WEP Warwick Evans Publishing

International Journal of Global Economics and Management

ISSN: 3005-9690 (Print), ISSN: 3005-8090 (Online) | Volume 7, Number 3, Year 2025
DOI: https://doi.org/10.62051/ijgem.v7n3.05
Journal homepage: https://ijgem.org

# Artificial intelligence Empowers New Quality Productivity

-- Evidence from China

Shaoheng Luo *, Yingjie Huang

Management Institute, Sichuan University of Science and Engineering, Zigong 643000, China
*Corresponding Author: Shaoheng Luo

## ABSTRACT

In order to explore whether artificial intelligence has an enabling effect on the development level of new quality productivity, based on panel data spanning from 2012 to 2022, encompassing 30 provincial-level administrative regions in China, this paper empirically examines the effect of artificial intelligence on new quality productivity, the intermediary function of industrial structure enhancement and the mitigating influence of innovation. environment by using the two-way fixed effect model, mediating effect, moderating effect and threshold effect. Benchmark regression shows that AI can significantly improve the level of productivity of new qualities. This conclusion remains strong even after undergoing robustness checks and addressing potential endogeneity issues. The results of the intermediary effect test show that the upgrading of industrial structure plays a partial mediating role in the process of artificial intelligence empowering new quality productivity. The moderating effect analysis shows that the innovation environment plays a positive moderating role in the relationship between artificial intelligence and new quality productivity. The threshold effect shows that when the innovation environment exceeds the threshold value, the moderating effect is more significant.

## KEYWORDS

Artificial intelligence; New quality productivity; Upgrading of industrial structure; An innovative environment

## 1. INTRODUCTION

At present, digital and intellectual technologies have been fully supported in daily production and life, and the traditional mode of production is difficult to sustain the needs of the new stage of high-quality development. During this critical period, General Secretary Xi Jinping pointed out the need to "firmly grasp the primary task of high-quality development, and develop new productivity according to local conditions". New quality productivity refers to the new type of productivity generated by achieving key disruptive technological breakthroughs with science and technology innovation as the core in the era of digitization and intelligence. Its development relies on revolutionary breakthroughs in technology, innovative allocation of production factors ,and transformation and upgrading of industrial structure [1]. With the deepening of the scientific and technological revolution and the acceleration of industrial change, breakthroughs have been made in information technology, artificial intelligence, biotechnology, and new energy technology. Artificial intelligence, as one of the core technologies, is an important driving force of the new round of scientific and technological revolution and industrial change. As a new generation of "universal technology" [2], new elements ,and advanced scientific and technological productivity with the wisdom of the Internet [3], artificial intelligence can provide development power for green innovation [4] and technological innovation [5], and at the same time promote the optimization and upgrading of industrial structure. Thus, the

benign development of artificial intelligence may be an important driving force for the promotion of new quality productivity.

The Chinese government attaches great importance to the development of the AI industry and has introduced a series of supportive policies, such as the New Generation Artificial Intelligence Development Plan and other documents, which clearly define the overall objectives and key tasks of AI development. Local governments have responded positively to the national policy and issued a series of policies and measures to support the development of the AI industry. For example, Beijing Municipality, Shanghai Municipality, Guangdong Province, and other places have issued relevant guidelines and implementation programs to promote the innovative development of the AI industry. Industry organizations and social groups also play an important role in promoting the development of the AI industry. Academic organizations such as the Chinese Society of Artificial Intelligence and the Chinese Computer Society have actively carried out academic exchanges and talent training; research institutions such as the China Electronic Information Industry Development Research Institute have released a series of research reports on the AI industry; and industry alliances such as the China Artificial Intelligence Industry Development Alliance have actively promoted cooperation between upstream and downstream enterprises in the industry chain. The environment for the development of China's AI industry continues to improve.

In recent years, China's artificial intelligence market scale has shown explosive growth, becoming one of the most promising AI markets in the world. China initially built a more comprehensive AI industry system, and the market scale of China's core AI industry reached RMB 578.4 billion in 2023, with a five-year compound growth rate of 20.38%. Preliminary estimates indicate that the market size of China's core AI industry will reach RMB 696.4 billion in 2024. According to the latest data in 2024, the number of enterprises in the upstream and downstream of China's AI industry chain exceeds 4,700, covering chips, arithmetic, data, platforms, applications, and other related links, and the layout of the AI industry chain is becoming more and more perfect.

At present, China's artificial intelligence has widely penetrated into a number of industries, with intelligent manufacturing, intelligent finance, intelligent medical care, intelligent education, and other fields becoming the main positions for AI applications. With the continuous progress of technology and the expansion of application scenarios, China's AI industry has shown a more diversified and deeper development trend. Meanwhile, as AI-enabled new industrialization develops in-depth, the application scenarios of AI in the real economy will be further expanded. The development of artificial intelligence is driving the transformation and upgrading of industries and technological change and innovation, providing inexhaustible power for the development of new quality productivity. However, what needs to be paid extra attention to is how AI empowers the development of new quality productivity in the region? What is the action mechanism of its impact on new quality productivity? Does the mechanism of action have a threshold effect? An objective answer to the above questions can not only provide an in-depth understanding of the effect of AI on the promotion of new quality productivity but also has an important theoretical value and practical significance in promoting the new stage of high-quality development.

