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"The Dual Mediating Effect" of Talent Agglomeration and Industrial Synergy —— Mechanism Test of Artificial Intelligence Promoting High-Quality Regional Economic Development

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Abstract: *As the digital economy continues to empower the real economy, artificial intelligence serves as a critical driving force for regional high-quality development in the process of nurturing new-quality productivity. Based on the panel data of 30 Chinese provinces from 2015 to 2024, this paper constructs a comprehensive high-quality development index to conduct empirical analysis. Taking the development level of artificial intelligence as the core variable, this paper examines the dual parallel mediating effects of talent agglomeration and industrial collaborative agglomeration and sorts out the internal transmission mechanism. The study also conducts endogeneity treatment and regional heterogeneity analysis to compare the differences in effects among the eastern, central, and western regions. On this basis, in response to the pilot policy of artificial intelligence innovation development pilot zone, this paper leverages the quasi-natural experimental characteristics of its phased implementation and adopts the event study method to conduct a parallel trend test, so as to verify the rationality of model specification. The research findings of this paper reveal the action mechanism and spatial heterogeneity law of artificial intelligence development, which can provide empirical reference for industrial layout and regional coordinated development across regions.*

Keywords: *Artificial Intelligence; Talent Agglomeration; Industrial Synergy; Regional Coordinated Development; High-Quality Development*

1. Introduction

Currently, as a new generation of general-purpose technology, artificial intelligence (AI) has become the core engine driving the transformation and upgrading of the real economy and fostering new quality productive forces. To seize the commanding height in global competition of intelligent technology, the Chinese government has successively issued a series of top-level design documents including the "New Generation Artificial Intelligence Development Plan" and the "Opinions on Deepening the Implementation of the 'Artificial Intelligence+' Action," elevating artificial intelligence to a major national strategy. To promote the implementation and practical effect of intelligent technologies and give play to regional demonstration effects, China has established national new generation artificial intelligence innovation and development pilot zones in batches since 2019. As of 2021, a total of 18 pilot zones have been approved, forming a phased and multi-batch pattern of exogenous policy shocks, providing rare quasi-natural experimental conditions for scientifically identifying the net effects of policies. According to data from the China Academy of Information and Communications Technology, the scale of China's core artificial intelligence industry has exceeded 1.2 trillion yuan by 2025, and the intelligent economy has become an important growth pole for high-quality development. However, it cannot be ignored that China's artificial intelligence innovation resources, high-end talents, and industrial production capacity exhibit significant spatial agglomeration characteristics. The eastern region has a prominent advantage as a first mover, while the central and western regions are relatively lagging behind in development. The imbalance in regional intelligence development is prominent, which restricts the full release of artificial intelligence empowerment. In this context, the systematic evaluation of the real impact, internal transmission mechanism, and regional heterogeneity characteristics of artificial intelligence development on regional high-quality development is not only a practical need to test the effectiveness of policy implementation, but also a key issue in optimizing the spatial layout of artificial

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intelligence and promoting regional coordinated high-quality development.

In recent years, the academic community has conducted extensive discussions on the economic and social impacts of artificial intelligence (AI). Li Haowang et al (2025) empirically found that artificial intelligence can significantly promote high-quality economic development, and talent agglomeration and industrial co-agglomeration agglomeration are key transmission channels. Dai et al(2025) confirmed from the perspective of talent agglomeration that high-end factor agglomeration can effectively improve development quality, and this effect is moderated by the institutional environment[4]. Studies by Zhang et al(2026) and Wang (2026) show that industrial co-agglomeration can significantly improve economic efficiency and facilitate urban-rural integrated development. Despite the growing body of relevant research outcomes[3], there are still three obvious shortcomings: First, most existing studies only focus on the correlation analysis between AI development and regional high-quality development, lacking support from exogenous shocks and failing to effectively address endogeneity issues. Second, although existing literature has examined the mediating roles of talent agglomeration and industrial co-agglomeration, it has not conducted parallel trend tests based on exogenous policy shocks, leading to insufficiently rigorous causal identification. Third, most of the existing regional heterogeneity analyses have not been conducted within the framework of alleviating endogeneity, resulting in insufficient reliability and robustness of research conclusions.

In view of this, this article uses panel data from 2015 to 2024 at the provincial level in China. Based on the scientific measurement of regional high-quality development level, this paper takes AI development level as the core explanatory variable, systematically tests the dual mediating mechanism of talent agglomeration and industrial co-agglomeration, and conducts in-depth regional heterogeneity analysis. Meanwhile, relying on the quasi-natural experiment of national AI innovation development pilot zones, this paper employs the event study method to test the parallel trend hypothesis, so as to improve the reliability of causal identification. The research conclusions can provide empirical evidence and decision-making reference for improving policies of AI pilot zones, optimizing the spatial layout of intelligent industries, and promoting high-quality regional collaborative development.

