

# The Influence of Artificial Intelligence on the High-quality Development of Three Eastern Urban Agglomerations

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**Abstract:** From five dimensions of the new development concept, a comprehensive index of high-quality development is constructed, and the relevant indicators are weighted by entropy method to obtain a high-quality development index. Based on the panel data of 63 prefecture-level cities in Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta from 2011 to 2018, the influence of artificial intelligence on high-quality development is analyzed. The empirical results show that artificial intelligence has significantly improved the high-quality development level of the three major urban agglomerations; From the perspective of intermediary effect, artificial intelligence can improve high-quality development by increasing residents' willingness to consume; From the threshold effect, we can see that the marginal effect of artificial intelligence on high-quality development is "N"-shaped nonlinear. On this basis, this paper puts forward some policy suggestions, such as increasing the investment in artificial intelligence research and development, formulating the development policy of artificial intelligence industry according to local conditions, and paying attention to personnel training in the field of artificial intelligence.

**Keywords:** Artificial intelligence; High quality development; Beijing-Tianjin-Hebei; Yangtze river delta; Pearl River Delta.

## 1. Introduction and Literature Review

China's economic development has shifted from a high-speed growth stage to a high-quality development stage. In Report to the 20th CPC National Congress, General Secretary Xi Jinping clearly emphasized that "high-quality development is the primary task of building a socialist modern country in an all-round way"[1]. Since the reform and opening up, China's economy has maintained a high growth rate of 10% for more than 30 years, with GDP increasing by 278.35 times and per capita GDP increasing by 189.65 times, and the total economic output ranks second in the world[2]. However, while achieving a miracle in quantity, there are still a series of quality problems, and the imbalance and uncoordinated economic development are still remarkable. Therefore, if China wants to achieve the goal from "getting rich" to "getting strong", it must pay attention to high-quality development. Since the reform and opening up, the development policy of "getting rich first and then getting rich" has successfully stimulated the initiative and vitality of local economic development in China. The urban agglomeration strategy plays the role of the growth pole of national economic and social development and is the main platform to support China's high-quality development. Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta are the three major urban agglomerations with large scale, strong economic strength and the most development potential in China. They play an important role in the economic and social development of "getting rich first and then getting rich" in China, and also play an important traction role in comprehensively promoting China's high-quality development.

At present, the great changes that have never happened in the world in a hundred years have accelerated their evolution, and a new round of scientific and technological revolution and industrial transformation have developed in depth [3].

Report to the 20th CPC National Congress of the Communist Party of China clearly pointed out that in the new era, we should speed up the construction of a new development pattern and build a new generation of growth engines such as information technology, artificial intelligence, biotechnology and new energy. In recent years, China's big data, artificial intelligence, cloud computing and Internet of Things industries have shown a good momentum of rapid development, and lead the world in many industrial fields. As an important driving force of the new round of global scientific and technological revolution and industrial transformation, artificial intelligence is deeply integrated with various fields of economy and society, and plays an important role in employment, consumption and economic growth [4-7], thus promoting China's high-quality development. Therefore, the impact of artificial intelligence on China's high-quality development has also led scholars to carry out exploratory research. Master (2020) started from the integration of artificial intelligence and social reproduction, and pointed out that artificial intelligence promotes the transformation and upgrading of all aspects of social reproduction, thus promoting high-quality development [8]. Li Cuini, Ge Jing, Zhao Shajunyi (2022), Chen Xiao, Zheng Yulu, Yao Di (2022) Based on the background of population aging, empirical tests prove that artificial intelligence inhibits the negative impact of population aging on high-quality development [9-10]; Yan Yazhen, Huang Xiaoyong and Wu Shucai (2022) observed that artificial intelligence technology can significantly promote the high-quality development of ethnic areas from three perspectives: macro-economy, meso-industry and micro-enterprise [11]; Yang Guang (2022) pointed out that artificial intelligence endowing fixed assets with movability will be the guarantee for China's high-quality development, and at the same time, we should pay attention to accurate consumption and employment issues [12]; Luo Liangzhong, Yu Yuqian and Tan Yunqing (2022) studied the influence of

artificial intelligence on the high-quality development of the Yangtze River Delta by measuring the high-quality development index and the density of industrial robots [13].

The Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta regions have always been the most developed regions in the country, which have played a significant role in promoting China's economic development. However, with the rapid economic development, the imbalance between regions has gradually emerged, and the effect of urban agglomerations driving the high-quality development of surrounding cities needs to be further strengthened. As a general technology to promote the fourth industrial revolution [14-15], artificial intelligence technology can help regional unbalanced growth to coordinate development through technology spillover and deep integration with the real economy [16], further expand the economic radiation driving role of urban agglomerations, and promote the change of China's economic development mode, which is the power source of China's high-quality development. So what impact does artificial intelligence have on the high-quality development of these three major urban agglomerations?

In this paper, the application level of artificial intelligence is measured by the ratio of fixed assets investment in information transmission, computer services and software industry to regional GDP. Using the panel data of 63 prefecture-level cities in Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta urban agglomerations from 2011 to 2018, combined with the intermediary effect and threshold effect model, the influence of artificial intelligence on the high-quality development of these three urban agglomerations is analyzed.

## **2. Theoretical Analysis and Research Hypothesis**

### **2.1. Artificial intelligence has a direct impact on high-quality development**

Under the background of the new era, the core connotation of high-quality development is five new development concepts, and artificial intelligence promotes regional high-quality development from these five aspects. In terms of innovation, artificial intelligence technology can shorten the R&D cycle and reduce the R&D cost of enterprises, thus having more time and funds for a new round of innovation and improvement and improving the R&D efficiency of enterprises, thus having a positive impact on technological innovation and technological progress and practicing the concept of innovation and development; In terms of coordination, artificial intelligence technology, as a universal technology, its own radiation diffusion effect can drive technological innovation and industrial structure upgrading in backward areas, thus solving the problem of unbalanced and insufficient regional development and promoting regional coordinated development; On the green side, artificial intelligence transforms the public from high-energy consumption to green intelligent consumption through intelligent planning and green trading mode, and green intelligent consumption further promotes green intelligent production, thus promoting social energy conservation and emission reduction and realizing green economic development; In terms of opening up, artificial intelligence promotes the transformation from traditional foreign trade to digital foreign trade, reduces transaction costs, promotes the smooth flow of international trade, and has a positive role in

promoting the stability and quality of foreign trade; In terms of sharing, on the one hand, artificial intelligence solves the problem of information asymmetry through big data analysis, effectively improves the efficiency of resource allocation and income distribution, and enables the labor force to share the results of economic growth. On the other hand, in terms of medical service treatment, the combination of artificial intelligence and Internet technology and equipment can realize remote operation and teaching, thus increasing the supply of medical services and increasing people's sharing of high-quality medical services.

Therefore, this paper puts forward the following assumptions:

H1: Artificial intelligence plays a positive role in promoting high-quality development.

### **2.2. Indirect influence of artificial intelligence on high quality development**

Consumption is the ultimate demand, and it is the key link and important engine to smooth the domestic circulation. Expanding domestic demand is the key to building a new development pattern in China. Since the 18th National Congress of the Communist Party of China, promoting high-quality development through consumption upgrading has become an important orientation of macro policies. As one of the "Troika" driving economic growth, consumption plays an important role in promoting high-quality development. In recent years, with the application of artificial intelligence, a new format and new mode have emerged in economic development, which leads to new consumption to accelerate the high-quality development of the economy. Especially in the application of enterprise production, artificial intelligence has improved residents' willingness to consume by reducing production costs and providing intelligent products. On the one hand, in the production process of enterprises, the intelligent production mode generated by the application of artificial intelligence optimizes the allocation of production resources, effectively reduces production costs and thus promotes the expansion of consumption scale; On the other hand, the intelligent products produced by enterprises are multifunctional, which can meet the diversified needs of consumers, create new consumption needs and promote the upgrading of consumption structure.

Therefore, this paper puts forward the following assumptions:

H2: Artificial intelligence can improve residents' willingness to consume, thus promoting high-quality development.

