A Study of the Effects of Artificial Intelligence on New Quality Productivity in Provincial Areas of China

Yuhan Su*

School of Accounting, Shandong University of Finance and Economics, Shandong Province, Jinan, China

19709781758@163.com

*Corresponding author

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Abstract: The purpose of this paper is to explore the effect of AI on the new quality productivity of Chinese provinces and its mechanism of action. Against the background of China's vigorous development of new quality productivity and entering a new stage of development, this paper empirically analyzes it based on the panel data of 30 provinces in China from 2010 to 2022, using a two-way fixed-effects model. It is found that AI has a significant positive impact on new-quality productivity, and this conclusion still holds after a series of robustness tests and endogeneity tests. The mechanism analysis shows that the overall upgrading of industrial structure plays a mediating role between AI and new-quality productivity, which promotes the improvement of regional science and technology innovation level. Heterogeneity analysis found that the impact of AI on new quality productivity is more obvious in the eastern and high economic development level regions. Therefore, the government and enterprises should propose appropriate strategies for the development level of AI in different regions to help the growth of new productivity and realize the high-quality development of China's economy.

1. Introduction

Unlike traditional productive forces, the driving engine of new productive forces is disruptive and cutting-edge technology, which is embodied in “new” changes and “qualitative” improvements in the three elements of productive forces, namely, the worker, the means of labor, and the object of labor, and is a new type of high-level productive force. The traditional comparative advantages of China's traditional productive forces are gradually fading, and the past crude economic growth model is unsustainable, with scientific and technological innovation, upgrading of the factor structure, and the digital economy becoming important means of promoting industrial upgrading.2024 Among the government's work tasks, vigorously pushing forward the construction of a modernized industrial system and accelerating the development of new-quality productive forces are in the first place, especially at the important juncture when China's socialist modernization has entered a new stage of development. Especially in the important node of China's socialist modernization into a new stage of development, the development of new quality productivity is the proper meaning of realizing high-quality development.

Artificial Intelligence, with advanced science and technology as its core, contains elements such as high-end labor, new production tools and equipment, and plays a significant role in the new quality productivity, which is the engine of the new quality productivity.AI forms the new quality productivity by empowering various industries, such as generative artificial intelligence represented by ChatGPT, which realizes the expansion of universality and fusion with natural language, and enables AI to be truly integrated into thousands of lines and hundreds of industries. At the same time, AI forms new productivity by shaping new types of laborers, creating intelligent “laborers” that are different from human beings, and playing an important role in unmanned laboratories and unmanned factories, which greatly improves production efficiency.

As China enters a new stage of development, especially in the current situation of overcapacity, the development of new productivity is an important way to get rid of the traditional crude and

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unsustainable development. Studying the impact of artificial intelligence on new quality productivity in the province, using AI to empower advanced new quality productivity, and through scientific and technological innovation and intelligent transformation, we can improve production efficiency and product quality, make revolutionary breakthroughs in technology, innovative configuration of production factors, and in-depth transformation and upgrading of industries, and at the same time, will surely bring about a change in the way of development and production, and promote the productivity of China's society to achieve a new leap forward, and Promote the high-quality development of the economy and lay a more solid material and technological foundation for the comprehensive construction of a modern socialist country. At the same time, artificial intelligence, as an important driving force of the new round of scientific and technological revolution and industrial change, is profoundly changing the economic structure and form of productivity of provinces and regions. Studying the impact of AI on the new quality productivity of provinces and regions is of great theoretical and practical significance for promoting the high-quality development of regional economy and realizing the coordinated development of the region.

At present, the theoretical research on the new quality productivity is relatively abundant, and the academic definition of the new quality productivity is clear, i.e., the new quality productivity is led by scientific and technological innovation, and it is the advanced productivity quality that is more adapted to the present time after the qualitative change on the basis of the traditional productivity. The research mainly focuses on the connotation definition, characteristics, formation logic and realization path of the new quality productivity. The study found that data elements, scientific and technological innovation, fiscal policy, digital economy and other factors can promote the development of new quality productivity. In the future, it is of great research value to conduct research on how specific fields can empower the development of new quality productivity, especially the advanced technology field represented by artificial intelligence.

