

# Management Transformation and Development Path of China's New Quality Productive Forces Driven by Artificial Intelligence

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## ABSTRACT

New Quality Productive Forces refer to a productive form dominated by technological innovation. As a strategic technology leading the new round of technological revolution, artificial intelligence became the core engine driving the development of New Quality Productive Forces by empowering production factors, restructuring production processes, and fostering emerging business formats. Based on panel data of 2012-2022 from 30 provinces in China, the research attempts to explore the intrinsic relationship between artificial intelligence and New Quality Productive Forces in China by means of direct effect and mediating effect. The main conclusions are following. The first, Artificial intelligence significantly promotes the New Quality Productive Forces in China. The second, scientific technology innovation plays a significant mediating role between artificial intelligence and the New Quality Productive Forces in China. The study aims to clarify the mechanism of action between the two and provide theoretical reference and practical guidance for effectively utilizing artificial intelligence to cultivate New Quality Productive Forces.

**Keywords:** Artificial Intelligence, New Quality Productive Forces, Scientific Technology Innovation, Management Transformation

## 1. Introduction

In today's world, a new round of technological revolution and industrial transformation is advancing rapidly, with digitalization emerging as a key force reshaping global competitiveness and promoting sustainable development (Rania et al., 2024). Against this backdrop, New Quality Productive Forces (NQPF)—driven by scientific and technological innovation and breaking away from traditional economic growth models—have become an essential requirement for sustaining China's long-term development. Rooted in revolutionary technological breakthroughs and deep industrial upgrading (Jun, 2024), NQPF emphasizes the transformation of laborers, labor tools, and labor objects as its core elements (Yang & Zhang, 2025). Amid intensifying global economic competition, cultivating NQPF has become vital for enhancing national strength and international competitiveness. At the same time, artificial intelligence, as a strategic technology shaping the future, is permeating all economic and social fields with unprecedented breadth and depth. It is driving the reallocation and optimal configuration of production factors (Lilian, 2025) and promoting profound industrial upgrading (Tran et al., 2025), thereby providing strong momentum for the development of NQPF. In the medical field, AI-assisted diagnostic systems can rapidly analyze medical images, helping doctors identify diseases with greater accuracy (Lukas, 2025). In the transportation sector, the continuous

advancement of autonomous driving technology is reshaping mobility patterns and transforming logistics models (Ramírez et al., 2022). In manufacturing, intelligent automation has significantly improved production efficiency and product quality (Aurelija et al., 2025). Artificial intelligence is not only a central component of the NQPF system but also the core engine driving qualitative change across all other factors. The academic community generally acknowledges the profound impact of artificial intelligence on economic development. Existing research either examines the macro-level role of artificial intelligence in promoting economic growth or analyzes its micro-level applications in supporting enterprise digital transformation, reducing costs, and improving efficiency. However, systematic studies that investigate artificial intelligence within the theoretical framework of New Quality Productive Forces (NQPF) remain limited. This research aims to fill this gap by providing a comprehensive and systematic analysis. Using panel data from 30 Chinese provinces from 2012 to 2022, this study explores the internal mechanism through which artificial intelligence influences the development of NQPF in China. First, an OLS model is employed to examine the direct effect of artificial intelligence on NQPF. Second, the Bootstrap method is used to analyze the mediating role of scientific and technological innovation in the relationship between artificial intelligence and NQPF. The remainder of the study is structured as follows: Section 2 reviews the existing literature and formulates the research hypotheses; Section 3 introduces the research methods and variables; Section 4 reports the empirical results; and Section 5 presents the conclusions and policy recommendations.

