industrial fixed capital investment as capital input, number of industrial employees as labor factor input, total industrial energy consumption as energy factor input; industrial added value as expected output; industry The emissions of solid waste, liquid waste, and gaseous waste are regarded as environmental undesired output. The industrial fixed capital stock is calculated by referring to the treatment method of Zhang Jun and using the perpetual inventory method with 2005 as the base period. , And other value quantities have also been deflated based on the 2005 base period. The industrial green total factor productivity calculated by using the undesired output super-efficiency SBM model represents a relative efficiency value and can only be used for horizontal and vertical comparisons in a certain region. The global ML index (GML index) is used to evaluate the dynamic changes of the province's industrial green total factor productivity. The GML index can effectively solve the problem of insufficient transitivity and infeasible solutions in the ML index. The expression is as follows:

$$GML_k(t,s)=\frac{1+D^G\left(x_k^t,\vartheta_k^{gt};y_k^{bt},y_k^{gt},-y_k^{bt}\right)}{1+D^G\left(x_k^s,\theta_k^{\beta s},\gamma_k^{bs};y_k^{gs},-y_k^{bs}\right)}$$

Among them, D^G (x_k^t, y_k^{gt}, y_k^{bt}; y_k^{gt}, $-y_k^{bt}$), DG (x_k^s, y_k^{gs}, y_k^{bs}; y_k^{gs},$-y_k^{bs}$) means that the possible set of production composed of all input and output values during the study sample period is used as the common set of different periods When referring to the technology set, the distance function of the decision-making unit in period t and period s. When $GML_k(t,s)>1$ means efficiency is improved, $GML_k(t,s)=1$ means efficiency remains unchanged, $GML_k(t,s)<1$ means efficiency decreases are shown in Table 1.

Table 1: Total factor productivity measurement index

Indicator type	First level indicator	Secondary indicators	unit
Investment index	Capital investment	Industrial fixed capital stock	100 million yuan
	Labor factor	Number of industrial employees	Ten thousand people
	Energy factor	Total industrial energy consumption	Ten thousand tons
Output indicators	Expected output	Industrial added value	100 million yuan
	Undesired output	Industrial solid waste discharge	Ten thousand tons
		Discharge of industrial liquid waste	Ten thousand tons
		Industrial SO2 emissions	Ten thousand tons

4. Esult Analysis

4.1 Analysis on the Characteristics of Time Evolution of China's Industrial High-quality Development

The study uses the Super-SBM model to measure the efficiency of the provincial panel data from 2005 to 2018, in order to evaluate the high-quality development of China's industry (Figure 1)

The high-quality development efficiency of China's industry is generally on the rise, but it shows obvious differences at different stages. From 2005 to 2012, there was a clear upward trend in the scores of the industrial high-quality development index, which coincided with the entry into the WTO and the acceleration of the process of building a well-off society in an all-round way and industrialization. China's integration into globalization, strong domestic demand, high investment and consumption rates, and abundant and low-cost labor resources have promoted the rapid development of industry. After 2012, the quality of industrial development level has declined, which was prominently manifested by overcapacity and decline in industrial efficiency. In order to effectively resolve overcapacity, the government implemented a supply-side structural reform of "three removals, one reduction and one supplement". The distortion of factor allocation has been corrected to a large extent, the industrial structure has been gradually optimized, and the innovation-driven capacity has been significantly improved. The effects of supply-side reforms began to appear after 2015, and the industry has returned to a steady upward track of high-quality development. In 2018, Sino-US trade frictions increased the uncertainty of China's external environment and posed a greater threat to the development of China's industrial economy. It has a greater impact on the eastern region, but the overall development trend of the country has not changed. This also further shows that China's comparative advantage is still prominent. Even if the external environment becomes more uncertain, it is difficult to cause disruptive changes to the global industrial division of labor and competitive advantages in the short term. It also

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shows that China has sufficient market space and policies. Space and institutional advantages to deal with the uncertainty of the world economy.