Due to the complexity of the data, the mechanism of the impact of AI on the level of new quality productivity in the province remains to be explored. Based on this, the marginal contribution of this paper is as follows: based on Chinese provincial panel data, this study examines the effect and mechanism of AI's influence on provincial new-quality productivity by using a two-way fixed-effects model, combined with theoretical analysis and empirical tests. The main findings are as follows: (1) AI has a significant positive effect on new quality productivity, and this conclusion still holds after a series of robustness and endogeneity tests. (2) Mechanism analysis shows that the overall upgrading of industrial structure can promote the positive impact of AI on new quality productivity, and that improving the level of regional scientific and technological innovation and promoting the upgrading of industrial structure are important means for AI to promote the development and progress of new quality productivity. (3) The heterogeneity test shows that obvious regional heterogeneity and economic heterogeneity are the two main characteristics of AI development, and the impact effect of AI is more obvious in the eastern region and regions with high economic development level.

Studying the impact of AI on the new quality productivity in the provincial area not only helps to understand how technological progress promotes the high-quality development of regional economy, provides the basis for local governments to make scientific decisions, and promotes the optimization of economic structure and the transformation and upgrading of industries, but also has important theoretical and practical significance for the formulation of policies to promote the coordinated development of the region.

2. Literature Review

2.1. Academic Research on Artificial Intelligence

Artificial Intelligence (AI), as an important driving force of the new round of scientific and technological revolution and industrial change, is profoundly changing the economic structure and form of productivity in all provinces and regions of China. With the introduction and rapid

development of AI, there have been results in its related fields as follows: by analyzing the big data of enterprise recruitment, Chen Lin et al. (2023) [1] found that AI penetration increased the demand for labor in non-conventional occupations, especially managerial and technical positions, and at the same time increased the wage level of related occupations. This suggests that AI has a positive role in promoting the optimization of employment structure and improving the quality of the labor market. Further, Tang, Y. and Li, W. (2023) [2] analyzed the impact of AI on manufacturing employment based on the Marxian social reproduction model, and proposed the conclusion that AI promotes the seniorization of employment by promoting the "T" differentiation of the employment structure. Moreover, Liu Jindong et al.'s study [3] utilized OECD countries' data to confirm the relationship between AI development and youth unemployment rate, and pointed out that AI significantly reduces the youth unemployment rate. Lin Xiaoyue's study showed [4] that AI adoption intensity significantly enhances the innovation performance of firms by improving market intelligence response and innovation capabilities. Meanwhile, data quality and organizational flexibility, as key factors, moderated the relationship between AI and innovation performance, providing a new perspective on business management practices. In addition, the application of AI in the manufacturing industry drives firms to climb up the global value chain by improving resource allocation efficiency and enhancing R&D innovation, as confirmed in the study of Zhao et al [5]. These studies provide important perspectives for understanding the role of AI in promoting structural transformation of employment and enhancing R&D capabilities, as well as pointing out the heterogeneous impacts of AI on different groups and in different economic environments. Future research could further explore the role of AI in the economic development of different regions and how to maximize its positive impact through policy adjustments.

2.2. Academic Research on New Quality Productivity

As a new driving force to promote high-quality economic development, the combination of new quality productivity and artificial intelligence has become a hot research topic. Han Wenlong et al. (2023) [6] found that new quality productivity has a significant role in promoting economic growth by constructing a new quality productivity index system, and this role is heterogeneous in different regions. Wu Yan and He Zhengchu (2023) [7], on the other hand, from the perspective of industrial upgrading, pointed out that the new quality productivity promotes the depth and centrality of industrial integration structure. Further, Zhou Mi and Li Dongyu (2023) [8] argued that new-quality productivity is an important driving force for industrial integration and high-quality economic and social development, and that new-quality productivity occupies a central position in the industrial integration network, which facilitates the deepening and centering transformation of the industrial integration structure. And Zhou Jie and Wang Hui [9] explored the impact of scientific and technological innovation on digital new quality productivity and its mechanism of action, and found that scientific and technological innovation has a significant role in promoting digital new quality productivity.

2.3. Academic Research on the Impact of Artificial Intelligence on New Quality Productivity

Artificial intelligence, as an important part of the new quality productivity, plays a key role in promoting industrial upgrading, improving production efficiency and promoting regional economic growth. The study of Yi Liu and Zhengchu He (2024) [10] found that artificial intelligence has a significant impact on enhancing provincial new quality productivity by promoting industrial synergistic agglomeration and innovation ecosystem through the comprehensive application of entropy value method, coupling coordination degree and E-G index. It has a significant positive impact on enhancing the new quality productivity of the province. In addition, the study highlights the interregional differences in industrial synergistic agglomeration, new productivity development, innovation ecosystem construction, and high-quality development of the manufacturing industry. Future research can more deeply explore how AI affects regional economic development by influencing various aspects of new productivity.

