Research on the Impact of China's Artificial Intelligence on the Transformation and Upgrading of Industrial Structure Based on Dynamic Panel Data Model

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Abstract

In the new era, China's economy has changed from a high-speed growth stage to a high-quality development stage, facing the new task of industrial structure transformation and upgrading, and it is urgent to cultivate new kinetic energy. At present, scholars generally believe that the leading technology of new scientific and technological revolution with artificial intelligence as its core is the most capable and promising weapon to promote the transformation and upgrading of China's industrial structure. Therefore, this thesis uses the panel data of 31 provinces, municipalities and autonomous regions in China from 2008 to 2020, takes artificial intelligence as the core explanatory variable, selects the level of economic development, the degree of opening to the outside world, foreign direct investment and the degree of government intervention as the control variables, and makes an empirical analysis by using generalized moment estimation. It is found that the development level gap of artificial intelligence in the eastern, central and western regions of China is obvious, but it tends to decrease year by year. On the whole, artificial intelligence can promote the transformation and upgrading of China's industrial structure.

Keywords: *Artificial intelligence, Industrial structure transformation and upgrading, Generalized moment estimation*

1.INTRODUCTION

In recent years, the transformation and upgrading of China's industrial structure has faced many problems: the internal structure of the primary industry needs to be optimized, the secondary industry, especially the industry, is "big" but not "strong", is at the bottom of the global value chain, the product structure is unreasonable, the development of the tertiary industry lags behind, and the proportion of high-tech industries is low. At the same time, the international economic structure will also usher in the opportunity to reshape, and the power brought by the traditional quantitative growth characterized by scale expansion can hardly promote the high-quality development in the new stage [17]. The whole country's economic development is influenced by the external environment and internal conditions, and the progress is slow. Therefore, there is an urgent need to cultivate new kinetic energy for economic growth, transform and upgrade new fuels for industrial structure, and achieve efficiency-enhancing and quality-oriented growth. Whether we can seize the historic opportunity brought by the development of artificial intelligence and accelerate the transformation and upgrading of China's industrial structure is a key issue related to China's further progress towards the ranks of world economic powers. This thesis will focus on the impact of artificial intelligence on the transformation and upgrading of China's industrial structure, and focus on "Will the emergence of artificial intelligence in China have an impact on the transformation and upgrading of industrial structure?" What kind of influence does it have? How big is the regional gap of this influence? " These three issues should be explained and discussed reasonably.

At present, Foreign Foreign scholars believe that the main factors leading to industrial structure transformation and upgrading are: policy factors, technical factors and financial factors. [1], based on the

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data of 28 departments in 29 countries from 1990 to 2001, used cointegration analysis to prove that there is a long-term relationship between finance and industrial structure, that is, financial development promotes industrial technological progress, and then promotes industrial structure transformation and upgrading. The research of [20] concluded that information and communication technology (ICT) can promote the transformation and upgrading of industrial structure in regional industrial optimization and technological innovation. [2] by analyzing the relevant data of Chinese industry from 1998 to 2007, found that industrial policies allocated to competitive sectors or sectors that promote competition can improve their production capacity. Influenced by the research of foreign scholars, for a long time, baumol effect and Engel effect have been regarded as the most important factors affecting the transformation and upgrading of industrial structure. According to China's national conditions, the factors affecting the transformation and upgrading of industrial structure can be attributed to social needs, foreign direct investment, human capital, technology market, institutional arrangements and so on. [7] used four kinds of factors, namely, social demand, human resources, technological innovation and institutional impact, to explore the impact on China's industrial transformation and upgrading level. [11] explored the impact of foreign direct investment on the transformation and upgrading of industrial structure by establishing a fixed effect model. The results showed that both the stock and flow of foreign direct investment in China could have a positive impact on the transformation and upgrading of industrial structure. The theoretical exposition by [4] and cross-country data show that the accumulation of human capital has a direct role in accelerating the advanced development of industrial structure.