### **2.3. The nonlinear influence of artificial intelligence on high-quality development**

Although artificial intelligence plays a positive role in promoting high-quality development, it may have a certain threshold for promoting high-quality development because of its "substitution effect" and "creation effect". Among them, the "substitution effect" effectively makes up for the shortage of industrial labor brought about by the aging population in society, and at the same time, the intelligent industrial production links improve labor productivity, consolidate the export competitiveness of China's labor-intensive industries to a certain extent, thus promoting China's high-quality development. With the wide application of artificial intelligence, its high cost performance makes the labor force no longer have a comparative advantage over capital, and

labor-intensive industries tend to use skilled talents and artificial intelligence. Although the "creative effect" of artificial intelligence at the same time increases the employment demand of service industry and the number of knowledge-based skilled jobs is increasing, its "substitution effect" crowds out low-skilled talents, which makes the labor market have a major impact, and the increase in unemployment leads to insufficient consumption, thus having a significant negative impact on high-quality development; With the maturity of artificial intelligence, the transaction cost of artificial intelligence is declining and the labor productivity is significantly improved. The spillover effect of artificial intelligence makes enterprises in the upper, middle and lower reaches introduce artificial intelligence technology to expand reproduction and increase the demand for skilled talents. The positive effect of the demand for skilled talents is greater than the crowding-out effect of unskilled talents, which increases the employment income level, expands people's consumption demand and willingness for products and promotes high-quality development.

Therefore, this paper puts forward the following assumptions:

H3: The role of artificial intelligence in promoting high-quality development presents an "N" nonlinear growth.

### 3. Model and Data

#### 3.1. Model

Based on the data of 63 prefecture-level cities in Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta from 2011 to 2018, this paper investigates the direct and indirect effects of artificial intelligence on high-quality development by constructing benchmark regression model and intermediary effect model respectively. At the same time, in order to investigate the nonlinear effects of artificial intelligence on high-quality development, the panel threshold model is constructed by using the relevant models of Hansen(1999) and Wang(2015) to test whether there is a threshold effect [17-18].

(1) Benchmark regression model

$$Y_{it} = \alpha_0 + \alpha_1 AI_{it} + \alpha_2 C_{it} + \mu_i + \sigma_t + \varepsilon_{it}(1)$$

Among them, the explained variable Y is high-quality development, the core explanatory variable AI is artificial intelligence level, and C is the control variable in this model, including the degree of government intervention (Gov), the level of infrastructure (IF), the level of foreign direct investment (FDI), the population density (PP), I is the region, T is the time, and it is a fixed urban effect, a fixed year effect and a random error term.  $\mu_i \sigma_t \varepsilon_{it}$

(2) Mediating effect model

Artificial intelligence indirectly affects high-quality development by increasing consumer willingness. In this paper, consumer willingness is chosen as the intermediary variable to construct the following model.

$$Y_{it} = \alpha_0 + \alpha_1 AI_{it} + \alpha_2 C_{it} + \mu_i + \sigma_t + \varepsilon_{it}(2)$$

$$CW_{it} = \beta_0 + \beta_1 AI_{it} + \beta_2 C_{it} + \mu_i + \sigma_t + \varepsilon_{it}(3)$$

$$Y_{it} = \gamma_0 + \gamma_1 AI_{it} + \gamma_2 CW_{it} + \gamma_3 C_{it} + \mu_i + \sigma_t + \varepsilon_{it}(4)$$

Among them, it is the intermediary variable of this paper, that is, the willingness to consume.  $CW_{it}$

(3) Panel threshold model

The influence of artificial intelligence on high-quality development is preliminarily analyzed through benchmark

regression model and intermediary effect model. According to the previous theoretical analysis and assumption H3, it is known that artificial intelligence itself has "substitution effect" and "creation effect", and this "double effect" may make artificial intelligence have a nonlinear influence on high-quality development. Therefore, this paper takes artificial intelligence as a threshold variable and constructs the following threshold effect model:

If there is only one threshold, the single threshold model formula (5) is used.

$$Y_{it} = \alpha_0 + \beta_1 AI_{it} I(Q_{it} \leq q) + \beta_2 AI_{it} I(Q_{it} > q) + \delta C_{it} + \mu_i + \sigma_t + \varepsilon_{it}(5)$$

If there are two thresholds, the double threshold model formula (6) is used.

$$Y_{it} = \alpha_0 + \beta_0 AI_{it} I(Q_{it} \leq q_1) + \beta_1 AI_{it} I(q_1 < Q_{it} \leq q_2) + \beta_2 AI_{it} I(Q_{it} > q_2) + \delta C_{it} + \mu_i + \sigma_t + \varepsilon_{it}(6)$$

If there are three thresholds, the three-threshold model formula (7) is used.

$$Y_{it} = \alpha_0 + \beta_0 AI_{it} I(Q_{it} \leq q_1) + \beta_1 AI_{it} I(q_1 < Q_{it} \leq q_2) + \beta_2 AI_{it} I(q_2 < Q_{it} \leq q_3) + \beta_3 AI_{it} I(Q_{it} > q_3) + \delta C_{it} + \mu_i + \sigma_t + \varepsilon_{it}(7)$$