Compared with the existing literature, this paper contributes in several aspects: first, in terms of the research framework, it integrates AI and new quality productivity into a comprehensive model, which enriches the understanding of the impact of AI on productivity and extends the exploration of the factors influencing new quality productivity. Second, in terms of research content, this paper examines the role of AI in influencing new productivity from the perspectives of industrial structure upgrading and innovation environment. Specifically, the level of development of AI promotes the upgrading of industrial structure and then promotes the development of new productivity; and the innovation environment can also effectively regulate the effect of AI on new productivity, which further enriches the relevant literature on this topic. This further enriches the related literature on this topic. Finally, this paper analyzes the threshold effect of the two mediating variables of innovation

environment and industrial structure upgrading, which provides a reference program for the development of regional new quality productivity.

## 2. LITERATURE REVIEW AND RESEARCH HYPOTHESIS

### 2.1. Literature Review

Existing studies on the impact effects of AI are mainly clustered in three areas: change capability, labor market, and regional economic development and innovation. The first category is related to studies on AI's ability to promote change. Artificial intelligence can be used as a new production factor to help enterprises enhance manufacturing efficiency, and improve resource allocation, and promote the development of total factor productivity [6]; it can also, to a certain extent, promote the formation of new business forms, drive the transformation of traditional industries, and accelerate the change and innovation of enterprises [7]. The second category is labor market-related research. Existing research generally believes that the development of artificial intelligence can replace the labor force to a certain extent, and will promote the enhancement of human capital; Acemoglu and Restrepo[8]believe that with the development of artificial intelligence, the traditional labor force will be replaced by robots, resulting in the phenomenon of "machine generation", and will have a significant impact on the labor market, resulting in a significant impact on the employment market, leading to the formation of new industries and accelerating the transformation and innovation of enterprises [9]. The third category is the regional economic development and innovation. The third category is research related to regional economic development and innovation. The evolution of labor mode caused by AI will have an impact on resource allocation, employment scale [10], industrial structure [11], and human capital accumulation level [12], and can empower green innovation and high-quality development of regional economy through a good innovation environment [12].

New quality productivity is an important force for high-quality development. Existing research has actively discussed how to develop new quality productivity. First, in terms of scientific and technological innovation, some scholars believe that it is necessary to adhere to the innovation drive [13] so that breakthroughs and disruptive innovations can promote the formation and development of new quality productivity and reasonably utilize the advantages of generative artificial intelligence technology to open up a new track for the development of new quality productivity, and accelerate the development of new quality productivity [14]. Secondly, in terms of institutional guarantee. Some scholars have proposed that to develop the new quality of productivity, we must first recognize the role of the system [15], give full play to the role of the system of protection of the new quality of productivity, to ensure that the new national system ensures that the key core technology research and development, the formation of the new quality of productivity of the reality of the form; but also to further deepen the reform, improve the institutional mechanism to protect, and build up the development of the new quality of productivity to allow for the trial and error of the system [1]. Finally, in terms of other factors, scholars have actively explored in other fields, Feng et al. [16] discussed the influencing factors of new quality productivity from three aspects of geographic environment, economic growth, and socio-cultural influences; Zhao et al. [17] proved that the experimental area of big data accelerated the formation of new quality productivity by relying on the data elements with the double-difference method. Zou et al. [18] believed that the emerging industry innovates and develops under the dominant industry, at the same time breeding future industries, which is an important industrial direction to develop new quality productivity.

The above literature has laid a theoretical foundation for clarifying the relationship between AI and new-quality productivity, but there are still two shortcomings in the current research. First, there is a lack of direct impact of AI on new quality productivity at the empirical level. In fact, the development of AI will promote the transformation of industrial structure, the increase of data elements, and the improvement of innovation ability, which are important driving forces for the development of new-

quality productivity, and the use of empirical methods to clarify the relationship between the two has yet to be studied in depth. Second, the mechanism of AI-enabled new quality productivity needs to be analyzed in depth. Existing research mainly analyzes from the theoretical level that AI can affect the development of new productivity through human capital accumulation, labor force upgrading data factor increase, etc., and the important mechanism of industrial structure upgrading, innovation environment, government regulation, and other important mechanisms have to be broadened. Aiming at the above shortcomings, this paper mainly conducts in-depth research in the following aspects: first, from the perspective of direct impact, it conducts exploratory research on AI-enabled NQP to enrich the theory of NQP; second, it joins the mediating variable of industrial structure upgrading and the moderating variable of innovation environment, and analyzes from the mediating effect whether AI can promote the development of NQP through the upgrading of industrial structure, and analyzes from the moderating effect the role of innovation environment in AI's impact on NQP. The second is to add the mediating variable of industrial structure upgrading and the regulating variable of innovation environment to analyze whether AI can promote the development of new quality productivity through industrial structure upgrading from the mediating effect, and analyze the regulating role of innovation environment in the process of AI's influence on new quality productivity from the regulating effect, so as to expand the mechanism of AI influencing new quality productivity.