Artificial intelligence, as a new key element of economic growth, has become a hot topic of academic research in recent years, and it is also the focus of widespread concern in society. At present, most foreign literatures are related research and analysis on artificial intelligence industry and economic growth. [3] studied the potential impact of artificial intelligence on economic growth, pointing out that automation brought by artificial intelligence may form the path of economic singularity. On the positive side, [8] used the relevant data of intelligent robots' use and economic operation in some countries from 1993 to 2007 to analyze their impact on the labor market, and found that robot automation can effectively improve the economic growth rate. The research on the influence of artificial intelligence on industrial structure transformation and upgrading in China can be summarized from the following four angles: (1) The integration of artificial intelligence and real economy forms intelligent economy. [10] highlighted that artificial intelligence can achieve deep integration with the real economy through upgrading and innovating the real economy. (2) The influence of artificial intelligence on social labor force. [12] thinks that artificial intelligence will promote the upgrading of industrial structure like electricity and network, so as to realize the transition of people's employment level, that is, from simple low-level labor to complex high-level labor. (3) The impact of artificial intelligence on industry. [18] constructed a dynamic panel model to analyze the influence mechanism of artificial intelligence on industrial structure transformation and upgrading. The results show that artificial intelligence has relatively little effect on industrial transformation and upgrading.(4) The impact of the development of artificial intelligence itself. [19] theory states that artificial intelligence, as a general technology, can fully release the technology spillover effect and promote the transformation and upgrading of China's industrial structure through the market scale effect and the organic integration with big data and the Internet of Things.

According to the current research situation at home and abroad, scholars' research on the factors affecting the transformation and upgrading of industrial structure is relatively perfect, but few scholars include artificial intelligence. In this thesis, on the basis of the original factors affecting the transformation and upgrading of industrial structure, artificial intelligence is added as the core explanatory variable to study its influence on the transformation and upgrading of industrial structure.

2.INFLUENCE MECHANISM

This section analyzes the action path of artificial intelligence on industrial structure transformation and upgrading from three aspects: industrial transformation, industrial integration and industrial empowerment, as shown in Figure 1:

AI promotes industrial production efficiency with new technologies, stimulates the internal vitality of the industry with new models, and promotes industrial innovation ability with new ecosystems, thus realizing the orderly and healthy development of traditional industries. AI improves industrial integration efficiency with new engines, shortens industrial integration cycle with new platforms, enriches industrial development content with new formats, and realizes more efficient integration of traditional industries. AI stands on the shoulders of giants such as the Internet, big data and cloud computing, so its development speed is even faster, and it has effectively empowered the three industries.

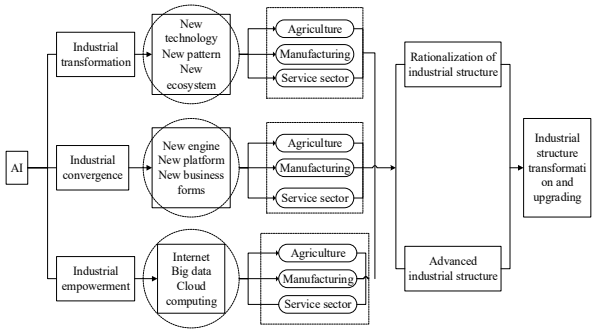

Figure 1: Influence mechanism of AI on industrial structure transformation and upgrade

At present, artificial intelligence mainly empowers "big" agriculture, that is, the primary industry with a wide planting scale and a large number of breeding. These primary industrial organizations mainly use artificial intelligence equipment for remote sensing observation and real-time monitoring, and introduce intelligent agricultural machinery and robot feeding, which can reduce labor force, reduce livestock mortality and improve production efficiency on a large scale. However, due to the high application cost of modern artificial intelligence, the lack of publicity and training of ordinary farmers, and the bias towards risk avoidance, it is found that artificial intelligence in China still has a large enabling space for the primary industry. The empowerment of artificial intelligence to the secondary industry is mainly reflected in the manufacturing industry. The original intention of the industrial revolution was to liberate the labor force and free people from the complicated productive labor, but then the pace of life accelerated, and people had to take on more services instead. Artificial intelligence, a new revolutionary product of science and technology, can replace people in dangerous and heavy work. This is the scene where artificial intelligence empowers the manufacturing industry most, including robot handling, production equipment maintenance, aerial work, etc. Artificial intelligence has maximized the empowerment of medical care, education, transportation, retail and other fields in the tertiary industry. After the outbreak of COVID-19, artificial intelligence has played an important role in the initial virus monitoring, mid-term drug research and development, and later vaccine injection.

3.EMPIRICAL ANALYSIS

On the basis of theoretical research, this part will combine the dynamic panel data model to estimate the generalized moment, and answer the three questions raised in the introduction from an empirical point of view. This thesis uses the relevant panel data of 31 provinces, municipalities and autonomous regions in China from 2008 to 2020, mainly from statistical yearbooks, and some missing data are filled by moving average method.