3. Research Design

3.1. Data Sources

The research sample of this paper is 30 provinces in China from 2010 to 2022 (Hong Kong, Macao, Taiwan and Tibet are excluded due to missing data), and the AI indicators are derived from Science and Technology Statistics, China Information Yearbook to measure. New quality productivity data are from China Science and Technology Statistics Yearbook, China Statistical Yearbook, and provincial statistical yearbooks. The data of control variables come from the National Bureau of Statistics and the statistical yearbooks of each province, and the interpolation method is used to fill in the missing values of the relevant data of individual provinces (autonomous regions and municipalities) in a certain year.

3.2. Modeling

A two-way fixed-effects model is used in the study of the effect of AI on the new quality productivity of Chinese provinces. This model is able to control for province-specific effects that do not vary over time and common time-specific effects, thus estimating more accurately the impact of AI on provincial new quality productivity.

The general form of the model is as follows:

$$\mathrm{Newp}_{it} = \alpha + \beta_1 \mathrm{AI}_{it} + \beta_2 X_{it} + \gamma_i + \delta_t + \varepsilon_{it} \quad (1)$$

Newp_{it} is an explanatory variable representing the new quality productivity of the province i at t time; AI_{it} is a core explanatory variable representing the level of AI development of the province i at time t; X_{it} is a set of control variables; γ_i represents province fixed effects capturing the characteristics of each province that do not change over time; δ_t represents time fixed effects capturing the time-specific impacts that are common to all provinces; and ε_{it} is a random perturbation term.

3.3. Explanation of Variables

1) Explanatory variable:new quality productivity (Newp_{it}).

New-quality productivity refers to the new momentum of productivity development driven by new technologies, new industries, new business forms and new models in the modern economic system. Drawing on the research of Tian Youchun et al. (2017) [11], this paper defines new quality productivity as the comprehensive embodiment of the high-quality development of a region's economy. As shown in Table 1, the evaluation of new quality productivity in this paper is built on the basis of three first-level indicators of scientific and technological productivity, green productivity and digital productivity, and draws on the practice of Lu Jiang et al. (2024) [12] to construct the evaluation index system of new quality productivity. The improved entropy weight-TOPSIS method is used to assign weights to the indicators at each level of new quality productivity, so as to obtain the national development level of new quality productivity.

Table 1 New quality productivity evaluation indicator system.

First class	Second class	Serial number	Third class	Account for	Unit (of measure)	Causality
Technological productivity	Innovative productivity	A1	Innovative R&D	Number of domestic patents granted	classifier for individual things or people, general, catch-all classifier	+
		A2	innovative industries	Business income from high-tech industries	ten thousand dollars	+
		A3	innovative products	Industrial Innovation Funding for Regulated Industrial Enterprises	ten thousand dollars	+

	Technological productivity	A4	Technical efficiency	Labor productivity of industrial enterprises on a regular basis	%	+
		A5	Technical Research and Development	Full-time equivalents of R&D personnel in industrial enterprises on a regular basis	h	+
		A6	technical production	Robot mounted raw density	%	+
Green Productivity	Resource-efficient productivity	B1	energy intensity	Energy consumption/GDP	%	-
		B2	energy structure	Fossil energy consumption/GDP	%	-
		B3	water intensity	Industrial water use/GDP	%	-
	Environmentally friendly productivity	B4	Utilization of Waste	Comprehensive utilization/generation of industrial solid waste	%	+
		B5	Wastewater discharge	Industrial wastewater discharges/GDP	%	-
		B6	exhaust emission	Industrial SO2 emissions/GDP	%	-
Digital productivity	digital industry production capability	C1	Electronic Information Manufacturing	IC production	ten thousand	+
		C2	Telecommunications business communications	Total telecommunication services	ten thousand dollars	+
	Industry Digital Productivity	C3	Internet penetration	Number of Internet broadband access ports	classifier for individual things or people, general, catch-all classifier	+
		C4	software service	Revenue from software operations	people	+
		C5	digital information	Length of fiber optic cable lines/area	m	+
		C6	e-commerce	E-commerce sales	ten thousand dollars	+

2) Core explanatory variables: artificial intelligence (AI)

As a key factor in promoting the development of modern productivity, the role of artificial intelligence in promoting economic growth and industrial upgrading has received increasing attention. Referring to the research of Zou Weiyong and Xiong Yunjun (2022) [13], this paper adopts the number of AI technology patent applications as a proxy variable for the level of artificial intelligence development in the province.

3) Control variables: the following indicators that have a greater impact on the new quality productivity are selected as control variables, which include the following:

(a) Economic Development Level (EDL), measured by GDP per capita. This indicator reflects the overall scale of regional economic activities and the average economic well-being of residents, and is an important indicator of the level of regional development.