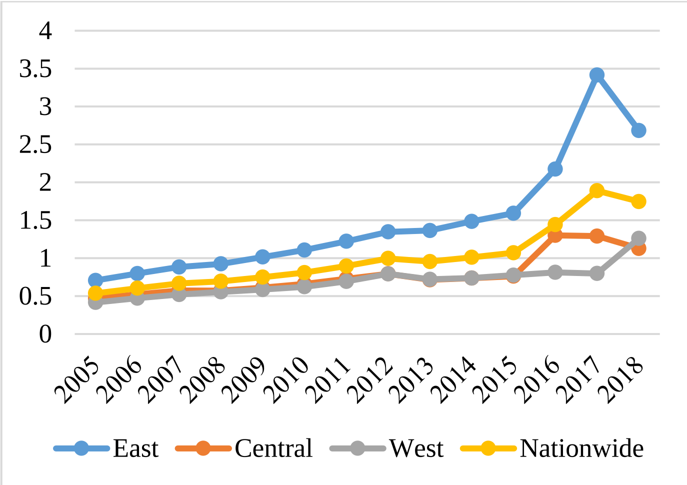

Figure 1: Time series change curve of industrial high-quality development efficiency from 2005 to 2018

4.2 Analysis on the Characteristics of the Evolution of China's Industrial High-quality Development Space

The Malmquist index can dynamically reflect the changing trend of industrial high-quality development efficiency in various provinces. Therefore, DEAP2.1 software is used to analyze the industrial high-quality development efficiency data of 30 provinces in China from 2005 to 2018, and then examine the spatial development of industrial high-quality development. Evolution characteristics and heterogeneity.

Table 2: Malmquist index and decomposition of industrial high-quality development in various provinces

province	Technical efficiency	skill improved	Total Factor Productivity Index
Beijing	1.042	1.122	1.169
Tianjin	1.032	1.164	1.202
Hebei	0.964	1.086	1.047
Shanxi	0.986	1.077	1.061
Inner Mongolia	1.097	0.985	1.080
Liaoning	0.977	1.082	1.057
Jilin	1.009	1.083	1.094
Heilongjiang	0.889	1.114	0.990
Shanghai	0.983	1.106	1.087
Jiangsu	0.967	1.096	1.060
Zhejiang	0.964	1.106	1.067
Anhui	1.324	0.889	1.177
Fujian	1.048	1.019	1.068
Jiangxi	0.947	1.089	1.031
Shandong	0.962	1.100	1.057
Henan	0.955	1.356	1.295
Hubei	0.986	1.084	1.068
Hunan	0.969	1.084	1.050
Guangdong	1.027	1.177	1.209
Guangxi	0.962	1.084	1.042
Hainan	1.195	1.084	1.295
Chongqing	0.972	1.091	1.060
Sichuan	0.985	1.088	1.072
Guzhou	1.008	1.079	1.088
Yunnan	0.988	1.086	1.073
Shanxi	0.984	1.086	1.069
Gansu	0.963	1.079	1.039
Qinghai	1.435	1.105	1.586
Ningxia	0.998	1.072	1.070
Xinjiang	0.926	1.120	1.036

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Table 3: Malmquist Index and Decomposition of High-quality Industrial Development in Various Regions

province	Technical efficiency	skill improved	Total Factor Productivity Index
East	1.015	1.104	1.120
Central	1.008	1.097	1.096
West	1.029	1.080	1.110
Nationwide	1.018	1.093	1.110

(1) Analysis of overall efficiency changes. It can be seen from Table 2 that the average value of my country's industrial high-quality development efficiency index from 2005 to 2018 was 1.10, showing an overall upward trend, and the industrial high-quality development efficiency index during the study period was greater than 1, indicating that my country's industrial high-quality development is in a steady rising stage . In terms of decomposition, technical efficiency increased by 1.8%, and the average value of technological progress increased by 9.3%, indicating that the technological progress of my country's industry played a major role in the improvement of overall efficiency, followed by the driving role of management level and resource utilization efficiency.