2. Theoretical Analysis and Research Hypotheses

In the context of the deep development of the digital economy and the accelerated cultivation of new quality productive forces, the traditional extensive growth model relying on traditional factors such as capital, labor, and land is gradually weakening its growth momentum, and the development model is solidified, making it difficult to support long-term high-quality development of the regional economy[5].As a new generation of revolutionary general-purpose technology, artificial intelligence (AI) is distinguished from specialized technologies confined to single domains, featuring core technical attributes of high permeability, extensive spillover effects, and strong innovativeness. It is capable of breaking through the growth constraints and development bottlenecks of traditional factors and deeply empowering the transformation of the real economy and the upgrading of regional economies. The continuous improvement of regional AI development levels can fully unleash its unique technological attributes. It can not only directly optimize regional development models, but also drive the optimization and reconstruction of core factors including talents and industries through technological spillover effects. Relying on the two core paths of talent agglomeration and industrial synergy aggregation, AI releases development momentum and has become a core enabling carrier driving the transformation, upgrading, and high-quality development of regional economies. This article relies on the general purpose technology theory, human capital agglomeration theory, and industrial spatial spillover theory, and takes a dual perspective of direct empowerment and indirect transmission. From the three dimensions of direct technology empowerment, talent agglomeration transmission, and industrial collaborative agglomeration transmission, it systematically analyzes the internal mechanism of the impact of artificial intelligence development level on regional high-quality development, providing solid theoretical support for subsequent empirical testing. In order to effectively identify causal effects in the field of artificial intelligence and ensure the robustness and reliability of empirical results, this article subsequently conducted parallel trend tests based on the quasi-natural experimental characteristics of the artificial intelligence innovation and development experiment differentiation pilot. Other core empirical studies, such as benchmark regression, mechanism testing, and heterogeneity analysis, were conducted with the level of artificial intelligence development as the core explanatory variable.

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2.1 Analysis of the Direct Enabling Mechanism

Mechanism is based on the theory of general purpose technology, and traditional regional economy has shortcomings such as solidified development mode, lagging industrial upgrading, and single growth momentum. As a cutting-edge general technology, artificial intelligence has the empowering characteristics of global penetration and technology spillover and can be deeply integrated into regional industrial systems. As the development level of regional AI improves, it can promote intelligent transformation of traditional industries, optimize production and operation models, facilitate quality improvement, efficiency enhancement, transformation and upgrading of industries, and consolidate the industrial foundation for high-quality development. Meanwhile, the industrialization of AI can optimize regional industrial structure, directly elevate the level of regional high-quality development, and form a direct action pathway for AI to enable regional high-quality development.

Based on this theoretical logic, this paper proposes Hypothesis H1: AI development exerts a significant positive promoting effect on regional high-quality development.

2.2 Analysis of the Mediating Mechanism of Talent Agglomeration

Based on the human capital agglomeration theory, talents are the core endogenous factor for the implementation and enabling of AI technology and regional high-quality development. AI is a knowledge and technology-intensive industry. And its development will continue to stimulate the demand for technological iteration and industrial upgrading, forming a significant talent siphon effect and attracting high-end innovation and technological talent to gather in the region. Gathering talents can generate positive knowledge spillovers through knowledge exchange, technological collaboration, and achievement transformation. By activating regional innovation vitality, improving total factor productivity, transforming the advantages of artificial intelligence technology into endogenous growth drivers, and empowering high-quality regional development, the first core indirect transmission path is formed.

Accordingly, this paper proposes Hypothesis H2: Talent agglomeration plays a mediating role in AI-driven regional high-quality development.

Based on the theory of industrial spatial agglomeration and spillover, the traditional real economy generally suffers from industrial fragmentation and insufficient industrial linkage, making it difficult to form collaborative development advantages. AI boasts strong capabilities in resource integration and spatial connectivity. Artificial intelligence has strong capabilities in resource integration and spatial connectivity. Its development can break industrial information barriers and geographical constraints, lower cross-industry cooperation costs, and advance the in-depth integration of artificial intelligence, the real economy and upstream and downstream industries. It drives coordinated layout among affiliated industries and shapes a pattern of industrial collaborative agglomeration.This pattern accelerates technology diffusion, optimizes industrial division of labor and resource allocation, enlarges the technological spillover effect of AI, advances the quality upgrading of regional industrial systems and fuels high-quality economic development, which serves as the second core indirect transmission pathway.

Accordingly, this paper proposes Hypothesis H3: Industrial collaborative agglomeration plays a positive mediating role between AI development and regional high-quality development.