## **2. Literature Review and Hypothesis**

### **2.1 The Direct Relationship between AI and NQPF**

Artificial intelligence (AI) has developed a profound, symbiotic, and mutually reinforcing relationship with the formation of New Quality Productive Forces (NQPF). The existing literature generally agrees that AI is not merely a tool for improving production efficiency, but a transformative force that reshapes the internal structure of the productivity system and directly contributes to the advanced nature of NQPF (George, 2024). Its impacts are mainly reflected in three core dimensions:

The first dimension is that AI lays the foundation for NQPF by driving disruptive changes in production factors. At the level of laborers, AI does not simply replace human labor; rather, through human–machine collaboration, it enables human intelligence to be concentrated on higher-value creative and innovative activities (Kunz et al., 2025). At the level of labor means, AI algorithms, computing-power platforms, and intelligent hardware together form a new generation of core production tools, whose autonomous decision-making and execution capabilities far exceed those of traditional automated equipment (Yadav et al., 2024).

Second, AI acts as the core engine driving the upgrading of industrial structure. It operates in two key ways: a. AI has directly given rise to new industrial clusters represented by AI chips, large-scale models, and computing-power service industries (Michael et al., 2021), all of which inherently embody the characteristics of NQPF. b. Through the integrated penetration of the “AI+” model, AI profoundly restructures the value chains of traditional industries (Otonas, 2025). From AI-based machine vision for intelligent quality inspection to large-model-supported personalized R&D, and from predictive maintenance to smart supply

chain management, AI has significantly enhanced the efficiency and flexibility of every stage—including R&D, production, distribution, and consumption (Sujan et al., 2025)—thereby accelerating the transformation of industrial systems toward higher efficiency and sustainability.

Finally, in recent years, cutting-edge academic research has increasingly emphasized AI as a foundational force catalyzing a revolution in innovation paradigms. The rise of generative AI has transformed it from an analytical tool that merely “optimizes existing solutions” into an invention engine capable of “creating unknown possibilities.” Through combinatorial innovation, it can explore solution spaces that human experts have never reached (Léonard et al., 2024), thereby accelerating breakthrough discoveries in frontier areas of basic science and injecting into the NQPF the most fundamental driving force derived from revolutionary technological advances.

Therefore, the research proposes the first hypothesis H1: Artificial intelligence can directly and effectively promote the improvement of the NQPF in China.

## **2.2 The Mediating Effect of STI**

### **2.2.1 The Relationship between AI and STI**

Currently, the academic community widely agrees that AI is fundamentally transforming the nature, processes, and paradigms of innovation (Radanliev, 2024). Its impacts are profound and multi-dimensional. First, a substantial body of research shows that AI, as a powerful enabling tool, greatly enhances the efficiency of innovation activities. In the early stages of R&D, AI can rapidly analyze vast amounts of scientific literature, patents, and market data through natural language processing, helping researchers identify cutting-edge trends and potential opportunities (Wang & Lin, 2023) and effectively overcoming the challenge of information overload. For example, in drug discovery, AI models can screen candidate molecules at unprecedented speed, dramatically shortening the preclinical research cycle (Kit-Kay & Mallikarjuna). Second, AI not only optimizes existing R&D pathways but also opens up new “data-driven” and “generative” innovation paradigms. Generative AI can propose design solutions, write code, or generate scientific hypotheses that humans may not have conceived, using combinatorial innovation to push innovation from an “experience-driven” to an “algorithm-inspired” stage (Shakke & Whitney, 2023). Some scholars describe this expanded innovation capability as the “inventor’s paradox”: humans define problems and evaluate value, while AI explores the vast solution space.

However, existing literature also offers important critical reflections. On the one hand, AI may lead to dependence on and lock-in of specific innovation paths (Schwardt, 2024). Models trained heavily on historical data often favor incremental optimization rather than truly disruptive breakthroughs, potentially reinforcing existing technological trajectories. On the other hand, the high cost associated with AI-driven innovation may intensify resource concentration (Kejriwal, 2023), consolidating innovation activities within a small number of large technology enterprises and creating significant challenges for small and medium-sized firms as well as the broader startup ecosystem.