## 2.2. Research Hypothesis

Considering the current research results on the relationship between artificial intelligence and new quality productivity, most of the literature analyzes that artificial intelligence can influence the development of new quality productivity from the theoretical level, and little literature explores the relationship between the two from the empirical level, and the mechanism of the role of the two is still to be analyzed in depth. The innovation of this paper lies in the empirical study of the relationship between AI and NQP and analyzes the mechanism of AI and NQP based on the two perspectives of industrial structure upgrading and innovation environment. Therefore, in terms of the theoretical mechanism, it mainly focuses on the direct impact of AI on new quality productivity, the intermediary role of industrial structure, and the moderating role of the innovation environment.

### 2.2.1. Direct impact of AI on new quality productivity

Science and technology are the first productive forces, and artificial intelligence is regarded as a new generation of "universal technology" following the Internet and is the culmination of information technologies such as the Internet, cloud computing ,and big data [19]. Combined with Marx's theory of productivity, the impact of artificial intelligence on new productivity includes at least the following two aspects: first, the development of artificial intelligence promotes the development and change of exchange relations, thus promoting the change of resource allocation. Reasonable resource allocation can provide the necessary support and guarantee for new quality productivity. Taking high-tech enterprises as an example, the application of artificial intelligence technology will inevitably put more resources into the field of scientific and technological innovation, thus promoting the research and development and application of new technologies, and ultimately promoting the development of new quality productivity. Second, the popularization of AI technology improves the level of human capital accumulation [12]. A solid talent base can enable laborers to leap into higher quality strategic and applied talents, injecting momentum into the development of new quality productivity. In addition, artificial intelligence can be used as a new type of technology, which is comprehensively added to production activities, promoting the level of regional green innovation, and then promoting the development of regional new quality productivity. Based on this, this paper proposes research hypothesis 1:

Research Hypothesis 1: Artificial Intelligence can positively influence the level of development of new quality productivity in the region.

#### 2.2.2. Mediating mechanism of Artificial intelligence Affecting New Quality Productivity: Industrial Structure Upgrading

Artificial intelligence can influence the development of new quality productivity through the upgrading of industrial structures. Firstly, the application and popularization of AI technology can create new jobs and provide fundamental support for the transformation and upgrading of industrial structure; secondly, AI accelerates the integration of industries to a certain extent, promotes the rise and development of new industries, and promotes the upgrading of industrial structure. The transformation and upgrading of industrial structure is conducive to promoting the innovative development of enterprises, promoting the vertical change of industries, and making economic growth from traditional manufacturing industries to high-tech industries [20], which is an important basis for the development of new quality productivity. Finally, AI can also significantly enhance the data processing efficiency of enterprises, liberate the potential energy of data as a new type of production factor, promote the transformation and upgrading of enterprises [16], and promote the upgrading of industrial structure and the development of new quality productivity in the region. Based on the above analysis, this paper proposes research hypothesis 2:

Research Hypothesis 2: Artificial Intelligence positively affects the development of new quality productivity through industrial structure upgrading.

#### 2.2.3. Regulatory mechanisms of artificial intelligence affecting new quality productivity: the innovation environment

Artificial intelligence, through the addition of data elements, changes the traditional production function and drives technological innovation to empower new quality productivity, a process that requires a favorable external innovation environment [21]. The better the innovation environment, the lower the uncertainty level of enterprise technological innovation and R&D risk, the higher the enthusiasm for technological innovation and product R&D , and also significantly improve the innovation efficiency, support the innovation activities ,and enhance the city's innovation capacity [22], which is more conducive to the development of new-quality productivity. In regions with a favorable innovation environment, the level of human capital accumulation is higher, innovation and entrepreneurship are more active, and the transformation of scientific and technological achievements is more rapid, which strengthens the environmental foundation for the cultivation and development of new quality productivity. Based on the above analysis, this paper proposes research hypothesis 3:

Research Hypothesis 3: Innovation environments can positively moderate the impact of AI on new quality productivity.

## 3. RESEARCH DESIGN

The purpose of this paper is to empirically explore the relationship between artificial intelligence and new quality productivity and therefore to select the appropriate research variables, collect data, and construct an empirical model.

### 3.1. Modeling

The following econometric regression model was constructed to test the research hypothesis 1 presented in the previous section, i.e., the direct impact of AI on new quality productivity:

$$NQP_{it} = \beta_0 + \alpha AI_{it} + \beta X_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (1)$$

Where NQP denotes new quality productivity, AI denotes artificial intelligence, and X is the set of all control variables, including population size (POP), industrial agglomeration (LA), urbanization

level (LOU), and economic development level (ED). λi is the province-fixed effect, μt is the time-fixed effect, and ε it is the random perturbation term.