3. Empirical Design

3.1 Data sources

This paper selects the panel data of 30 provincial administrative regions in Chinese mainland from 2015 to 2024 as the research sample. Considering the large differences in the statistical caliber of data in Xizang and the serious lack of some indicators, it is eliminated. The economic and industrial indicator data involved in the research are respectively taken from the China Statistical Yearbook, the China Science and Technology Statistical Yearbook, the China Marketization Index Database, and the official statistical yearbooks of various provinces and cities over the years. For the small amount of missing data within the sample interval, this paper adopts the linear interpolation method to complete it, and finally forms a balanced panel dataset containing 300 observations.

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3.2 Variable Definition

3.2.1 Explained variable: High-quality Economic Development level (HQED)

The existing literature mainly measures high-quality economic development by the single indicator method and the comprehensive index method. Single indicators are mostly measured by GDP, total factor productivity [6],and so on. It can only reflect the total amount or efficiency and cannot embody the multi-dimensional connotations such as innovation, green development, and sharing [1]. This paper draws on existing research and takes the new development concepts as the core guidance to construct an index system from five dimensions: innovation, coordination, green development, openness, and sharing. Nine third-level indicators are selected to build a comprehensive evaluation system for the level of high-quality economic development. The entropy method[2] is used to calculate the comprehensive index. The specific indicators are shown in Table 1.

Table 1: Evaluation indicator system for high-quality economic development.

Primary Indicator	Secondary Indicator	Third-level indicator	Indicator attribute
Innovative Development	Innovation Input	R&D Expenditure Intensity	Positive
	Innovation Output	Sales Revenue of New Products from Industrial Enterprises above Designated Size	Positive
Coordinated Development	Industrial Structure	Industrial Structure Upgrading	Positive
	Urban-Rural Structure	Urban-rural Income Ratio	Negative
Green Development	Energy Consumption	Energy Consumption per Unit of GDP	Negative
Open Development	External Vitality	Degree of Dependence on Foreign Trade	Positive
	Foreign Capital Utilization	Capital Amount	Positive
Shared Development	Economic Growth	GDP Per Capita	Positive
	Healthcare	Number of Medical and Health Beds	Positive

3.2.2 Core Explanatory Variable: Artificial Intelligence Development Level (AI)

Most existing studies measure artificial intelligence by using industrial robot data or a single patent indicator, which can hardly reflect the overall intelligentization level of a region. To comprehensively characterize the development level of artificial intelligence, this article constructs a comprehensive evaluation index system for artificial intelligence[1] [4] using the entropy method from three dimensions: digital investment, technological innovation, and intelligent application. The specific evaluation indicators are shown in Table 2.

Table 2: Evaluation Index System for Artificial Intelligence Capability.

Primary Indicator	Secondary Indicator	Indicator Description	Attribute
Digital Input (Basic Support)	Telecommunication Infrastructure Investment	Total Volume of Telecommunication Services	Positive
Technical innovation	Technology R&D Output	Number of Authorized Artificial Intelligence Invention Patents	Positive
Intelligent Application (Output of Achievements)	Industrial Application Scale	Number of Employees in High-tech Industries	Positive

3.2.3 Mediating Variable

(1) Talent Agglomeration (TA)

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Following the approach proposed by Dai Xiang (2025) and Li Haowang (2025), this paper measures the level of talent agglomeration by dividing the proportion of employed persons with college degree or above in a province to the total employed persons in that province by the proportion of employed persons with college degree or above across the country to the total national employed persons. The calculation formula is as follows:

$$TA = \left(\frac{L_{ei}/L_i}{L_e/L}\right) \tag{1}$$

In Equation (1),L_{ei} *r*epresents the number of employed persons with college degree or above in a province. L_i represents the total number of employed persons in the province.$L_e$represents the number of college graduates and above employed nationwide. *L* represents the total number of employed persons nationwide and TA indicates the level of talent agglomeration.

(2) Industrial Co-agglomeration Index

Referring to the research of Zhao Junli (2025) and Zhang Lirong (2026), this paper adopts the adjusted E-G index to measure the co-agglomeration level of manufacturing and producer services, with the formula specified as:

$$Coagg_u = 1 - \frac{|aggm - aggps|}{aggm + aggps} + (aggm + aggps) \tag{2}$$

In Equation (2), $aggm$is the location quotient of manufacturing and$aggps$is the location quotient of producer services, both of which are calculated based on employment data. $Coagg_u$is the industrial co-agglomeration index, which simultaneously reflects the synchronicity and overall level of inter-industry agglomeration. A larger value indicates a higher co-agglomeration degree of manufacturing and producer services.