(b) Government Intervention Level (GID), measured by the share of fiscal expenditure in regional GDP. The government's fiscal policy and expenditure level directly affects the economic structure and development of the region.

(c) Research and Development Intensity (RDI), measured by the share of internal expenditure on R&D funding in regional GDP. R&D investment is an important driver of technological innovation and progress.

(d) Openness to the outside world (OWD), measured by the share of (total import and export of goods*USD to RMB exchange rate) in regional GDP. This indicator reflects the degree of the region's connection to the global economy and its ability to participate in the international division

of labor.

(e) Human Capital Level (HCL), measured by the number of students enrolled in higher education as a share of the total population. Human capital is a key factor in driving economic growth.

(f) Industrial Structure (IS), measured by the share of output value of the tertiary industry in the output value of the secondary industry. The optimization and upgrading of industrial structure plays an important role in improving productivity and economic diversity.

4. Empirical Analysis

4.1. Descriptive Statistics

In this study, the paper begins with a descriptive statistical analysis of the key variables to obtain the basic trends and distributional characteristics of the data. The statistical results are summarized in Table 2.

Table 2 Descriptive statistics.

Variables	Number of observations	Average value	Standard deviation	Minimum value	Maximum values
Newp	390	19.874	17.657	2.850	82.965
AI	390	23.692	50.254	0.020	316.720
IS	390	1.236	0.653	0.549	4.035
EDL	390	58157.982	29000	13119	156000
HCL	390	0.020	0.006	0.008	0.036
OWD	390	0.268	0.298	0.019	1.548
RDI	390	0.017	0.011	0.002	0.060
GID	390	0.270	0.199	0.095	1.251

Among them, the mean value of Newp is 19.874, and the standard deviation is 17.657, indicating that the level of new quality productivity shows an uneven state in different regions of China, highlighting the development differences between regions. The mean value of the indicator AI is 23.692, and the standard deviation is 50.254, revealing that there are obvious differences in the development process of various regions in China in the field of artificial intelligence, further reflecting the unbalanced characteristics of the level of intelligence between provinces.

4.2. Baseline Analysis

In order to assess the impact of AI on provincial new quality productivity, this paper conducts a series of fixed-effects regression analyses, as shown in Table 3. This paper gradually controls for variables such as industrial structure, economic development level, human capital level, degree of openness to the outside world, R&D intensity, and government intervention, and considers the fixed effects of province and time in order to exclude the possible effects of these factors.

Table 3 Regression to baseline.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	A1	A2	A3	A4	A5	A6	A7	A8
Variables	Newp	Newp	Newp	Newp	Newp	Newp	Newp	Newp
AI	0.053***	0.053***	0.037***	0.038***	0.035***	0.026***	0.027***	0.060***
	(0.008)	(0.008)	(0.010)	(0.011)	(0.010)	(0.007)	(0.008)	(0.022)
AI^2								-0.000*
								(0.000)
IS		-0.805	-0.087	-0.074	-0.380	-1.007	-0.713	-0.896
		(1.325)	(1.283)	(1.289)	(1.362)	(1.270)	(1.333)	(1.324)
EDL			0.000***	0.000***	0.000***	0.000***	0.000**	0.000
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
HCL				37.010	77.871	69.262	49.106	94.566
				(121.073)	(135.127)	(137.004)	(135.706)	(145.562)
OWD					-3.427	-5.676*	-5.900*	-6.491**

					(3.559)	(3.079)	(3.039)	(3.112)
RDI						745.016***	760.464***	717.042***
						(128.776)	(130.000)	(124.849)
GID							-11.509**	-12.501**
							(5.356)	(5.354)
Constant	18.607***	19.607***	12.264***	11.399***	12.587***	3.008	7.207**	8.527***
	(0.268)	(1.705)	(2.146)	(2.952)	(3.082)	(3.613)	(3.293)	(3.185)
Observations	390	390	390	390	390	390	390	390
R-squared	0.961	0.961	0.963	0.963	0.963	0.967	0.968	0.968
Time fixed effect	YES	YES	YES	YES	YES	YES	YES	YES
Province fixed effects	YES	YES	YES	YES	YES	YES	YES	YES

Note: *** indicates a significance level of 1%, ** indicates a significance level of 5%, and * indicates a significance level of 10%.