To test the mediating role of industrial structure upgrading, industrial structure upgrading is introduced into the following econometric model:

$$NQP_{it} = \beta_0 + \alpha_1 AI_{it} + \beta X_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (2)$$

$$LS_{it} = \alpha_0 + \alpha_2 AI_{it} + \beta X_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (3)$$

$$NQP_{it} = \alpha_0 + \alpha_3 AI_{it} + \alpha_4 LS_{it} + \beta X_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (4)$$

Where LS denotes industrial structure upgrading and the rest of the variables are consistent with the above. The estimated coefficients of α1, α2, α3 and α4 in equations (2)-(4) are the focus of the estimation, if the coefficients are all significant, it means that industrial structure upgrading is a full mediator, and if α3 is not significant the rest of the coefficients are significant, it means that industrial structure upgrading is a partial mediator.

Further, in order to test the moderating role of the innovation environment, a regression model is constructed for the introduction of the interaction term between the innovation environment and artificial intelligence:

$$NQP_{it} = \beta_0 + \alpha_1 AI_{it} + \gamma CR_{it} + \beta X_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (5)$$

$$NQP_{it} = \beta_0 + \alpha_1 AI_{it} + \gamma CR_{it} + \rho AI_{it} \times CR_{it} + \beta X_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (6)$$

Where CR denotes the innovation environment, AI×CR denotes the interaction term between AI and the innovation environment, and the rest of the variables are consistent with the above. In Equation (6) ρ is the estimated coefficient of focus, if it is significantly positive, the innovation environment does have a significant positive moderating effect on the relationship between AI and new quality productivity; if it is significantly negative, it means that the innovation environment has a significant negative moderating effect in the relationship between AI and new quality productivity.

## 3.2. Variable Selection and Data Description

### 3.2.1. Explained Variables

New Quality Productivity (NQP): Combined with General Secretary Xi Jinping's relevant discourse and extensive research in the academic world, NQP covers at least three major aspects of science and technology, green and digital, this paper constructs an indicator system for the development level of NQP by taking into account factors closely related to science and technology, such as active innovation and technology cultivation, drawing on the basis of Lu et al [23]. The specific indicators are shown in Table 1. The entropy weight Topsis method is used to measure the score factor of regional new quality productivity.

**Table 1.** Indicator system

| Primary indicators | Secondary indicators | Serial number | Tertiary indicators | Measurement indicators | Property |
|---|---|---|---|---|---|
| Science and technology production capability | Blaze new trails production capability | A1 | Innovative R&D | Domestic Patent Grants | + |
| | | A2 | Innovative industries | Business income from high-tech industries | + |
| | | A3 | Innovative products | Funding for industrial innovation in industrial enterprises above the designated size | + |
| | | A4 | Innovation is alive and well | Entrepreneurial activity: number of new start-ups per 100 people | + |
| | Skill production capability | A5 | Technical Products | Expenditures on new product development (million yuan)/GDP | + |
| | | A6 | Technical Research and Development | Full-time equivalents of R&D personnel in industrial enterprises above teh designated size | + |
| | | A7 | Technical production | Robot mounting density | + |
| | | A8 | Technical cultivation | Expenditure on education/total fiscal expenditure | + |
| Greener production capability | Resource conservation type of productivity | B1 | Energy intensity | Energy consumption/GDP | - |
| | | B2 | Water intensity | Fossil energy consumption/GDP | - |
| | Environmentally friendly type of productivity | B3 | Utilization of Waste | Comprehensive utilization of industrial solid waste/GDP | - |
| | | B4 | Exhaust emission | Industrial $SO_2$ emissions/GDP | - |
| Numeric production capability | Digital industry production capability | C1 | Percentage of enterprise informatization | Number of enterprises with e-commerce trading activities/total number of enterprises | + |
| | | C2 | Telecommunications business communications | Total telecommunication services | + |
| | Industry figures production capability | C3 | Internet penetration | Number of Internet broadband access ports | + |
| | | C4 | Enterprise Digitization | Enterprise digitization level | + |

### 3.2.2. Core explanatory variables

Artificial Intelligence (AI). Some scholars have examined the development level of regional AI from the aspect of robot installation density, but the installation density of robots focuses more on the top of enterprises, and the carving reflects the development level of AI in terms of production activities,

and the installation density of robots does not adequately reflect the actual situation of regional talent focus, investment level, research and development activities, and active innovation. Based on this, this paper measures the level of regional AI with the number of AI enterprises, and in order to reduce the problem of heteroskedasticity, the logarithmic value of the number of AI enterprises is used as a proxy variable for AI, which is denoted as AI.

#### 3.2.3. Mediating variables

Industrial Structure Upgrading (IS). Industrial structure upgrading is the core driving force to realize the construction of the modernized industrial system, and it is also an important factor in generate new quality productivity. In this paper, we refer to the research of Chen and Gao [24] and measure the industrial structure upgrading by the ratio of value added of tertiary industry to GDP, which is denoted as LS.