### **2.2.2 The Relationship between STI and NQPF**

As the core indicator of scientific and technological progress and knowledge creation capacity, STI is regarded as the fundamental source that nurtures and shapes NQPF (Liang & Huang, 2025). Existing literature generally recognizes an inherent and decisive causal relationship between STI and the development of NQPF.

First, STI—especially disruptive technological breakthroughs—is the direct driving force behind the formation of NQPF. The academic community widely agrees that NQPF essentially represent the manifestation of technological paradigm revolutions at the level of productive forces (Li, 2024). When STI remains confined to incremental improvements, it can generate only marginal gains for traditional productivity. However, once disruptive innovations occur in fundamental scientific domains or key technological fields—such as breakthroughs in artificial intelligence, quantum computing, or synthetic biology—entirely new production tools, objects of labor, and industrial forms emerge (Vural & Nezh, 2017), thereby defining the foundational structure of NQPF. This “technology–industry” causal chain constitutes the most direct and profound pathway through which STI shapes the development of NQPF.

Second, the improvement of STI provides the micro-foundation for NQPF by reshaping the endowment and allocation of production factors (Wang & Ma, 2022). High-level innovation not only generates new technological knowledge but also deeply integrates with production factors. It cultivates new types of laborers equipped with cutting-edge expertise, transforms intangible elements such as data and algorithms into key objects of labor, and upgrades traditional means of labor through intelligitization (Piekkola, 2020). This comprehensive innovation and qualitative enhancement across all three components of productive forces enable total factor productivity to break through the limitations of traditional growth models, forming the core characteristic that distinguishes NQPF from conventional productivity.

Finally, relevant research further shows that the structure of innovation ecosystems and shifts in innovation paradigms exert a significant influence on the evolutionary trajectory of NQPF. A region’s overall STI capacity depends not only on individual technological breakthroughs but also on the completeness and openness of its innovation ecosystem (Adner & Kapoor, 2009). An open and collaborative innovation paradigm accelerates knowledge spillovers and the transformation of research outcomes, promoting a shift in innovation activities from a “linear model” to a more “networked and integrated” approach. Such high-level innovation ecosystems can more effectively nurture future-oriented and green industries (Grillitsch & Hansen, 2019), thereby shaping the speed, quality, and sustainability of NQPF development.

In summary, the academic consensus is that STI fundamentally shapes the emergence, characteristics, and evolutionary trajectory of NQPF through three major mechanisms: providing the technological driving force, restructuring production factors, and optimizing the innovation ecosystem.

### **2.2.3 The Effect Mechanisms of the Mediating Role of STI**

#### **2.2.3.1 Technology R&D Transmission Path**

Artificial intelligence promotes the paradigm transformation of STI by innovating R&D methods, thereby empowering the development of NQPF (Wang & Liu, 2025). In the basic research stage, AI’s ability to

process massive volumes of data breaks through the cognitive limits of traditional scientific research, accelerating breakthroughs in fundamental scientific fields. In the applied research stage, the deep integration of AI with industry scenarios enables STI to align more closely with actual industrial needs. This pathway—“AI optimizes R&D processes → STI output increases → production technologies iteratively upgrade → NQPF improves” (Sadek et al., 2024)—forms the core logic of the mediating role of STI. The key mechanism lies in AI’s ability to enhance both the efficiency and the quality of STI across the entire innovation process.

#### 2.2.3.2 Factor Allocation Transmission Path

Artificial intelligence improves the allocation efficiency of production factors through STI, thereby supporting the development of NQPF. On one hand, AI-driven STI enhances the value extraction of data elements, transforming data into a key production factor that works alongside traditional factors such as labor and capital to raise overall factor productivity. On the other hand, STI strengthens market-oriented mechanisms for factor allocation, ensuring that new production factors—such as technology and data—flow to the most innovative entities, promoting more efficient resource utilization and consequently advancing the development of NQPF (Aurimas, 2025). The core of this mechanism is that STI serves as a “bridge” for factor transformation, translating the technological advantages of artificial intelligence into higher factor allocation efficiency and ultimately enabling a qualitative leap in productivity.