3.2.4 Control Variables

To mitigate the endogeneity bias caused by omitted variables and improve the accuracy of regression results, this paper comprehensively refers to existing relevant studies[7][8] and selects the following variables as control variables: economic development level is measured by per capita gross regional product. Urbanization rate is characterized by the proportion of urban population in the total regional population. Informatization level is reflected by internet penetration rate. Government intervention is calculated by the proportion of local general public budget expenditure to regional GDP. The degree of opening-up is expressed by trade dependence. And industrial structure is measured by the proportion of value-added of the tertiary industry in GDP.

3.3 Model Construction

3.3.1 Benchmark Regression Model

To examine the direct impact of artificial intelligence on high-quality economic development, this paper constructs a two-way fixed effects model as follows:

$$HQED_{it} = \alpha_0 + \alpha_1 AI_{it} + \sum \beta\, Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \tag{3}$$

In Equation (3), *i* denotes the province and *t* denotes the year; $HQED_{it}$represents the level of high-quality economic development; AI_{it} represents the development level of artificial intelligence; $Control_{it}$denotes the set of control variables; $\mu_i$captures the province fixed effect, $\delta_t$captures the time fixed effect, and ε_{it} is the random disturbance term.

3.3.2 Mediating Effect Model

The stepwise regression method is adopted to test the mediating transmission paths of talent agglomeration and industrial collaborative agglomeration:

$$M_{it} = \gamma_0 + \gamma_1 AI_{it} + \sum \beta\, Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \tag{4}$$

$$HQED_{it} = \eta_0 + \eta_1 AI_{it} + \eta_2 M_{it} + \sum \beta\, Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \tag{5}$$

In the equations, M_{it}represents talent agglomeration and industrial collaborative agglomeration sequentially.

3.3.3 Endogeneity Test Model

To alleviate the endogeneity problem caused by two-way causality, this paper takes the one-period

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lagged level of artificial intelligence as the explanatory variable for regression estimation:

$$HQED_{it} = \varphi_0 + \varphi_1 AI_{i,t-1} + \sum \beta \, Control_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (6)$$

4. Empirical Results and Analysis

4.1 Analysis of Baseline Regression Results

Table 3 summarizes the benchmark estimation results of the impact of artificial intelligence development on high-quality economic development. To avoid the problem of omitted variables as much as possible, control variables are gradually introduced from column (1) to column (6) to observe the influence of each variable. Column (1) presents the regression results without adding control variables but only controlling for regional and time fixed effects. It can be seen that the impact of artificial intelligence development on high-quality economic development is significantly positive at the 1% significance level. From column (2) to column (6),Urbanization rate, Internet penetration rate, Government intervention,Degree of Opening-up, industrial structure, and GDP Per Capita are added in sequence. The estimated coefficient of artificial intelligence development remains significantly positive at the 1% significance level, which verifies the validity of hypothesis H1.

Table 3: Benchmark Regression Results of the Impact of Artificial Intelligence on High-Quality Economic Development

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	-0.7752	0.176	-4.408	0.000	-1.120	-0.431
ai_weighted	0.3103	0.030	10.196	0.000	0.251	0.370
urban_rate	-0.3149	0.062	-5.082	0.000	-0.436	-0.193
internet_pen	0.0259	0.022	1.153	0.249	-0.018	0.070
gov_int	-0.1664	0.029	-5.705	0.000	-0.224	-0.109
open_degree	0.1759	0.021	8.204	0.000	0.134	0.218
ind	0.0357	0.015	2.405	0.016	0.007	0.065
lngdp	0.0954	0.019	5.097	0.000	0.059	0.132

Note: The figures in parentheses are robust standard errors. *** p < 0.01, ** p < 0.05, * p < 0.1.

All models control for two-way fixed effects of region and time. Artificial intelligence can leverage technological research and development, digital industry transformation, and employment structure optimization to enhance regional innovation and production efficiency, and promote high-quality development from multiple dimensions including industry, resources, and people's livelihoods.

The results of control variables show that opening - up, industrial structure, and per capita GDP have significant positive effects; extensive urbanization and excessive government intervention are likely to cause resource misallocation, with negative influence coefficients for both; the marginal pulling effect of Internet penetration is no longer significant.

4.2 Robustness test

The previous section has verified the promoting effect of artificial intelligence on the high-quality development of the regional economy through benchmark regression. To further enhance the credibility of the research conclusions, this paper conducts robustness tests from two aspects: data pre - processing and sample scope adjustment. The results are shown in Table 4.

Firstly, data pre-processing. To mitigate the interference of extreme values and heteroscedasticity on the regression results, this paper conducts a two-sided winsorization at the 1% level for all continuous variables in the model. Meanwhile, the natural logarithm of per capita GDP is taken to reduce the estimation bias caused by dimensional differences.