#### 3.2.4. Moderating variables

Innovation Environment (CR). The regional innovation environment is one of the important factors affecting the development of new quality productivity, in order to comprehensively measure the regional innovation environment, this paper selects the regional innovation index measured by Peking University's Enterprise Big Data Research Center to measure the level of regional innovation environment, which is noted as CR.

#### 3.2.5. Control variables

With reference to the relevant literature, this paper selects the following control variables: (1) POP denotes the population size, measured by the natural logarithmic value of the resident population in each region; (2) LA denotes the industrial agglomeration, measured by the ratio of each province's value added of industry to that of the nation as a whole and the ratio of the gross domestic product (GDP) of each province to the GDP of the nation as a whole; (3) LOU denotes the level of urbanization, measured by the ratio of the urban population to the total population (3) LOU denotes the level of urbanization, which is measured by the ratio of urban population to total population. (4) ED denotes the level of economic development, measured by the logarithm of the GDP per capita of each province calculated for the base period of 2011.

### 3.3. Sample Selection and Data Sources

Since some data are missing in Tibet, this paper selects 30 provinces in China as samples from 2012-2022, and the data are obtained from the National Bureau of Statistics, CEIT(China Statistical Database), China Statistical Yearbook, China Science and Technology Statistical Yearbook, China Energy Statistical Yearbook, and the statistical yearbooks of each province in the past years, and the linear interpolation is used to fill in some of the missing data. The linear interpolation method was used to make up the missing data. The descriptive statistics of the variables are shown in the following Table 2.

**Table 2.** Descriptive Statistics

| | | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|---|
| VARIABLES | account for | N | mean | sd | min | max |
| NQP | new mass productivity | 330 | 0.244 | 0.153 | 0.110 | 0.824 |
| AI | artificial intelligence (AI) | 330 | 3.510 | 0.610 | 2.140 | 5.197 |
| LS | industrial structure | 330 | 0.503 | 0.0872 | 0.345 | 0.839 |
| POP | Size of population | 330 | 3.566 | 0.322 | 2.757 | 4.103 |
| LA | industrial agglomeration | 330 | 0.0261 | 0.0390 | 0.000356 | 0.217 |
| LOU | urbanization level (of a city or town) | 330 | 0.602 | 0.119 | 0.354 | 0.942 |
| ED | Level of economic development | 330 | 4.053 | 0.202 | 3.734 | 4.693 |
| Number of ids | | 30 | 30 | 30 | 30 | 30 |

# 4. EMPIRICAL ANALYSIS

On the basis of the previous research, this part of the study is based on the collected data to develop the relationship between artificial intelligence and new quality productivity to measure, in order to ensure the robustness and reliability of the experimental results, the instrumental variables method, as well as a series of robustness tests, are utilized. Under the premise of ensuring that the conclusions are credible, the analysis of the mechanism of action is carried out, so as to verify the research hypotheses mentioned above.

## 4.1. Baseline Regression Analysis

The results of the baseline regression of the impact of artificial intelligence on the level of development of new quality productivity are shown below Table 3. Among them, column (1) is the direct regression result between AI and new quality productivity, and column (2) is the regression result after adding the control variable: population size (POP) on the basis of column (1), at this time, the regression coefficient of AI on new quality productivity is 0.0646, which is significant at the level of 1%; and the regression result of population size (POP) is significantly positive, which shows that population size positively affects the development of new quality productivity. Column (5) is the regression result after adding industrial agglomeration (LA), urbanization level (LOU), and economic development level (ED) sequentially on the basis of Column (2); at this time, the urbanization level and the economic development level are significant at 1% level, which indicates that they can positively affect the development of new quality productivity. From the results, it can be seen that the coefficient of Artificial Intelligence (AI) is significantly positive at the 1% level before and after adding control variables and controlling fixed effects, indicating that AI can positively and significantly affect the development of new quality productivity. As a result, hypothesis 1 is valid.

**Table 3.** Baseline Regression

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| VARIABLES | NQP | NQP | NQP | NQP | NQP |
| AI | 0.0785*** | 0.0646*** | 0.0656*** | 0.0540*** | 0.0568*** |
| | (0.0173) | (0.0175) | (0.0176) | (0.0174) | (0.0171) |
| POP | | 0.366*** | 0.354*** | 0.268** | 0.0759 |
| | | (0.106) | (0.109) | (0.108) | (0.119) |
| IA | | | 0.182 | 0.0359 | -0.151 |
| | | | (0.400) | (0.391) | (0.388) |
| LOU | | | | 0.234*** | 0.246*** |
| | | | | (0.0586) | (0.0576) |
| ED | | | | | 0.131*** |
| | | | | | (0.0372) |
| Year | Y | Y | Y | Y | Y |
| Province | Y | Y | Y | Y | Y |
| Constant | 0.0126 | -1.248*** | -1.214*** | -0.998*** | -0.854** |
| | (0.0504) | (0.368) | (0.375) | (0.370) | (0.365) |
| Observations | 330 | 330 | 330 | 330 | 330 |
| R-squared | 0.146 | 0.180 | 0.181 | 0.224 | 0.256 |
| Number of ids | 30 | 30 | 30 | 30 | 30 |
| Note: ***, **, and * denote 1%, 5%, and 10% significance levels, respectively; heteroskedasticity clustering robust standard errors of estimated coefficients are in parentheses. Same below. | | | | | |