Column (1), controlling only for year and province fixed effects, finds that the regression coefficient for AI is 0.053 and is significantly positive at the 1% level. This implies that even after controlling for province and time heterogeneity, AI still has a positive effect on new quality productivity. Column (2) The regression coefficient of AI decreases slightly with the addition of control variables, but it is still significant at the 1% level, indicating that AI can drive new quality productivity. With the increase of control variables, the coefficient of AI always remains significant, indicating that AI has a positive impact on new quality productivity. This result verifies the hypothesis of this paper that AI can promote the development of provincial new quality productivity.

In order to deeply understand the impact of AI on new quality productivity, this paper explores the possible nonlinear relationship between the two. The results, as shown by the regression coefficients in Column 8 of Table 4, show that the regression coefficient of AI is significantly positive at the 10% level, while the coefficient of the squared term of AI (AI2) is significantly negative, which suggests that the impact of AI on new-quality productivity exhibits an inverted U-shape relationship - the positive impact of AI increases with the increase in the level of AI but, when the level of AI exceeds a certain threshold, its marginal effect on new quality productivity begins to decline and may even become negative. The reason for this inverted U-shaped relationship may be driven by several factors: first, in the early stages of AI development, AI technology may have a significant positive impact on productivity, but as the technology matures, its marginal benefits diminish. Second, while increasing productivity, AI may replace part of the labor force, leading to a decline in the utilization of human capital and thus negatively affecting productivity at higher levels of AI. Finally, as AI becomes more widely used, overinvestment in it may crowd out investment in other factors of production, such as R&D and human capital, thereby dampening productivity growth at higher levels of AI.

4.3. Robustness Test

In order to test the robustness of the benchmark regression results, the following three tests are performed:

4.3.1. Lagged Explanatory Variables

In the robustness test, this paper first uses AI lagged one period as an explanatory variable to help the paper control for potential reverse causality and measurement error. The regression results, as shown in column (1) of Table 4, show that the positive effect of AI with one period lag on new quality productivity remains significant, indicating that the conclusions of this paper are robust.

4.3.2. Excluding Municipalities

As municipalities directly under the central government in China, Beijing, Shanghai, Tianjin and Chongqing are of unique political and strategic importance. As a result of policy favoritism, these cities tend to have access to more quality resources, more advanced infrastructure and more

attractive talent policies. As a result, they are differently developed compared to other regions. In conducting the study, consideration may be given to excluding these cities as special cases to avoid their specificity affecting the generalizability of the findings. The regression results after excluding municipalities are shown in column (2) of Table 4, where the positive effect of AI on new quality productivity remains significant, indicating that the conclusions of this paper are still robust after excluding municipalities.

4.3.3. Tailoring

The new quality productivity indicator is a multidimensional composite evaluation system whose components involve a wide range of information categories and a large data set. Given the complexity and diversity of the data, the existence of outliers is inevitable, and these outliers may cause significant bias to the analysis results. In order to minimize the impact of outliers on the statistical analysis, this study adopts a robust data processing method, i.e., applying the 5% and 95% quantile tailoring treatment to all the variables in the baseline regression model. The results of the regression after the shrinkage treatment are shown in column (3) of Table 4, and the positive impact of AI on new quality productivity remains robust, which further confirms the findings of this paper.

Table 4 Robustness test.

	(1)	(2)	(3)
	Lagged explanatory variables	Delete municipalities	Shrinkage treatment
Variables	Newp	Newp	Newp
AI		0.030***	0.023**
		(0.009)	(0.010)
L.AI	0.019**		
	(0.007)		
IS	-0.418	0.659	1.496
	(1.397)	(1.405)	(1.586)
EDL	0.000***	0.000***	0.000**
	(0.000)	(0.000)	(0.000)
HCL	55.712	-61.114	-474.762***
	(129.246)	(161.565)	(152.875)
OWD	-6.448**	-9.798**	3.600
	(3.109)	(4.793)	(2.531)
RDI	753.875***	741.900***	481.419***
	(151.743)	(166.878)	(135.887)
GID	-11.805**	-11.624*	-24.887***
	(5.170)	(6.050)	(8.079)
Constant	6.623**	8.336**	19.292***
	(3.309)	(3.513)	(3.768)
Observations	360	338	390
R-squared	0.971	0.968	0.964
Time fixed effect	YES	YES	YES
Province fixed effects	YES	YES	YES

Note: *** indicates a significance level of 1%, ** indicates a significance level of 5%, and * indicates a significance level of 10%.