3.1. Principal Component Analysis

This thesis draws lessons from the research achievements of [5][6][13][14][15][21] and combines them. Considering the dynamic characteristics of artificial intelligence and the complete availability of data, six qualified secondary indicators are selected. After dimensionless, the weight of each indicator is determined by principal component analysis, as shown in Table 1.

Table 1: AI dynamic multi-index evaluation system.

Primary index	Weight	Secondary index	Weight
Technological innovation ability	0.340	Gross industrial output value of intelligent manufacturing enterprises	0.167
		R&D funds	0.173
Human resource level	0.330	Number of R&D personnel in software and electronic information technology industry	0.177
		Turnover of technology market per 10,000 scientific and technical personnel	0.153
Infrastructure construction	0.330	Investment in fixed assets such as information transmission, software and information technology services	0.164
		Broadband number	0.166

It can be seen that the weight share of each first-level index differs by only 0.010, in which the technological innovation capability accounts for 0.340 at the maximum, and the human resource level and infrastructure construction account for 0.330 at the same share. It shows that technology, talents and infrastructure play a vital role in the development of artificial intelligence. Among the secondary indicators,

the number of R&D personnel in software and electronic information technology industry accounts for 0.177, which shows that the development of science and technology and the construction of infrastructure are inseparable from the investment of talents, who are the cornerstone of national rejuvenation and social progress. And the proportion of R&D funds is 0.174, second only to the proportion of R&D personnel in software and electronic information technology industries. Generally speaking, the weight shares of these six secondary indicators are almost the same, indicating that the selected indicators have certain credibility. The artificial intelligence comprehensive evaluation calculated by weight share can make the final data more scientific and accurate.

Next, using (Shen 2019) approach as a reference, the rationalization of industrial structure (TL) and the elevation of industrial structure (TS) are respectively given a weight of 0.5 to calculate the industrial structure transformation and upgrading index. Thus, the industrial structure transformation and upgrading index can be calculated by formula (1):

$$AD = 0.5 \times TL + 0.5 \times TS \tag{1}$$

3.2. Generalized Method of Moments

In view of the influence of multiple factors on the transformation and upgrading of industrial structure, this thesis takes artificial intelligence as the core explanatory variable, synthesizes existing research, and adds factors such as economic development level, degree of opening to the outside world, level of foreign investment and degree of government intervention as control variables, and establishes the following model:

$$AD_{it} = c_i + \beta_1 \ln AI_{it} + \beta_2 EI_{it} + \beta_3 OP_{it} + \beta_4 FDI_{it} + \beta_5 GI_{it} + \mu_{it} \tag{2}$$

Type, I said the province, t said the time, that is, the year. AD is an explained variable, indicating the index of industrial structure transformation and upgrading. C represents the individual effect, β represents the parameter to be estimated, μ represents the error term, AI is the core explanatory variable, indicating the level of artificial intelligence, EI is the level of economic development, OP is the degree of opening to the outside world, FDI is foreign direct investment, and GI is the degree of government intervention. The variables and their calculation methods are shown in Table 2.

Table 2: Main variables and their calculation methods.

Variable category	Variable name	Mediator variable	Calculation method
Explain	AD	TL	$DIS = \sum_{j=1}^{n}\left(\frac{Y_{ij}}{Y_i}\right)\sqrt{\left(\frac{Y_{ij}}{L_{ij}}/\frac{Y_i}{L_i}-1\right)^2}$
ed variable			$TL = 1/DIS$
		TS	$TS = \frac{Y_3}{Y_2}$
Core explanatory variable	AI	See table 1.	Principal component analysis $AI_j = \sum_{j=1}^{13}\frac{j}{\sum_{k=1}^{13}k}\sum_{i=1}^{9}w_i z_{ij}$
Control variable	EI	——	Logarithm of regional GDP per capita
	OP	——	Total import and export as a percentage of GDP
	FDI	——	The proportion of foreign investment actually utilized in the region in GDP
	GI	——	Proportion of local general budget expenditure to regional GDP

According to the calculation methods provided in Table 2, the operation data in the dynamic model can be obtained. [9] Firstly, the basic data of variables in the research of artificial intelligence affecting industrial structure transformation and upgrading in China are sorted out, and Table 3 is obtained.