Secondly, adjusting the sample scope. On the one hand, a sub-sample from the eastern region is selected for re-regression. On the other hand, the four municipalities directly under the Central Government (Beijing, Shanghai, Tianjin, and Chongqing) are excluded, and the non-municipality samples are used for testing to eliminate the interference of factors such as resource inclination and policy preference of special administrative units.

The regression results indicate that the coefficients of the development level of artificial intelligence

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(ai_weighted) in each group of regressions are 0.341, 0.341, and 0.326 respectively, all of which are significantly positive. The estimated values are highly consistent with the results of the benchmark regression. Meanwhile, the coefficient signs and significance levels of control variables such as the urbanization rate, Internet penetration rate, and degree of opening - up are consistent with those of the benchmark regression. This suggests that the impact directions of each control variable on high-quality economic development are stable, and the model setting is consistent.

In conclusion, after data processing and sample adjustment, there are no substantial changes in the results of the core explanatory variables, which confirms that artificial intelligence can significantly promote high-quality regional economic development. The research conclusions of this paper are highly robust and reliable.

Table 4: Results of the Robustness Check

	(1)	(2)	(3)
	Double Clustering	Eastern Region	Non-municipalities directly under the Central Government
ai_weighted	0.341**	0.341***	0.326***
	(0.150)	(0.100)	(0.109)
urban_rate	-0.447	-0.447**	-0.394**
	(0.417)	(0.213)	(0.189)
internet_pen	0.000	0.000	0.036
	(0.051)	(0.058)	(0.049)
open_degree	0.130	0.130	0.043
	(0.154)	(0.157)	(0.169)
ind	-0.018	-0.018	-0.020
	(0.021)	(0.026)	(0.023)
lngdp_pc	-0.039	-0.039	-0.040
	(0.043)	(0.049)	(0.047)
gov_int_w	0.236*	0.236*	0.210
	(0.118)	(0.128)	(0.131)
_cons	0.757	0.757	0.723
	(0.586)	(0.543)	(0.527)
N	300	300	280

Note: Standard errors are presented in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

4.3 Endogeneity test

There is a two-way causal relationship between the development of artificial intelligence and high-quality regional development. The improvement of the economic development level will aggregate digital factors and support the construction of the intelligent industry, which in turn leads to endogeneity estimation bias. This paper selects the one-period lag of artificial intelligence development as an instrumental variable and conducts a test using the two-stage least squares method. The results are presented in Table 5.

The first-stage regression shows that the one-period lagged level of artificial intelligence has a significant positive correlation with the current core variable. The instrumental variable meets the requirements of relevance and exogeneity, indicating that the selection is valid. The results of the second stage indicate that the coefficient of artificial intelligence is significantly positive, showing an increase compared to the benchmark regression value. After correcting for endogenous interference, its enabling effect is objectively reflected. The overall effect trend of the control variables is consistent with the benchmark results, and the empirical characteristics of the model are stable. In summary, after alleviating the endogeneity problem, artificial intelligence can still significantly promote high-quality regional development, and the core research conclusion of this paper is robustly established.

Table 5: Results of the Endogeneity Test

	(1)	(2)
VARIABLES	stage1 hqed_weighted	stage2 hqed_weighted
ai_weighted		0.398***
		(0.111)

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urban_rate	-0.697***	-0.717***
	(0.251)	(0.214)
internet_pen	0.021	0.025
	(0.061)	(0.048)
open_degree	0.187	0.190
	(0.177)	(0.163)
ind	-0.017	-0.018
	(0.022)	(0.023)
lngdp_pc	-0.019	-0.049
	(0.052)	(0.049)
gov_int_w	0.181	0.206
	(0.137)	(0.130)
L.ai_weighted	0.239***	
	(0.068)	
Constant	0.692	1.328**
	(0.596)	(0.608)
Observations	270	270
R-squared	0.945	0.945
year FE	YES	YES
povince FE	YES	YES

Note: Robust standard errors are presented in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

5. Empirical Analysis of the Dual Mediating Pathways

5.1 Test of the Mediating Effect of Talent Agglomeration

To explore the internal transmission path through which the development level of artificial intelligence affects the high-quality development of regions, this paper conducts a test of the mediating mechanism from the dimension of talent agglomeration. The results are shown in Table 6. The results in Column (1) confirm that the main effect of the development level of artificial intelligence is significantly positive, indicating that the main effect holds. Column (2) shows that the improvement of the regional artificial intelligence development level can effectively attract the inflow of high-end talents and significantly enhance the regional talent agglomeration level. After simultaneously including the core variable and the mediating variable in Column (3), the coefficients of both are significantly positive. The coefficient of artificial intelligence decreases, indicating that talent agglomeration is an important intermediate channel through which the development level of artificial intelligence exerts its effect, and there is a significant partial mediating effect.