4.4. Endogeneity Analysis

In this study, despite the fact that several control variables have been included with a view to mitigating potential endogeneity issues, the findings may still be affected by endogeneity bias. The presence of reverse causality is the main source of endogeneity. Specifically, there may be a two-way dynamic relationship between AI development and NQP levels: on the one hand, AI development may contribute to the increase of NQP; on the other hand, higher levels of NQP may provide a more favorable economic environment for regional technological innovation and overall upgrading of the industrial structure, which in turn may have a reverse effect on AI development. In

addition, the problem of omitted variables may also have an impact on the estimation results of the model, leading to endogenous bias. For this reason, this paper employs instrumental variables to deal with these endogeneity problems and tests different instrumental variables.

Firstly, one period lagged AI (L.AI) is used as an instrumental variable to address possible endogeneity issues. In the first stage regression, the coefficients of the instrumental variables are significant, which suggests that there is a strong correlation between L.AI and AI, in line with the correlation test for instrumental variables. This result provides a basis for the validity of using L.AI as an instrumental variable. As shown in Table 5, the coefficient of the core explanatory variable AI in the second-stage regression is 0.017, which is significant at the 1% significance level, indicating that artificial intelligence has a significant positive impact on new quality productivity. Meanwhile, this paper also introduces Barkit as an instrumental variable, and the coefficient of AI in the second-stage regression is 0.019, which is significant at the 5% significance level, further verifying the robustness of the model.

In addition, in order to test the validity of instrumental variables, this paper conducted the Kleibergen-Paap rk Wald F statistic and Kleibergen-Paap rk LM statistic. The results show that both statistics passed the significance test with 455.721, 560.451 and 34.217, 38.853, respectively, indicating that there is sufficient correlation between instrumental variables and endogenous explanatory variables and that the instrumental variables are not weakly instrumental variables, and that the model's over-identification constraints are also satisfied. It shows that there is no problem of weak instrumental variables and non-identifiability, thus ensuring the consistency and credibility of the estimation results.

Table 5 Endogeneity test results.

	(1)	(2)	(3)	(4)
	Phase I	Phase II	Phase I	Phase II
Variables	AI	Newp	AI	Newp
AI		0.020***		0.024***
		(0.007)		(0.007)
L.AI	0.924***			
	(0.043)			
Barkit			0.933***	
			(0.039)	
IS	-5.126	-0.315	-0.040	-0.264
	(3.707)	(1.300)	(2.068)	(1.293)
EDL	0.000**	0.000***	0.000**	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
HCL	-183.518	59.390	-589.225*	74.086
	(432.166)	(119.758)	(319.987)	(120.209)
OWD	-37.421***	-5.698**	6.761	-5.122*
	(14.090)	(2.904)	(7.432)	(2.824)
RDI	59.543	752.682***	-226.475	743.853***
	(372.794)	(140.558)	(286.653)	(140.008)
GID	3.774	-11.881**	10.207	-12.261**
	(16.380)	(4.815)	(13.863)	(4.816)
Constant	9.567	-12.657	1.819	-13.332
	(11.971)	(10.219)	(9.268)	(10.224)
Kleibergen-Paap rk Wald F statistic		455.721		560.451
Kleibergen-Paap rk LM statistic		34.217***		38.853***
Observations	360	360	360	360
R-squared	0.978	0.972	0.992	0.972
Time fixed effect	YES	YES	YES	YES
Province fixed effects	YES	YES	YES	YES

Note: *** indicates a significance level of 1%, ** indicates a significance level of 5%, and * indicates a significance level of 10%.

5. Mechanism Testing and Heterogeneity Analysis

In China's social context, the rapid development of Artificial Intelligence (AI) has become a key force driving economic transformation and upgrading. This study aims to explore the impact of AI on provincial new quality productivity, with a special focus on its mechanism of action and the heterogeneous effects of different regions and levels of economic development.

5.1. Mechanism Testing

In this study, this part aims to explore the impact of AI technology on the overall upgrading of industrial structure and the mediating role of the overall upgrading of industrial structure in the relationship between AI and the development of new quality productivity. Overall upgrading of industrial structure is considered to be a key factor in promoting economic growth and technological progress, and the application of AI technology may realize this goal by increasing production efficiency, promoting innovation and improving resource allocation. To this end, this paper adopts a two-step approach to mechanism testing, first analyzing the direct impact of AI on the overall upgrading of industrial structure, and subsequently examining the mediating effect of the overall upgrading of industrial structure in the impact of AI on new quality productivity.

Table 6 Mechanism Tests.