Overall, the average value of industrial structure transformation and upgrading index is 2.219, the standard deviation is 2.570, and the difference between the maximum value of 16.072 and the minimum value of 0.698 is 15.374. On the one hand, it shows that the development of industrial structure in various regions of China is unbalanced, on the other hand, it shows that there is still room for adjustment in industrial structure transformation and upgrading. The average value of artificial intelligence is 4.832, and the measured standard deviation is 3.917, which is the largest of all variables. It reflects that the development level of artificial intelligence in various regions is mixed, with

the minimum value of 0.060 and the maximum value of 24.001, and the difference between the maximum value and the minimum value is 23.941, far exceeding the average value of artificial intelligence in various regions. It also shows that the development level of artificial intelligence, a new industry, is high or low in various regions and there is a big gap. The average value of economic development level is 1.426, which indicates that China's economy has experienced a rising and leaping stage in the past ten years.

Table 3: Descriptive statistical characteristics of data.

Research variable	Zone	Average	Standard deviation	Min	Max
AD	Entirety	2.219	2.570	0.698	16.072
	East	4.010	3.659	1.088	16.072
	Middle	1.393	0.402	0.843	2.704
	West	1.129	0.310	0.698	2.134
AI	Entirety	4.832	3.917	0.060	24.001
	East	6.342	5.017	0.397	24.001
	Middle	4.823	2.292	1.749	12.411
	West	2.556	2.089	0.060	10.619
EI	Entirety	1.426	0.526	0.015	2.799
	East	1.828	0.454	0.570	2.799
	Middle	1.250	0.353	0.368	2.046
	West	1.175	0.460	0.015	2.026
OP	Entirety	0.438	0.488	0.019	2.300
	East	0.911	0.556	0.163	2.300
	Middle	0.181	0.065	0.070	0.388
	West	0.175	0.111	0.019	0.653
FDI	Entirety	0.191	0.287	0.001	1.497
	East	0.450	0.351	0.025	1.497
	Middle	0.060	0.037	0.009	0.140
	West	0.041	0.060	0.001	0.295
GI	Entirety	0.284	0.203	0.100	1.354
	East	0.186	0.063	0.100	0.349
	Middle	0.228	0.058	0.129	0.377
	West	0.410	0.272	0.172	1.354

China's overall economic development is in good condition, with a standard deviation of 0.526, which shows that the development gap among different regions is small and has a trend of further narrowing. The average opening degree is 0.438, the standard deviation is 0.488, and the overall gap is relatively small, which shows that China's opening-up policy and development philosophy promulgated in recent years have been effectively implemented. The control variable of foreign direct investment has an average value of 0.191 and a standard deviation of 0.287, which indicates that China has actively developed foreign enterprises and introduced foreign investment in recent years, which contributes to the development of China's industrial structure to a certain extent. All descriptive indicators of government intervention degree are small, with an average value of 0.284 and a standard deviation of 0.203, which indicates that there is no significant difference in government intervention degree among regions.

In terms of regions, on the one hand, except for the degree of government intervention, the maximum values of other indicators are in the eastern region, which shows that the eastern region of China is developing relatively fast, the transformation and upgrading of industrial structure is relatively perfect, the application level of artificial intelligence is high, the economy is developing rapidly, the degree of opening to the outside world is also high, and foreign direct investment is in a far leading position, which undoubtedly provides a virtuous circle for the development of the eastern region. The minimum level of government intervention exists in the eastern region, and the invisible hand brings good development to the eastern region, so the intervention

level of the visible hand, i.e. government macro-control, is relatively low. On the other hand, there is a certain gap between the average value and standard deviation of artificial intelligence in the central and western regions. The average value of artificial intelligence in the central region is 4.823, while the average value in the western region is only 2.556, slightly higher than half of the average value in the central region. The standard deviation of artificial intelligence in the central region is 2.292, and that in the western region is 2.089, indicating that the fluctuation of artificial intelligence in the central region is stronger than that in the western region. In addition, there is no obvious difference in the mean and standard deviation of each index in the central and western regions.

Then, the data stationarity is checked and the lag order of the model is selected.

Table 4: Data stationarity test results.