The results of the Bootstrap (2000 times) test show that the indirect effect is -0.0629, and the 95% confidence interval is [-0.1094, -0.0244]. Since the interval does not contain 0, it proves that this transmission channel is robust and reliable. In terms of the mechanism, the development level of artificial intelligence indirectly promotes the high-quality development of regions by agglomerating high - end talents and relies on knowledge spillover and the release of innovation vitality. Research hypothesis H2 is verified.

Table 6: Test results of the mediating mechanism of talent agglomeration

	(1)	(2)	(3)
VARIABLES	hqed_weighted	hqed_weighted	ai_weighted
ai_weighted	0.341***	0.272**	
	(0.093)	(0.124)	
talent		1.101*	2.298***
		(0.570)	(0.433)
urban_rate	-0.447**	-0.118	0.260
	(0.220)	(0.242)	(0.265)
internet_pen	0.001	-0.001	-0.161***
	(0.048)	(0.060)	(0.046)
gov_int	0.237**	0.214*	0.216
	(0.103)	(0.116)	(0.147)

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ind	-0.017	-0.017	0.021*
	(0.017)	(0.024)	(0.011)
open_degree	0.130	0.149	-0.195
	(0.108)	(0.157)	(0.189)
ln_gdp_pc	-0.039	-0.031	0.087
	(0.038)	(0.043)	(0.063)
Constant	0.755*	0.417	-0.993
	(0.419)	(0.480)	(0.711)
Observations	300	300	300
R-squared	0.946	0.947	0.968
year FE	YES	YES	YES
povince FE	YES	YES	YES

5.2 Test of the Mediating Effect of Industrial Co - agglomeration

To further identify the transmission path, this paper tests the mediating effect of industrial co-agglomeration. The results are shown in Table7, Table8, and Table9. It has been confirmed in the previous text that the development level of artificial intelligence has a significant positive promoting effect on high-quality development. The results in Column (2) show that the development of artificial intelligence can break down information barriers, optimize resource allocation, effectively promote industrial integration, and improve the level of regional industrial co-agglomeration. The regression results after including the mediating variable indicate that the coefficients of both artificial intelligence and industrial co-agglomeration are significantly positive, which means that industrial co-agglomeration also plays a partial mediating role.

The results of the Bootstrap (2000 times) test show that the indirect effect is 0.0177, and the 95% confidence interval is [0.0051, 0.0341]. Since the interval does not contain 0, it further confirms that the mediating mechanism is robust and effective. The development of artificial intelligence relies on industrial synergy and agglomeration to deepen division of labor, accelerate technology diffusion, and continuously empower high-quality regional development. Research hypothesis H3 is verified.

Table 7: Mediating Mechanism Test of Industrial Co-agglomeration: Total Effect of X on Y

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	-0.7752	0.176	-4.408	0.000	-1.120	-0.431
ai_weighted	0.3103	0.030	10.196	0.000	0.251	0.370
urban_rate	-0.3149	0.062	-5.082	0.000	-0.436	-0.193
internet_pen	0.0259	0.022	1.153	0.249	-0.018	0.070
gov_int	-0.1664	0.029	-5.705	0.000	-0.224	-0.109
open_degree	0.1759	0.021	8.204	0.000	0.134	0.218
ind	0.0357	0.015	2.405	0.016	0.007	0.065
lngdp	0.0954	0.019	5.097	0.000	0.059	0.132

R-squared: 0.8310 | Observations: 300

Table 8: Mediating Mechanism Test of Industrial Co-agglomeration: Mediation Step 1(X→M)

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	1.3824	0.901	1.535	0.125	-0.383	3.148
ai_weighted	0.6212	0.127	4.907	0.000	0.373	0.869
urban_rate	2.2027	0.335	6.566	0.000	1.545	2.860
internet_pen	-0.8190	0.122	-6.727	0.000	-1.058	-0.580
gov_int	-0.7497	0.257	-2.920	0.004	-1.253	-0.246
open_degree	0.8110	0.095	8.558	0.000	0.625	0.997
ind	0.1954	0.136	1.431	0.152	-0.072	0.463
lngdp	0.0379	0.095	0.396	0.692	-0.149	0.225

R-squared: 0.7670 | Observations: 300

Table 9: Mediating Mechanism Test of Industrial Co-agglomeration: Intermediate step 2Step2(X+M→Y)

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	-0.8135	0.179	-4.547	0.000	-1.164	-0.463
ai_weighted	0.2931	0.031	9.496	0.000	0.233	0.354
ia	0.0277	0.010	2.810	0.005	0.008	0.047

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urban_rate	-0.3759	0.074	-5.077	0.000	-0.521	-0.231
internet_pen	0.0486	0.025	1.963	0.050	6.45e-05	0.097
gov_int	-0.1456	0.026	-5.561	0.000	-0.197	-0.094
open_degree	0.1535	0.020	7.731	0.000	0.115	0.192
ind	0.0303	0.015	2.012	0.044	0.001	0.060
lngdp	0.0944	0.019	5.024	0.000	0.058	0.131

R-squared: 0.8346 | Observations: 300

In conclusion, the development level of artificial intelligence can not only directly contribute to the high-quality development of a region, but also indirectly promote it through the two paths of talent aggregation and industrial synergy aggregation. Both dual mediating conduction channels are robustly established.