Where I () is indicator function, and I=1 if the bracket condition is met, otherwise I = 0; Q is the threshold variable artificial intelligence; Q is the threshold value; For Qq, the influence coefficient of artificial intelligence on high-quality development; When Q>q, the influence coefficient of artificial intelligence on high quality development. Double threshold and three threshold and so on.  $\beta_1 \leq \beta_2$

#### 3.2. Variable Selection

Explained variable: high quality development (lnY). Based on the new development concept in the new era of China, this paper selects 12 variables of 63 prefecture-level cities in Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta from 2011 to 2018 from five dimensions of innovation, coordination, green, openness and sharing, and uses entropy method to weight the relevant indicators to obtain a high-quality development index (see Table 1), and takes logarithm as the explained variable in this paper.

Core explanatory variable: artificial intelligence (AI). Referring to the practice of Borland and Coelli (2017), the application level of artificial intelligence is measured by the ratio of fixed assets investment in information transmission, computer services and software industry to regional GDP [19]. Because there are only provincial data, this paper uses the method of Chen Zhi, Cheng Chengping and Feng Litao (2022) to weight the proportion of fixed investment in cities in the province and get the data of fixed investment in information industry in cities [20].

Intermediate variable. Consumer willingness (CW). This paper uses the proportion of total retail sales of consumer goods in GDP to measure;

Control variables: degree of government intervention (Gov). It is expressed by the proportion of general government fiscal expenditure to GDP. Infrastructure level (IF). Expressed by highway mileage in each region. Foreign direct investment (lnFDI). Foreign direct investment is measured by the logarithm of the actual utilization of foreign investment in various regions. Urban population size (lnPP). It is expressed by the logarithm of population density in each region.

**Table 1.** High-quality development evaluation index system

Primary index	Secondary index	Three-level index	Indicator attribute	Index weight
High-quality development of Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta	innovate	Rd expenditure /GDP	+	0.2005997
	coordinate	Real GDP of cities/real GDP of provinces	-	0.0368674
		Tertiary industry /GDP	+	0.0768289
	green	Comprehensive utilization rate of general industrial solid waste	+	0.0196988
		Centralized treatment rate of sewage treatment plant	+	0.0189401
		Harmless treatment rate of domestic garbage	+	0.0133083
		Total wastewater discharge/ / GDP	-	0.0202157
		Sulfur dioxide emissions/ / GDP	-	0.0202005
	open	Industrial soot emissions/ / GDP	-	0.0014834
		Total import and export/ / GDP	+	0.4194002
	share	Number of beds per 100 people	+	0.0867501
		Number of doctors per 100 people	+	0.0857069

### 3.3. Description of data sources

The data used in this paper are the data of 63 prefecture-level cities in Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta urban agglomerations from 2011 to 2018.

The data come from the National Bureau of Statistics, China Urban Statistical Yearbook, the Ministry of Commerce of prefecture-level cities and statistical bulletins. The missing data in a certain year are supplemented by interpolation and trend method.

**Table 2.** Benchmark Regression Results

variable	LnY (high quality development)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
lnY						0.206*** (3.93)
AI (artificial intelligence)	0.133*** (5.77)	0.126*** (5.78)	0.108*** (4.86)	0.106*** (4.78)	0.105*** (4.69)	0.076*** (3.17)
GOV (government participation)		1.349*** (7.23)	1.243*** (6.63)	1.193*** (6.27)	1.213*** (6.28)	1.133*** (5.63)
IF (infrastructure)			0.128*** (3.21)	0.115*** (2.82)	0.114*** (2.79)	0.039 (0.83)
Lnfdi (foreign direct investment)				0.014 (1.49)	0.014 (1.49)	0.004 (0.35)
Lnpp (population density)					-0.044 (-0.62)	-0.025 (-0.31)
constant term	2.922*** (218.77)	2.733*** (94.47)	2.620*** (57.74)	2.589*** (51.87)	2.663*** (20.44)	2.200*** (11.14)
Urban fixation	YES	YES	YES	YES	YES	YES
Fixed year	YES	YES	YES	YES	YES	YES
observed value	504	504	504	504	504	441
R2	0.714	0.745	0.751	0.752	0.752	0.694
Number of cities	63	63	63	63	63	63