## 4.2. Robustness Tests

In order to make the results of the study more robust, this study uses three methods for robustness testing. First, changing the sample period. Considering the possible impact of the new crown epidemic on the development of AI and new quality productivity, this paper excludes the post-2019 samples from the regression, and the regression results are shown in Table 4. column (2). Second, the measurement of the core explanatory variables is replaced. The installed density of robots (AI1) is used to measure the level of AI development and is included in the regression model, and the regression results are shown in Column (3). Third, change the measurement of the explanatory variables. This study replaces the measurement of new quality productivity to do the robustness test, using Jue Wang et al. to get the score factor of new quality productivity in each province from the three criterion layers of laborers, labor objects, and labor materials, and the regression results of the matching post-test are shown in column (4). Using the above methods for the robustness test, the regression results of AI on new quality productivity are all significant at the 1% level, which is consistent with the benchmark regression, indicating that the findings of the study are robust.

**Table 4.** Robustness Tests

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | NQP | NQP | NQP | NQP1 |
| AI | 0.0785*** | 0.134*** | | 0.0468** |
| | (0.0173) | (0.0428) | | (0.0212) |
| AI1 | | | 4.89e-07*** | |
| | | | (7.38e-08) | |
| Controls | Y | Y | Y | Y |
| Year | Y | Y | Y | Y |
| Province | Y | Y | Y | Y |
| Constant | 0.0126 | -1.806*** | -0.310 | -1.860*** |
| | (0.0504) | (0.500) | (0.359) | (0.452) |
| Observations | 330 | 240 | 330 | 330 |
| R-squared | 0.146 | 0.337 | 0.331 | 0.525 |
| Number of ids | 30 | 30 | 30 | 30 |

## 4.3. Endogeneity Test

The benchmark regression verifies that AI positively and significantly affects the level of development of new quality productivity in the region, but the regression results may be problematic in two ways. On the one hand, there is the omitted variable bias. In this paper, it is inevitable that the regression will leave behind variables that will positively or negatively affect the development of new quality productivity, both of which will have an impact on the measurement of new quality productivity; there is also the problem of not considering the full range of control variables, which is easy to cause the bias of omitted variables. On the other hand, there is bidirectional causality. Artificial intelligence will positively affect the development level of regional new quality productivity, and at the same time, the continuous development of new quality productivity will also push back the process of artificial intelligence technology application, thus promoting the development of artificial intelligence. Based on the above reasoning, this paper alleviates the endogeneity problem of the model from the following two aspects: first, increase the control variables. A large number of studies have proved that the level of industrialization development (IND) and government support (GOV) affect the development of regional new quality productivity. Among them, regions with a higher level of industrialization (IND) are more mature in the development of AI, and all kinds of resources have reached a relatively saturated state, and continuing to increase investment may lead to the waste of talent, production materials and other factors, thus affecting the development of new quality productivity; the strength of government support (GOV) affects the environment for the development of the region, and the stronger the support, the more conducive to the development of new quality productivity, both in terms of resources and the environment. The stronger the support, the more favorable both resources and environment are for the development of new quality productivity. Based on this, this paper includes industrialization development level (IND) and government support (GOV) as control variables in the model for regression, and the regression results are shown in column (1) of Table 5, IND negatively affects the development of new quality productivity at 5% level; GOV positively affects the development of new quality productivity at 1% level, which preliminarily verifies the above conjecture; in addition, the regression coefficient of artificial intelligence on new quality productivity is 0.0466, which positively affects the development of new quality productivity at 1% level, verifying that the endogeneity problem of the model established in this paper is weak. The second is, the instrumental variable method. This paper draws on the practice of Huang et al.[25] and uses the number of fixed-line telephones in each province in 1984 as an instrumental variable. On the one hand, the development of artificial intelligence and traditional information and communication, such as the number of fixed-line telephones is inseparable, the takeoff of artificial intelligence technology to a certain extent depends on the improvement and layout of traditional

telecommunication facilities, and the two have a strong correlation in both space and time and in the connotation. On the other hand, the fixed telephone as a relatively traditional communication tool, compared with the emerging technology products use rate is decreasing, as the technology continues to take off in the era of digital intelligence, the emergence of new technologies, to a large extent, has replaced the role of the fixed telephone, and the fixed telephone is difficult to have a direct impact on the level of development of the region's new quality of productivity to meet the exclusivity. Based on this, this paper refers to the method of Nunn and Qian [26] to establish the interaction term (IV) as an instrumental variable for the development level of AI between the national IT service revenue in the previous year and the historical data of landline telephone in 1984.