6. Group Testing and Dynamic Effect Analysis

6.1 Analysis of regional heterogeneity

To explore the regional disparities in high-quality development empowered by artificial intelligence, this paper divides the samples into the eastern, central, and western regions and conducts grouped regression. The results are presented in Table10. The positive effect of artificial intelligence is only highly significant in the eastern region (coefficient: 0.5304, $p < 0.01$). The coefficients in the central and western regions are not significant, showing obvious non-equilibrium characteristics.

Table 10: Results of Heterogeneity Test

Region	AI Coefficient	Std.Err	P-value	Significance
East	0.5304	0.1203	0.0000	***
Central	-0.0725	0.0679	0.2857	-
West	0.0365	0.0967	0.7055	-

Different from the conclusion of traditional literature, this paper provides an explanation from the perspective of mechanism. In the eastern region, the innovation ecosystem is well-developed, the factor foundation is solid, the intermediary channels for the coordinated agglomeration of talents and industries are unobstructed, and the technological dividends can be released. In contrast, the central and western regions are constrained by the thresholds of talent and industrial foundation, the transmission mechanism is blocked, and the enabling effect has not yet emerged. This indicates that the driving effect of artificial intelligence is subject to dual thresholds of factor and industrial foundation.

6.2 Analysis of the Dynamic Effects of the Pilot Policy for the Artificial Intelligence Pilot Zone

To test the parallel trend assumption of the DID model and explore the dynamic characteristics of the artificial intelligence pilot policy, this paper employs the event study method for analysis. The results are presented in Figure 1. The horizontal axis represents the relative year of policy implementation ($k = 0$ denotes the year of policy implementation), the vertical axis represents the policy effect coefficient, and the error bars indicate the 90% confidence interval.

Before the policy implementation (from $k = -4$ to $k = -1$), the coefficients in each period fluctuated around 0, and the 90% confidence intervals all included 0. This indicates that there was no significant difference in the high-quality development trends between the treatment group and the control group before the policy implementation, and the parallel trend assumption was satisfied, providing a reliable prerequisite for the policy evaluation based on the DID model in this paper.

In terms of the dynamic effect characteristics, in the initial stage of policy implementation (from $k = 0$ to $k = 4$), although the policy effect generally showed an upward trend, it did not pass the significance test in some periods. It was not until the $k = 5$ period that the policy effect rose, showing an obvious characteristic of lagged release. This can be explained in combination with the test conclusion in Table11. The interaction term between the policy and the intensity of the pandemic was significantly negative, proving that the pandemic had a significant inhibitory effect on the policy effectiveness. In the initial stage of policy implementation, affected by the pandemic, talent flow and industrial collaboration were restricted, and the policy dividends could not be fully released. Therefore, the short-term effect did not appear significantly. As the impact of the pandemic gradually subsided and the regional development order returned to normal, the policy continued to play its role, showing a significant positive enabling effect in the $k = 5$ period.

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The above results indicate that the enabling effect of the artificial intelligence pilot policy has obvious dynamic lag characteristics, and the external shock of the pandemic is one of the important objective factors that limit the initial effect of the policy.