#### 2.2.3.3 Industrial Upgrading Transmission Path

Artificial intelligence drives the transformation of industrial structures toward intelligence through STI, thereby indirectly promoting the development of NQPF (Do et al., 2023). In the manufacturing sector, technologies such as intelligent quality inspection, predictive maintenance, and intelligent scheduling—enabled by AI-driven STI—allow production processes to achieve self-perception, self-decision-making, and self-execution, fostering the emergence of “lights-out factories” and significantly improving manufacturing efficiency and quality. In the service sector, intelligent customer service systems, personalized recommendation models, and smart logistics solutions—also supported by STI—enhance service accuracy and operational efficiency, creating new service models and formats. This industrial upgrading not only directly increases productivity at the sectoral level but also stimulates the development of NQPF through cross-industry synergy effects, reflecting the industrial transmission mechanism underlying the mediating role of STI.

Therefore, the research proposes the second research hypothesis H2: STI plays a mediating role between artificial intelligence and the improvement of NQPF in China.

### 3. Research Methods and Data Description

#### 3.1 Entropy Weight Method

The method objectively determines weights based on the information contained in each evaluation index. It uses the degree of data dispersion to derive more objective weights and is not influenced by whether the indicators are positive or negative. A higher entropy value indicates greater dispersion in the index, resulting

in a larger weight in the comprehensive evaluation. This method is applied to evaluate and analyze the levels of artificial intelligence and NQPF in China from 2012 to 2022.

(1) Explanation of symbols. Assume there are  $c$  areas,  $m$  time periods and  $n$  indicators. And  $a=1, 2, 3, \dots, c$ .  $i=1, 2, 3, \dots, m$ .  $j=1, 2, 3, \dots, n$ . And  $x_{aij}$  represents the raw value of  $j$ -th indicator in  $i$ -th period in  $a$ -th area.

For the study,  $c=80, m=16, n=12$ .

(2) Constructing the original data matrix. And  $X = \{x_{aij} / 0 \leq i \leq m, 0 \leq j \leq n\}$ .

$$X = \begin{bmatrix} X_{a11} & \cdots & X_{a1n} \\ \vdots & \ddots & \vdots \\ X_{am1} & \cdots & X_{amn} \end{bmatrix}$$

(3) Standardization Processing Due to the multidimensional nature of the indicators and the substantial differences in their measurement units, it is necessary to standardize all indicators uniformly to eliminate the influence of dimensional discrepancies on data analysis. In addition, to avoid meaningless values after logarithmic transformation, it may be necessary to shift the data left or right by an appropriate number of units to ensure the validity of the transformed results. The steps of the standardization process are as follows:

For positive indicators:

$$Z_{aij} = (x_{aij} - x_{min}) / (x_{max} - x_{min}) \quad (1)$$

For negative indicators:

$$Z_{aij} = (x_{max} - x_{aij}) / (x_{max} - x_{min}) \quad (2)$$

Where  $Z_{aij}$  is the value after standardization, and  $x_{max}$  and  $x_{min}$  represent the maximum values and minimum values for all  $j$ -th indicators respectively.

(4) Normalization: It refers to calculating the weight of the  $j$ -th indicator in  $i$ -th period of  $a$ -th region.

$$P_{aij} = Z_{aij} / \sum_{a=1}^c \sum_{i=1}^m Z_{aij} \quad (3)$$

The following is indicator weight matrix, where:

$$P = \begin{bmatrix} P_{a11} & \cdots & P_{a1j} \\ \vdots & \ddots & \vdots \\ P_{ai1} & \cdots & P_{aij} \end{bmatrix}$$

And,  $P = \{P_{aij} / 0 \leq P_{aij} \leq 1\}$

(5) Calculating the entropy value  $E_j$  of the  $j$ -th indicator.

$$E_j = -K \sum_{a=1}^c \sum_{i=1}^m P_{aij} \times \ln P_{aij} \quad (4)$$

In the above formula,  $K=1/\ln(c \times m)$ , and  $K$  must satisfy  $K > 0$ .  $c \times m$  represents the total number of

samples,  $\ln$  represents natural logarithm symbol, and  $E_j$  satisfies  $0 \leq E_j \leq 1$ .