(2) Comparison of efficiency differences among provinces. It can be seen from Table 2 that from 2005 to 2018, except for Heilongjiang Province, where the industrial high-quality development efficiency index was lower than 1, the industrial high-quality development efficiency index of the other 29 provinces was greater than 1. It shows that the high-quality industrial development in the whole region of our country is in a good situation. Among them, in Heilongjiang province, the industrial high-quality development efficiency is lower than 1, mainly because the technical efficiency index is less than 1. That is to say, the insufficient industrial high-quality development level of this province is mainly affected by the gas management level and the efficiency of resource use. Therefore, the province should focus on improving its resource use efficiency and management level.

(3) Comparison of regional efficiency differences. It can be seen from Table 3 that from 2005 to 2018, the average values of the industrial high-quality development index of the eastern, central, and western regions were 1.120, 1.096, and 1.110 respectively, and the comprehensive ranking was: eastern region>western region>central region. The rapid development of high-quality industries in the eastern region is mainly due to technical efficiency, that is, the level of resource utilization efficiency; the western region needs to strengthen industrial technological progress and accelerate the promotion of technological progress and efficiency. The high-quality industrial development in the central region is slow, and the improvement of industrial management capabilities should be accelerated, and the investment in technology for technological progress should be increased.

4.2 Model Influencing Factors Analysis

In order to maintain the stability of the data and facilitate the evaluation of the robustness of the model, Stata13.1 software was used to perform the fixed effect, random effect and mixed effect regression on the basis of the panel model. The regression results are shown in Table 4

Table 4: Panel data regression results

Explained variable	Industrial high-quality development efficiency		
Explanatory variables	Fixed effects model	Random effects model	Mixed effects model
Ln_INT	0.077*** (2.18)	0.128*** (3.54)	0.445*** (10.35)
Ln_Development	0.354*** (6.58)	0.383*** (8.88)	0.500*** (17.49)
Ln_TRA	-0.119*** (-5.09)	-0.062*** (-2.77)	0.085*** (4.10)
Ln_RD	0.075*** (2.13)	0.059*** (2.11)	-0.076*** (-5.10)
Ln_ER	0.007 (0.40)	0.009 (0.47)	0.071 (2.52)
Ln_MOR	-0.263*** (-6.85)	-0.269*** (-7.05)	-0.206*** (-6.46)
_cons	-4.139*** (-9.32)	-4.428*** (-11.48)	-4.714*** (-9.61)
N	420	420	420
R2	0.8047	0.7790	0.7766
B-P inspection	chibar2(01) = 1190.6		
Wald inspection	F(6,413)=239.33		
Hausman inspection	chi2(6) = 49.42		

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5. Conclusion

Among many influencing factors, economic opening is not conducive to high-quality industrial development. For economic development, developing countries often pay little attention to environmental governance. The transfer of production of highly polluting products from developed countries to these countries has a significant impact on the host country's environmental pollution. It is not conducive to improving the efficiency of high-quality industrial development. The level of economic development has a significant positive impact on improving the level of high-quality development of the industry. This shows that with the continuous development of the economic level, the level of high-quality industrial development will also improve. The improvement of the level of economic development, on the one hand, means that the society has created more material wealth and spiritual wealth, but also provides high-quality industrial development. On the other hand, as life becomes more and more affluent, people seek to satisfy their spiritual needs after their material needs are satisfied. Their pursuit of green living and green travel makes the market demand for green products. We will further promote green industrial development. technical innovation and environmental regulation also have a positive impact on high-quality industrial development. The more the industry invests in technical innovation and environmental regulation, the higher the efficiency level of high-quality industrial development. Market reforms have the opposite effect on the development of high-quality industries. This is because non-state economy is more conducive to improving the quality of industrial growth than state economy. Industrial intelligence has a significant positive impact on the development of high-quality industries, which also verifies the previous hypothesis.

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