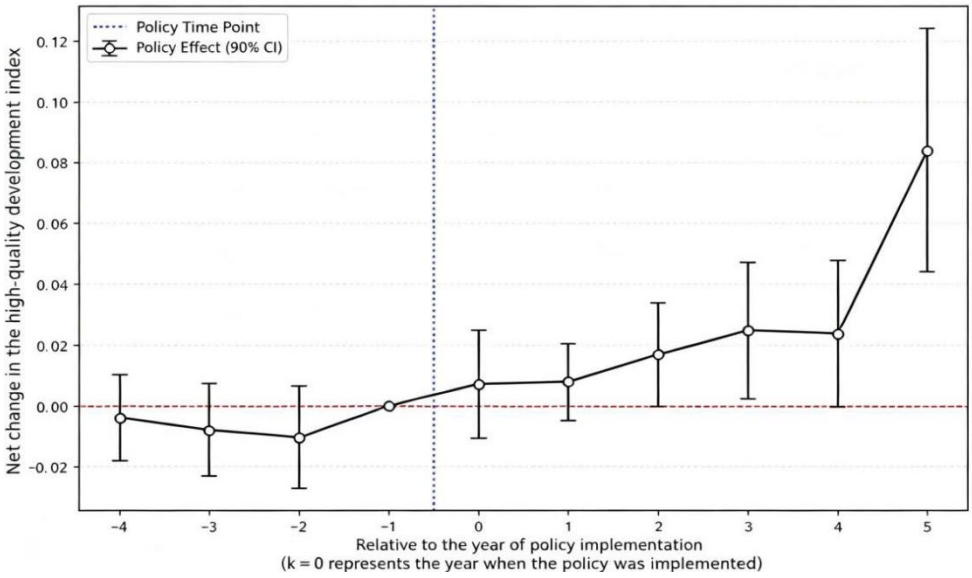

Figure 1: Results of Dynamic Parallel Trend Effect

Table 11: The Policy Effects of Artificial Intelligence

	Coefficient	P-value
Policy effect of AI	0.0176*	0.0549
Direct impact of the pandemic	0.0000***	0.0000
Policy × Pandemic intensity (core interaction term)	-0.0000***	0.0000

7. Conclusions

7.1 Key Findings

This paper constructs an evaluation system for high-quality regional development. Taking the provincial-level development level of artificial intelligence as the core variable, it conducts benchmark regression, double mediation tests, and regional heterogeneity analysis. On this basis, relying on the quasi-natural experiment in the pilot zone, it uses the event study method to verify the parallel trend. The conclusions are as follows:

First, the development of artificial intelligence significantly drives high-quality development, and there is a time lag in policy implementation. Affected by the COVID-19 pandemic, the enabling effect was relatively weak in the early stage of the pilot. After the supporting facilities were improved in the later stage, the dividends were gradually released, showing the characteristics of short-term pressure and long-term improvement.

Second, talent agglomeration and industrial collaborative agglomeration play a partial mediating role. The improvement of artificial intelligence leads to the gathering of high-end talents and the coordinated development of industries, and indirectly promotes economic quality improvement through knowledge and industrial spillover.

Third, the enabling effect decreases gradually from the eastern to the central and western regions. The eastern region has superior industrial innovation endowments and high efficiency in implementation and transformation, the central region has a heavy industrial structure and limited transformation ability, the western region has prominent factor shortages and insufficient carrying capacity, resulting in a pattern of regional differentiation.

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7.2 Policy Implications

Based on the three core conclusions drawn from the empirical research in this paper, namely the characteristics of policy dynamic time-lag, the dual-mediation transmission mechanism, and the regional heterogeneity differentiation, and considering the current situation of the development of China's artificial intelligence industry and high-quality regional development, this paper puts forward targeted and implementable detailed policy suggestions to help fully unleash the development efficiency of artificial intelligence and promote high-quality coordinated development across the whole region.

Firstly, based on the time-lag characteristics of artificial intelligence empowerment, a long-term cultivation mechanism should be established to enhance the risk resistance ability of the industry. Research has shown that there is a significant lag in the empowerment of high-quality regional development by artificial intelligence. In the short term, it is easily suppressed by external shocks such as epidemics, while in the long term, the empowerment dividends are gradually released. In this regard, various regions should abandon short-term development thinking, continuously improve digital infrastructure, steadily increase investment in artificial intelligence research and development, scenario applications, and industrial cultivation, and optimize the intelligent industry ecosystem.Meanwhile, the continuity and stability of supportive policies should be maintained, and investment should not be reduced merely on account of weak short-term empowering effects. A risk hedging system for digital industries shall be established to ensure the sustained and stable release of artificial intelligence’s empowering effects.

Secondly, smooth the dual transmission path of talent and industry, implement differentiated regional policies, and promote coordinated development across the entire region. The agglomeration of talents and the collaborative agglomeration of industries are the core paths for AI to empower high-quality development, and their empowerment effects are influenced by resource endowments, showing a gradient difference between the eastern, central, and western regions. All localities need to precisely break through the barriers to factor transmission. For example, they should improve the policies for attracting, cultivating, and motivating high-end artificial intelligence talents in a targeted manner, build innovation platforms integrating industry, academia, and research, and unleash the spillover effect of talent innovation. Additionally,local authorities should break down barriers to industrial integration, deepen the integration of artificial intelligence and the real economy, and foster industrial collaborative agglomeration. At the same time, targeted measures will be taken according to local conditions, and the eastern region will focus on the research and development of core technologies and the implementation of innovative scenarios, playing a demonstrative and radiating role. The central region focuses on the intelligent transformation of traditional industries, enhancing the level of technological transformation and industrial synergy. The western region will make up for the shortcomings in infrastructure and innovation elements, enhance the capacity to undertake intelligent industries and narrow regional development gaps.

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