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## 4. Empirical Results and Analysis

### 4.1. Benchmark regression

Table 2 shows the benchmark regression results of artificial

intelligence on the high-quality development of Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta. In order to control the missing variables, this paper gradually adds control variables (Model 1- Model 5), and finds that artificial intelligence significantly promotes high-quality

development at the level of 1%, which is also consistent with the previous assumption H1. Among the control variables, government participation can actively guide regional economic development, strengthen the application of regional artificial intelligence, and then promote regional high-quality development; The improvement of infrastructure can reduce regional transportation costs, strengthen regional economic ties and significantly promote high-quality development; The impact of foreign direct investment on high-quality development is not significant, but it has a positive impact. The knowledge and technology spillover brought by imported foreign direct investment can improve industrial technological innovation, thus promoting high-quality development to a certain extent; The increase of urban population density will lead to the congestion of urban public services and the relative decline of people's quality of life, which will have a certain negative impact on high-quality development.

## 4.2. Analysis of intermediary effect

Table 3 shows the regression results of consumer willingness as an intermediary variable. Model 8 is the regression result of total effect, and the core explanatory variable is significantly positive (0.105), indicating that artificial intelligence has a positive impact on high-quality development; The coefficient of artificial intelligence in model 6 is significantly positive (0.031), which shows that the improvement of artificial intelligence significantly promotes people's willingness to consume; Model 7 shows that the direct effect of artificial intelligence is significantly positive (0.094) and the coefficient of consumer willingness is significantly positive (0.337), which verifies that consumer willingness plays an intermediary effect between artificial intelligence and high-quality development, which also confirms the establishment of hypothesis 2 in the previous article.

**Table 3.** Test Results of Consumer Willingness as Intermediate Variable

variable	CW (willingness to consume) Model 6	LnY (high quality development) Model 7	LnY (high quality development) Model 8
AI (artificial intelligence)	0.031*** (2.80)	0.094*** (4.24)	0.105*** (4.69)
GOV (government participation)	0.197** (2.04)	1.146*** (5.99)	1.213*** (6.28)
IF (infrastructure)	0.093*** (4.53)	0.083** (2.01)	0.114*** (2.79)
Lnfdi (foreign direct investment)	0.003 (0.70)	0.013 (1.39)	0.014 (1.49)
Lnpp (population density)	-0.012 (-0.35)	-0.040 (-0.57)	-0.044 (-0.62)
CW (willingness to consume)		0.337*** (3.54)	
constant term	0.209*** (3.20)	2.593*** (19.92)	2.663*** (20.44)
Urban fixation	YES	YES	YES
Fixed year	YES	YES	YES
observed value	504	504	504
R2	0.493	0.760	0.752
Number of cities	63	63	63

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## 4.3. Nonlinear effect analysis

In this paper, artificial intelligence is taken as the threshold

variable, and it is tested by bootstrap self-sampling for 300 times. The test results are shown in Table 4.

**Table 4.** Self-sampling test of threshold effect

Threshold variable	Threshold number	variance ratio	P value	BS times	critical value		
					1%	5%	10%
artificial intelligence	A threshold	34.06	0.0033	300	24.4550	19.6857	16.8895
	Ermenkou	92.47	0.0000	300	21.4330	15.6337	13.8161
	Sanmenken	41.01	0.0000	300	26.1895	16.7517	9.8987

It can be seen from Table 4 that the single-threshold, double-threshold and triple-threshold models have passed the significant level of 10%, indicating that there is a triple-threshold effect on the influence of artificial intelligence on

high-quality development, that is, there are three threshold values in the model. Table 5 gives the estimation results of the threshold values.

**Table 5.** Threshold estimates and confidence intervals

Threshold variable	model	threshold value	95% confidence interval
artificial intelligence	Triple threshold	0.9738	[0.9580 0.9813]
		1.3570	[1.3563 1.3666]
		1.3666	[1.3570 1.3884]