Variable	Test method	
	LLC	IPS
D.AD	-1.628***	-3.168***
D.AI	-1.285***	-2.378***
D.EI	-0.687**	-1.719*
D.OP	-0.941***	-2.630***
D.FDI	-0.928***	-2.593***
D.GI	-0.922***	-1.941***

Note: The original assumptions of LLC and IPS tests are that H0 is the root of existence unit, and * * *, * *, * are significant in the confidence intervals of 1%, 5% and 10%, respectively.

Table 5: Hysteresis order of dynamic panel data model.

Lag	AIC	BIC	HQIC
1	-9.623	-6.947*	-8.553*
2	-8.633	-5.275	-7.285
3	-5.660	-1.495	-3.984
4	-10.073*	-4.933	-7.997
5	-8.921	-2.574	-6.349

Note: * represents the lag order of the selected model.

Finally, the final form of the model is determined as follows:

$$AD_{it} = c_i + \Gamma_1 AD_{i,t-1} + \beta_1 \ln AI_{it} + \beta_2 EI_{it} + \beta_3 OP_{it} + \beta_4 FDI_{it} + \beta_5 GI_{it} + \mu_{it} \quad (3)$$

The lag term of dependent variable exists in Equation 3, which indicates that there is correlation between lag dependent variable and disturbance term, and the consistency and unbiasedness of model estimation results will be disturbed. (Arellano et al 1991) solved this problem by using generalized moment estimation (GMM) and clarified that GMM can improve the effectiveness of the estimation. [16] This thesis uses this method for reference to calculate the data of 31 provinces (cities, autonomous regions) in China from 2008 to 2020, and on this basis, obtains the coefficients of the corresponding explanatory variables by using the method of adding variables one by one. In this way, the influence coefficients of artificial intelligence on the transformation and upgrading of industrial structure can be clearly and intuitively seen, and can also be compared with the coefficients after adding control variables. The results are shown in Table 6.

Table 6: Dynamic panel data estimation results.

	AD(1)	AD(2)
L.AD	0.432***	0.290**
	(7.707)	(2.849)
lnAI	0.087***	0.052***
	(3.903)	(3.347)
EI	—	0.103**
		(2.111)
OP	—	1.112*
		(0.464)
FDI	—	0.266*
		(0.075)
GI	—	-0.546*
		(-0.105)
_CONS	0.677***	1.679**
	(10.395)	(2.174)
ar1p	0.017	0.047
ar2p	0.322	0.316
hansen	15.803	5.960

Note: * stands for < 0.1, * * stands for < 0.05, * * * stands for < 0.01, and the values in brackets are.

It can be seen that both model estimations reject the original assumption of second-order residual autocorrelation, indicating that there is no residual autocorrelation. The Hansen test also rejected the original hypothesis, believing that the setting of tool variables was reasonable and passed the over-identification test. Specifically, when there are only the lagging term of the explained variable and the core explanatory variable in the model, the transformation and upgrading coefficient of the industrial structure lagging behind the first order is significantly 0.432 at the level of 1%, indicating that the transformation and upgrading of the industrial structure in each period will have a positive impact on the future industrial structure to a certain extent, i.e. every 1% increase in the transformation and upgrading of the industrial structure in the previous period will promote the transformation and upgrading of the industrial structure in the next period by 0.432%, which well indicates that the

transformation and upgrading of the industrial structure is a long-term accumulated result. The coefficient of the core explanatory variable artificial intelligence is positive 0.087, which is also significant at the level of 1%, which is consistent with the conclusion drawn by many domestic and foreign scholars. Science and technology are the primary productive forces. The continuous diffusion, penetration, integration and innovation of artificial intelligence technology will have a positive promoting effect on the transformation and upgrading of China's industrial structure. On average, for every percentage point of improvement of artificial intelligence, the transformation and upgrading of industrial structure will be optimized by 0.087%. Therefore, China should vigorously support the development of artificial intelligence and enjoy the changes brought by artificial intelligence. When the control variable is added to the model, the coefficient in the original model has changed to a certain extent, and the coefficient of the variable of industrial structure transformation and upgrading lagging behind by one stage becomes 0.290, indicating that the addition of other variables can affect the industrial structure transformation and upgrading of the current period to a certain extent. The coefficient of artificial intelligence is 0.052, which is also significant at the level of 1%, indicating that for every percentage point increase in the level of artificial intelligence, on average, the degree of transformation and upgrading of industrial structure will deepen by 0.052%. In addition, the level of economic development, the degree of opening to the outside world and foreign direct investment will also promote the transformation and upgrading of industrial structure. Generally speaking, when these variables increase by 1%, the transformation and upgrading of industrial structure will deepen by 0.103%, 1.112% and 0.266% respectively. The coefficient of the explanatory variable, the degree of government intervention, is negative 0.546, which will have a negative impact on the transformation and upgrading of the industrial structure. On average, a 1% increase in the degree of government intervention will slow down the progress of the transformation and upgrading of the industrial structure by 0.546%, indicating that the government should formulate appropriate policies and reasonably control the degree of intervention to achieve the purpose of promoting the transformation and upgrading of the industrial structure. The above statistical results show that artificial intelligence and other control variables can realize the transfer of elements from low-efficiency departments to high-efficiency departments from both qualitative and quantitative aspects of the industrial structure, thus realizing the transformation and upgrading of the industrial structure. From this point of view, a new path to promote the future development of China's industrial structure transformation and upgrading can be explored.