	(1)
	A1
Variables	industrial structure
AI	0.012***
	(0.004)
IS	4.548***
	(0.963)
EDL	0.000
	(0.000)
HCL	-52.382
	(98.850)
OWD	11.955***
	(2.361)
RDI	397.720***
	(71.584)
GID	-3.280
	(4.756)
Constant	224.207***
	(4.157)
Observations	390
R-squared	0.974
Time fixed effect	YES
Province fixed effects	YES

Note: *** indicates a significance level of 1%, ** indicates a significance level of 5%, and * indicates a significance level of 10%.

In the first step of analysis, this paper takes AI as an explanatory variable and overall upgrading of industrial structure as an explanatory variable, and carries out regression analysis through the fixed effect model. The results in Table 6 show that the coefficient of AI is 0.039 and is significant at the 1% significance level, indicating that the development of AI technology has a significant positive effect on the overall upgrading of industrial structure. This result suggests that the application and promotion of AI technology may have promoted the evolution of industrial structure in a higher-end and more complex direction. The second step introduces the interaction term between AI and the overall upgrading of industrial structure to test the mediating role of the overall upgrading of industrial structure in the relationship between AI and new quality productivity. The coefficient of the interaction term is 3.104, which is also significant at the 1% significance level, indicating that the overall upgrading of industrial structure significantly enhances the positive

impact of AI on new quality productivity. This finding suggests that the overall upgrading of industrial structure is not only a natural consequence of AI development, but also plays an important mediating role in the process of AI promoting the development of new quality productivity.

In terms of control variables, this paper controls for the level of economic development, the level of human capital, the degree of openness to the outside world, the intensity of R&D and the intensity of government intervention. The estimation results show that the degree of openness to the outside world and the intensity of R&D have a significant positive effect on the new quality productivity, while the effect of the level of human capital and the intensity of government intervention is not significant. This implies that at the current stage, openness to the outside world and technological innovation are the key factors driving the development of new quality productivity, while the roles of human capital and government intervention may be more complex.

The results of the mechanism test in this paper reveal the mediating role of the overall upgrading of industrial structure in AI's influence on the development of new-quality productivity, which provides an important insight for policy formulation: while promoting the development of AI technology, attention should be paid to the optimization and upgrading of industrial structure, so as to give full play to the potential of AI in promoting the development of new-quality productivity. This finding has important theoretical and practical implications for the formulation of science and technology innovation policies and industrial upgrading strategies.

5.2. Heterogeneity Analysis

5.2.1. Regional Heterogeneity

There are significant differences in the level of economic development, policy environment, and resource endowment across regions in China, which may lead to regional heterogeneity in the impact of AI on new quality productivity. Based on the geographical location of provinces this study divides the sample into eastern, central and western regions and estimates the impact of AI on new quality productivity separately. Table 7 below shows the regression results for regional heterogeneity.

Table 7 Regression results for regional heterogeneity.

	(1)	(2)	(3)
	the east	central section	western part
Variables	Newp	Newp	Newp
AI	0.048***	0.088	0.009
	(0.008)	(0.079)	(0.019)
IS	1.975	4.759	0.300
	(1.549)	(4.418)	(0.924)
EDL	0.000*	0.001***	0.000***
	(0.000)	(0.000)	(0.000)
HCL	942.424***	218.647	-337.053***
	(193.750)	(642.652)	(127.777)
OWD	-6.386*	-45.267	18.299***
	(3.705)	(38.993)	(4.933)
RDI	788.446***	2,318.280***	-97.499
	(156.881)	(446.201)	(123.165)
GID	7.403	117.335***	-9.609*
	(18.870)	(35.780)	(5.288)
Constant	-15.550*	-75.715***	10.371**
	(9.346)	(22.266)	(4.031)
Observations	156	104	130
R-squared	0.989	0.759	0.944
Time fixed effect	YES	YES	YES
Province fixed effects	YES	YES	YES

Note: *** indicates a significance level of 1%, ** indicates a significance level of 5%, and * indicates a significance level of 10%.

The regression results for the eastern region show the most significant positive impact of AI on new quality productivity, which is related to the more developed economic environment, higher acceptance of AI technology, more mature market environment, higher technological innovation capacity and stronger policy support in the eastern region. While the central and western regions also show a positive impact of AI, there are differences in effect size and significance level, reflecting the potential challenges that still exist in AI technology innovation and application in these regions. This result demonstrates the differences between regions in terms of their level of economic development, technological innovation capacity and policy support.

5.2.2. Economic Heterogeneity

This paper divides provinces into two groups, low and high economic development, based on median GDP billions, and estimates the effect of AI separately. Table 8 below shows the regression results for economic heterogeneity.

Table 8 Economic Heterogeneity Regression Results.