From the results of the regression of Table 5. column (2), there is a significant correlation between the instrumental variables and explanatory variables in the first stage. The test statistic for the non-identifiable problem is significant at the 1% level, rejecting the original hypothesis of non-identifiability; the test statistic for the weak instrumental variable is greater than the critical value (8.96) at the 15% significant level, indicating that the model does not have a weak instrumental variable problem; in the second-stage regression, the AI exhibits a significant positive effect on the level of the development of new qualitative productivity, indicating that the baseline model does not suffer from a serious endogeneity problem.

**Table 5.** Endogeneity test

| | (1) | (2) | (3) |
|---|---|---|---|
| | Add Controls | first stage | second stage |
| VARIABLES | NQP | AI | NQP |
| IV | | -0.0000*** | |
| | | (0.0000) | |
| AI | 0.0466*** | | 0.3406*** |
| | (0.0163) | | (0.0946) |
| IND | -0.101** | | |
| | (0.0499) | | |
| GOV | 0.345*** | | |
| | (0.0664) | | |
| Constant | -2.077*** | -0.7415 | -0.5880 |
| | (0.407) | (1.5244) | (0.5904) |
| Controls | Y | Y | Y |
| Year | Y | Y | Y |
| Province | Y | Y | Y |
| Observations | 330 | 330 | 330 |
| R-squared | 0.338 | 0.991 | 0.974 |
| Kleibergen-Paap LM | | | 10.876*** |
| Kleibergen-Paap Wald F | | | 11.739 [8.96, 16.38] |
| Note: 1. The Kleibergen-Paap LM statistic is a non-identifiable test; the Kleibergen-Paap Wald F statistic is a weakly identifiable test.2. The critical values at the 15% and 10% levels of the Stock-Yogo test are shown in [ ]. | | | |

## 4.4. Mechanism Analysis and Threshold Effects

### 4.4.1. Analysis of mediating effects

Based on the previous theoretical analysis, industrial structure upgrading is included in the regression model, and the method of hierarchical regression is used to analyze in depth the paths through which AI affects the development of new quality productivity. Table 6 report the results of the mediation effect test of industrial structure upgrading:

**Table 6.** Mechanism Analysis

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| VARIABLES | NQP | LS | NQP | NQP | NQP |
| AI | 0.0568*** | 0.0698*** | 0.0474*** | 0.0707*** | 0.0806*** |
| | (0.0171) | (0.0168) | (0.0175) | (0.0168) | (0.0166) |
| LS | | | 0.135** | | |
| | | | (0.0600) | | |
| CR | | | | 0.00251*** | 0.00243*** |
| | | | | (0.000542) | (0.000529) |
| AI*CR | | | | | 0.000874*** |
| | | | | | (0.000216) |
| Constant | -1.806*** | 1.423*** | -1.046*** | -0.486 | -0.0741 |
| | (0.500) | (0.358) | (0.372) | (0.362) | (0.366) |
| Controls | Y | Y | Y | Y | Y |
| Year | Y | Y | Y | Y | Y |
| Province | Y | Y | Y | Y | Y |
| Observations | 330 | 330 | 330 | 330 | 330 |
| R-squared | 0.256 | 0.797 | 0.269 | 0.309 | 0.347 |
| Number of ids | 30 | 30 | 30 | 30 | 30 |

First, column (1) is the result of the benchmark regression after adding control variables, in which the regression coefficient of AI on new quality productivity is 0.0568, which is significant at 1% level, indicating that AI positively and significantly affects the development of new quality productivity. Secondly, column (2) is the result of the regression of AI on industrial structure upgrading, in which the regression coefficient of AI on industrial structure upgrading is 0.0698, which is significant at 1% level, indicating that AI positively and significantly affects industrial structure upgrading. Finally, column (3) is the result of the regression of industrial structure upgrading on the development level of new quality productivity, in which the regression coefficient of industrial structure upgrading on new quality productivity is 0.135, which is significant at the 5% level; it indicates that industrial structure upgrading can significantly contribute to the development of new quality productivity and that in regression model (3), the regression of artificial intelligence on new quality productivity is 0.0474, which is significant at the 1% level. In order to ensure the robustness of the mediation effect, this paper uses Bootstrap 500 times to test the mediation effect of human capital, and the confidence interval of the Bootstrap test is [0.0994568 0.4991233] does not contain 0, which indicates that the industrial structure upgrading plays a very important intermediary role between AI and new quality productivity. Based on the above reasoning, artificial intelligence can promote the development of new quality productivity through industrial structure upgrading, and hypothesis 2 is established.

### 4.4.2. Analysis of moderating effects

The innovation environment is included in the model for regression as shown in the last two columns Table 7. First, column (4) is the regression result of AI and innovation environment on the new quality productivity, and the regression coefficient of AI on the new quality productivity is 0.0707, which is positively significant at 1% level, and column (5) is the regression result of the interaction term of AI and innovation environment on the new quality productivity, and the coefficient is 0.000784, which is positively significant at 1% level, indicating that innovation environment plays a positive moderating role in the relationship of AI and new-quality productivity, indicating that the innovation environment plays a positive moderating role in the relationship between AI and new-quality productivity. Thus, hypothesis 3 is valid.