The nonlinear regression results with artificial intelligence as the threshold variable are shown in Table 6: When AI is AI0.9738, the influence coefficient of AI (artificial intelligence) on high-quality development lnY is 0.315 and is the maximum, and the test of 1% significance level shows that the promotion effect of artificial intelligence level on high-quality development is the most significant at this time; When  $0.9738 < AI \leq 1.3570$ , the influence coefficient of AI (artificial intelligence) on high-quality development lnY passed the significance level of 1%, and the coefficient value was 0.242, indicating that the artificial intelligence level at this time significantly promoted high-quality development, but the promotion effect was weakened; When  $1.3570 < AI \leq 1.3666$ , the

influence coefficient of AI (artificial intelligence) on the high-quality development of lnY is significantly positive, but the coefficient value drops to the minimum of 0.151, indicating that the promotion effect of artificial intelligence level at this time continues to weaken to the minimum. When AI is AI1.3666, the influence coefficient of AI on high-quality development lnY is significantly positive and rises to 0.233, indicating that the promotion effect of higher artificial intelligence level on high-quality development is increased, which has a significant promotion effect. From the regression results, it can be seen that the promotion effect of AI on high-quality development has an N-type relationship, which is consistent with the previous hypothesis 3.

**Table 6.** Threshold Regression Results

variable	(1) lnY	(2) lnY
GOV (government participation)	1.213*** (6.28)	1.601*** (7.50)
IF (kilometer mileage)	0.114*** (2.79)	0.254*** (5.52)
Lndi (foreign direct investment)	0.014 (1.49)	0.025** (2.28)
Lnpp (population density)	-0.044 (-0.62)	0.113 (1.37)
AI	0.105*** (4.69)	
AI·I(AI0.9738)≤		0.315*** (11.22)
AI·I(0.9738AI1.3570)<≤		0.242*** (11.72)
AI·I(1.3570<AI1.3666)≤		0.151** (2.38)
AI·I(AI1.3666)>		0.233*** (10.13)
constant term	2.663*** (20.44)	1.571*** (3.05)
observed value	504	504
R2	0.752	0.659
Number of cities	63	63
Urban fixation	YES	YES
Fixed year	YES	YES

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

#### 4.4. Heterogeneity test

From the results of heterogeneous regression in Table 7, it can be seen that the impact of artificial intelligence on the high-quality development of Beijing-Tianjin-Hebei and Yangtze River Delta is significantly positive at the level of 1%, and the impact on the high-quality development of Pearl River Delta is positive but not significant. Among them, artificial intelligence plays the greatest role in promoting the high-quality development of Beijing-Tianjin-Hebei.

Compared with the Yangtze River Delta and Pearl River Delta urban agglomerations, Beijing-Tianjin-Hebei urban agglomerations have obvious unbalanced economic development problems. As a general technology, artificial intelligence's technology spillover can promote the coordinated development of Beijing-Tianjin-Hebei region, and realize the coordinated development pattern of large, medium and small cities based on urban agglomerations and metropolitan areas to promote regional coordinated development.

**Table 7. Heterogeneity Regression Results**

variable	LnY (high quality development) Beijing-Tianjin-Hebei	LnY (high quality development) Yangtze River Delta	LnY (High Quality Development) Pearl River Delta
AI (artificial intelligence)	0.230*** (3.10)	0.127*** (4.41)	0.059 (0.44)
GOV (government participation)	1.550*** (4.64)	0.790*** (3.82)	1.052 (1.04)
IF (infrastructure)	0.061 (0.80)	0.019 (0.50)	-0.094 (-0.54)
Lnfdi (foreign direct investment)	0.031** (2.23)	0.055*** (4.91)	-0.003 (-0.08)
Lnpp (population density)	0.140* (1.85)	0.043 (0.96)	0.182 (1.15)
constant term	2.093*** (11.69)	2.504*** (25.51)	2.844*** (6.64)
Urban fixation	YES	YES	YES
Fixed year	YES	YES	YES
observed value	104	328	seventy-two
Number of cities	13	41	nine

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

#### 4.5. Robustness test

In order to further test hypothesis 1, this paper uses the transformation sample range and GMM method to test the robustness respectively.

On the one hand, because there are some differences between the municipalities directly under the Central Government and other prefecture-level cities in terms of economic development and influencing factors, this paper re-examines the sample range by excluding Beijing, Tianjin and Shanghai. On the other hand, in order to alleviate endogenous

problems, this paper adopts systematic GMM method to estimate the model. As can be seen from Table 8, in the autocorrelation test, the P value of AR(2) test is > 0.1, which accepts the original assumption that there is no autocorrelation in the second-order difference and overcomes the endogenous problem. In the over-recognition test, the P value of Hansen's test is greater than 0.1, which indicates that there is no over-recognition of tool variables in this model. The results of these two tests show that artificial intelligence has a positive and significant impact on high-quality development, indicating that the research conclusion is robust.