	(1)	(2)
	Low level of economic development	High level of economic development
Variables	Newp	Newp
AI	0.025	0.029***
	(0.041)	(0.009)
IS	-1.339	-3.404*
	(1.372)	(2.058)
EDL	0.000*	0.000
	(0.000)	(0.000)
HCL	-247.692	612.014**
	(202.919)	(258.164)
OWD	-6.925	-9.804**
	(7.083)	(3.951)
RDI	644.515***	535.445***
	(230.049)	(153.154)
GID	7.858	-4.941
	(8.625)	(16.243)
Constant	-0.759	6.602
	(6.841)	(11.284)
Observations	164	221
R-squared	0.774	0.986
Time fixed effect	YES	YES
Province fixed effects	YES	YES

Note: *** indicates a significance level of 1%, ** indicates a significance level of 5%, and * indicates a significance level of 10%.

The regression results for regions with high economic development levels show a more significant positive effect of AI on new quality productivity, which suggests that the level of economic development may affect the application effect of AI technology by influencing the technological innovation capacity and human resource level of the region.

Through mechanism tests and heterogeneity analyses, this study delves into the mechanism of action and regional differences in the impact of AI on provincial new quality productivity. These findings provide important policy insights for the formulation and implementation of AI development strategies in different regions of China.

6. Conclusion and Recommendations

6.1. Conclusion

Advanced industries represented by AI, as an important way for the level of regional economic

development, can promote economic growth and help to build a new development pattern in which the domestic general cycle is the main body and the domestic and international double cycles promote each other. Based on China's provincial panel data, this study examines the effect and mechanism of AI's influence on provincial new quality productivity using a two-way fixed-effects model, combined with theoretical analysis and empirical tests. The main conclusions are as follows: (1) AI has a significant positive effect on new quality productivity, and this conclusion still holds after a series of robustness and endogeneity tests. (2) Mechanism analysis shows that the overall upgrading of industrial structure can promote the positive impact of AI on new quality productivity, and that improving the level of regional scientific and technological innovation and promoting the overall upgrading of industrial structure are important means for AI to promote the development and progress of new quality productivity. (3) The heterogeneity test shows that obvious regional heterogeneity and economic heterogeneity are the two main characteristics of AI development, and the impact effect of AI is more obvious in the eastern region and regions with high economic development level.

6.2. Recommendations

This paper puts forward the following policy recommendations from the perspectives of the government, enterprises and the public:

Policy Recommendations for Benchmarking Regression: first, the government should promote the deep integration of AI and industry, and encourage traditional industries to utilize big data and AI for digital transformation in order to enhance industrial competitiveness and promote the overall upgrading of industrial structure. In addition, it should strengthen the R&D and application of AI science and technology to provide a strong impetus for the development of new productivity. The government should support scientific and technological innovation activities, encourage enterprises to invest in R&D, and promote the development of high-tech industries. At the same time, it should strengthen cooperation with enterprises, educational institutions and research institutes to jointly promote the research and application of AI technology in order to realize the deep integration of industry, academia, research and application. Finally, it is also key to improve the public's digital intelligence literacy. By carrying out AI knowledge popularization activities and establishing an AI education platform, we can improve the public's understanding of AI and encourage the cultivation of high-tech talents in the direction of AI, so as to provide a strong talent guarantee for the rapid development of AI.

The mechanism analysis indicates that while promoting the development of AI technology, attention should be paid to the optimization and upgrading of industrial structure. Therefore, the government should formulate policies to promote the sophistication and overall upgrading of the industrial structure, for example, by providing incentives such as tax incentives and financial subsidies to encourage enterprises to invest in high-end technologies and innovative activities. In addition, policies should also focus on upgrading the regional level of science and technology innovation, and creating favorable conditions for the application and promotion of AI technology by establishing innovation platforms, strengthening intellectual property protection, and promoting the transformation of scientific and technological achievements.

Given the regional heterogeneity in the impact of AI on new quality productivity, the government should consider regional differences and formulate differentiated policies. In eastern regions with high economic development levels, more attention should be paid to the application and promotion of AI technology; while in central and western regions with low economic development levels, more attention should be paid to infrastructure construction and talent cultivation, and the government should increase its investment in AI infrastructure in order to improve Internet penetration and coverage. At the same time, a sound system for collecting, organizing and analyzing AI big data should be established to improve the quality and availability of data and provide strong support for the application of AI products. Through the above measures, the development of AI technology can be effectively promoted, accelerating the enhancement of new-quality productivity and promoting the sustained growth of the provincial economy and the

overall progress of society.

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