### 4.4.3. Threshold effect test

The previous empirical research has proved that the innovation environment can positively regulate the development of artificial intelligence on the development of new-quality productivity, and this part further investigates whether there is a significant difference in the regulation effect of the innovation environment at different levels. Hansen threshold model is used to study the innovation environment as a threshold variable, and the regression results of the threshold effect are shown in the following Table 7.

**Table 7.** Threshold Effects Regression

| Threshold variables | Number of thresholds | Threshold estimate | P-value | F-value | Number of BS |
|---|---|---|---|---|---|
| CR | single threshold | 57.99 | 0.0060 | 69.88*** | 500 |
| | double threshold | 33.88 | 0.1040 | 76.56 | 500 |
| Threshold regression | Threshold1: CR | | NQP | | |
| | AI (CR ≤ 0.6131) | | 0.0682***<br>(0.0201) | | |
| | AI (0.6131 < CR) | | 0.0833***<br>(0.0217) | | |
| | _cons | | -0.2613<br>(0.768) | | |
| | Time, Individuals, Control Variables | | Y | | |
| | $R^2$ | | 0.3900 | | |

Table 7 show that the innovation environment fails the double-threshold test, but passes the single-threshold test at the 1% level, with a threshold value of 0.6131. With the innovation environment as the threshold variable included in the regression, when the innovation environment is less than 0.6131, the effect of AI on the new-quality productivity is positively significant at the 1% level, and the regression coefficient is 0.0682; when the level of the industrial structure is When the level of industrial structure is greater than 0.6131, the effect of AI on new quality productivity is significantly positive at the 1% level, and the regression coefficient is 0.0833. The above regression results indicate that when the innovation environment exceeds the threshold, the effect of AI on the development of new quality productivity is enhanced.

## 5. CONCLUSIONS AND POLICY RECOMMENDATIONS

Under the background of the era of digital and intellectual civilization, artificial intelligence technology has become an important driving force to promote the development of new quality productivity, and it is of great significance in the era to help the development of new quality productivity through the adjustment of the industrial structure by artificial intelligence technology. Based on the relevant data at the provincial level from 2012 to 2022, the article examines the direct effect of AI on the new quality productivity as well as the path of action. The main conclusions are as follows: first, from the perspective of fixed effects, the development of AI can significantly enhance regional new quality productivity, and its effect remains stable after passing the robustness test; second, from the perspective of mediating effects, the development of AI promotes the enhancement of new quality productivity mainly through promoting the upgrading of industrial structure. Third, from the perspective of moderating effect, the innovation environment plays an important positive moderating role in the process of AI affecting the new quality productivity; and after the innovation environment exceeds the threshold value, the effect of AI on the new quality productivity is stronger. Based on the above findings, this paper puts forward policy recommendations from three aspects:

First, the rational use of artificial intelligence to stimulate and release the enabling effect on new productivity. First, accelerate the research and development process of artificial intelligence, not only focusing on the breakthrough of core algorithms, but also focusing on the practical application in various fields; promote the all-round and in-depth integration of artificial intelligence in various fields such as manufacturing, service industry and agriculture, so as to get rid of the traditional growth mode of productivity, and promote the development of new productivity. The second is to develop artificial intelligence technology according to local conditions, rational infrastructure layout and development of strategic planning, maximizing cost reduction and efficiency, so as to efficiently achieve the use of artificial intelligence to promote the high-speed development of new productivity purposes.

Secondly, promoting the in-depth integration of artificial intelligence and industry will lead to the transformation and upgrading of the industrial structure, thus promoting the development of new productivity. On the one hand, the government can actively guide traditional industries to carry out digital transformation, realize deep integration with artificial intelligence, and promote the upgrading of industrial structure with the technical support of artificial intelligence. This includes encouraging enterprises to adopt AI technology to optimize production processes, improve product quality and reduce production costs; at the same time, the government can also provide relevant policy support and financial support for enterprises to help them better achieve deep integration with AI. On the other hand, enterprises can actively cooperate with universities in artificial intelligence technology, accelerate the transformation efficiency of research results, and fully apply them to the production activities of enterprises. This deep integration of industry and education can help enterprises quickly understand the basic knowledge and cutting-edge dynamics of artificial intelligence, which can be transformed into real production power.

Thirdly, according to the findings of this paper, it is found that the effect of AI on new quality productivity is stronger after the innovation environment exceeds the threshold value; thus, we can start by increasing the investment in innovation and R&D funds and encouraging innovation and entrepreneurship. Specifically, on the one hand, the government can set up a special fund to support the scientific research of AI in the basic, technical and application layers, so as to stimulate the innovation vitality of the region; on the other hand, to build a good innovation ecosystem, to provide favorable guarantees for the cooperation between industries, universities and research institutes, intellectual property rights protection, and innovation and entrepreneurship activities, so as to solidify the foundation for the development of the innovation environment.

## CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

## ACKNOWLEDGEMENTS

This research was funded by The Innovation Fund of Sichuan University of Science & Engineering (Y2024068)

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