In order to ensure the accuracy of the measurement results, the robustness of the above model is tested by Stata software, and the results are shown in Figure 2.

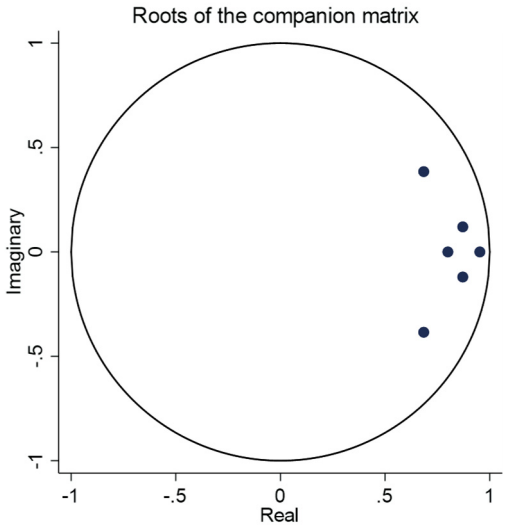

Figure 2: Stability test of PVAR model.

From the unit circle in Figure 2, we can intuitively see that each characteristic root falls in the circle, which shows that the stability of the dynamic panel data model constructed in this thesis is verified.

4.CONCLUSIONS

Based on the empirical study of panel data of 31 provinces (municipalities and autonomous regions) in China from 2008 to 2020, the following conclusions are drawn:

On the one hand, artificial intelligence has promoted the transformation and upgrading of China's industrial structure for a long time. There is a certain gap between the development of artificial intelligence in the eastern, central and western regions and the transformation and upgrading of industrial structure. Although it is decreasing year by year, at present, the whole is still in an unbalanced state. Among the selected series of control variables, the level of economic development, the degree of opening to the outside world and foreign direct investment can have different degrees of positive influence on the transformation and upgrading of industrial structure, while the degree of government intervention has a slight negative influence on the transformation and upgrading of industrial structure, that is, the deeper the government intervention, the less favorable the transformation and upgrading of industrial structure will be. Therefore, the degree of government intervention can be properly controlled, and the transformation and upgrading of industrial structure can be started from the positive influence variables. This provides a feasible path and way for the subsequent better transformation and upgrading of industrial structure. On the other hand, it also shows that there is a

"positive cycle" interaction between artificial intelligence and industrial structure, and the lag term of industrial structure transformation and upgrading index can promote the transformation and upgrading of industrial structure in the future, which is conducive to the formation of a long-term stable positive feedback mechanism between artificial intelligence and industrial structure.

To sum up, in the process of theoretical analysis and empirical research, this thesis keeps improving the overall framework of the thesis with a scientific and rigorous attitude, ensuring the credibility of the analysis process, the authenticity of the research process and the scientificity of the final conclusion. However, due to the influence of objective factors, the following improvement space and future research directions are proposed:

On the one hand, the original data has a certain time limitation. As we all know, the development of artificial intelligence in China is relatively short, and few data of that can be effectively counted. Therefore, approximate indicators or fitting indicators can only be used for alternative research. However, with the continuous evolution and deepening influence of artificial intelligence in China, the research fields that can be expanded, the number of years of data statistics and the expansion of index dimensions will be improved. Therefore, the future research on artificial intelligence can be more scientific.

On the other hand, there is room for optimization in method model selection. This thesis adopts the generalized moment estimation method. With the continuous development of econometrics, more suitable and scientific research models will appear. In the future, other econometric models can be used for research.

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