**Table 8. Robustness Test Results**

variable	Change the sample range	System GMM
AI (artificial intelligence)	0.087*** (3.76)	0.057* (0.033)
Control variable	YES	YES
N	480	441
AR (1)		0.091
AR (2)		0.639
Hansen		0.267

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## 5. Conclusions and Policy Implications

As a revolutionary and strategic technology that profoundly changes our social life, artificial intelligence is a new kinetic energy to promote regional coordinated development and enhance the driving ability of cities, and it is also an important starting point to realize the modernization development in the new era. Based on the panel data of 63 prefecture-level cities in Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta urban agglomerations from 2011 to 2018, this paper obtains the high-quality development index by using entropy method, and empirically tests the direct and indirect effects of artificial intelligence on high-quality development by using fixed effect, intermediary effect and threshold effect. The findings are as follows: firstly, in the overall regression results, artificial intelligence has significantly promoted the high-quality development of the

three major urban agglomerations; Second, from the intermediary effect, artificial intelligence can promote high-quality development by enhancing people's willingness to consume; Third, in terms of threshold effect, artificial intelligence has a threshold effect on high-quality development, and there is an "N"-shaped nonlinear growth on the promotion effect of high-quality development. Based on the research conclusion, in order to better play the role of artificial intelligence in promoting high-quality development, this paper puts forward the following suggestions:

First, increase investment in artificial intelligence research and development, and actively implement multi-scenario applications. At this stage, because the research and development of artificial intelligence products is still relatively weak, it is necessary to increase the investment in research and development of artificial intelligence technology and fully release the spillover of artificial intelligence

technology. First of all, enterprises should increase investment in independent research and development of scientific and technological innovation, actively improve the usability and model richness of machine learning open source framework, improve the overall versatility and learning ability, and realize multi-scenario application of artificial intelligence technology. Secondly, the government should provide some financial support for R&D investment in key technical fields of artificial intelligence, so as to alleviate the pressure of R&D funds in the early stage. Of course, the government can also implement financial subsidies for artificial intelligence patents developed by enterprises, which can reduce R&D costs to a certain extent, ensure the long-term investment of enterprises in R&D, and stimulate the R&D and application of artificial intelligence technologies.

Second, pay attention to personnel training and talent introduction in the field of artificial intelligence. At present, artificial intelligence is still in the stage of technical sprint and application exploration, and the construction of high-quality talent team is the key to the development at this stage. First of all, the central cities of urban agglomerations such as Beijing and Shanghai can make use of their rich advantages in universities and disciplines to build a discipline ecosystem and cultivate comprehensive talents. Secondly, local enterprises can establish their own talent training system by building artificial intelligence laboratories, and enterprises can also cooperate with universities to build research institutions through research donations, so as to promote the deep integration of Industry-University-Research. Finally, we should actively introduce relevant overseas talents to fill the gap of senior talents in the field of artificial intelligence, break through the bottleneck of core technology together with the trained talents, and solve the technical problems in the development of artificial intelligence.

Third, formulate policies for the development of artificial intelligence industry according to local conditions. There are many universities and scientific research institutions in Beijing, Tianjin and Hebei, especially in Beijing. We should make full use of our own talent advantages, strengthen the training and flow of talents between universities and enterprises, and pay attention to the research and development innovation of artificial intelligence technology. The industrial structure in the Yangtze River Delta region is mainly based on the secondary industry, so we should actively introduce high-tech talents and build a world-wide new manufacturing model with Shanghai as the core. However, in order to avoid disorderly competition in urban agglomerations, government departments should strengthen planning guidance and rationally allocate artificial intelligence industrial resources according to local differences and characteristics. Since the reform and opening up, the Pearl River Delta region has developed rapidly with its institutional advantages, but with the full play of the reform energy, this advantage has gradually disappeared. In order to better achieve high-quality development, on the one hand, for the electronic information industry, we should continue to enhance industrial innovation and form a higher value-added industrial chain. On the other hand, according to the development status and trend of artificial intelligence industry, a new batch of artificial intelligence industrial parks will be built, and at the same time, according to the degree of regional extroversion, the international market of artificial intelligence will be accelerated, an open innovation platform of artificial intelligence will be built, and it will be actively integrated into

the global artificial intelligence technology innovation network to continuously improve the international competitiveness of artificial intelligence technology.

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