(6) Calculating the redundancy  $D_j$  of  $j$ -th indicator.

The redundancy of indicators, also referred to as the information utility value or coefficient of variation, reflects the usefulness of an indicator. For the  $j$ -th indicator, the greater the variation among the values  $x_{aij}$ , the stronger the indicator's evaluation effect and the lower its entropy value. Therefore, the larger  $D_j$  value indicates a better result.

$$D_j = 1 - E_j \tag{5}$$

(7) Calculating the comprehensive weight coefficient  $W_j$  of the  $j$ -th indicator.

$$W_j = \frac{D_j}{\sum_{j=1}^n D_j} \tag{6}$$

(8) The following is weighted sum formula, which is used to calculate the final comprehensive evaluation score.

$$S_{ai} = \sum_{j=1}^n P_{aij} W_j \tag{7}$$

In the formula above,  $S_{ai}$  represents the comprehensive evaluation score of region  $a$  in  $i$  year.  $S_{ai}$  value means comprehensive evaluation level.

### 3.2 Benchmark Regression

First, a fixed-effects model is constructed to determine whether the impact of artificial intelligence on NQPF is significant. Based on the research hypotheses, a basic model is established to evaluate the effect of artificial intelligence on NQPF and to measure its direct influence.

$$NQPF_{i,t} = a_0 + a_1 AI_{i,t} + a_n CV_{i,t} + \epsilon_{i,t}$$

### 3.3 Mediating Effect Model

The construction of the mediating effect model involves two specific steps. First, a regression model is built to examine the effect of the independent variable (artificial intelligence) on the mediating variable (STI). Second, another regression model is established to examine the effects of both the independent variable (artificial intelligence) and the mediating variable (STI) on the dependent variable (NQPF), as shown in the following two formulas:

$$INNO_{i,t} = a_0 + a_1 AI_{i,t} + a_n CV_{i,t} + \epsilon_{i,t}$$

$$NQPF_{i,t} = a_0 + a_1 AI_{i,t} + a_2 INNO_{i,t} + a_n CV_{i,t} + \epsilon_{i,t}$$

In the above formulas,  $NQPF_{i,t}$  denotes the level of NQPF of the  $i$ -th province in year  $t$ .  $AI_{i,t}$  denotes the level of artificial intelligence of the  $i$ -th province in year  $t$ .  $INNO_{i,t}$  denotes the STI of the  $i$ -th province in

year  $t$ .  $CV_{i,t}$  denotes the total effect of control variables of the  $i$ -th province in year  $t$ .  $\xi_{i,t}$  represents the random error term.

### 3.4 Explanation of Variables and Data Sources

#### 3.4.1 Variables

Dependent Variable: NQPF is used as the dependent variable. An evaluation index system is constructed from three dimensions—laborers, objects of labor, and means of labor. The entropy weight method is applied to evaluate the indicator system, and the resulting comprehensive score is taken as the NQPF index.

**Table 1:** The Indicators System of NQPF

Criterion Layer	First-Level	Second-Level	Third-Level	Specific Measurement Standards
NQPF	Laborers	Labor Productivity	Economic Output	Per Capita GDP
			Economic Income	Per Capita Wage
			Employment Structure	Employment Proportion of the Tertiary Industry
		Labor Quality	Educational Attainment	Proportion of Population with Higher Education
			Cultivation Expenditure	Intensity of Educational Expenditure
			Knowledge Accumulation Potential	Structure of Students Enrolled in School
		Labor Spirit	Innovation Spirit	Investment in Innovative Human Resources
			Entrepreneurship Spirit	Entrepreneurial Activity
		Objects of Labor	Industrial Development	Informatization
	Proportion of Strategic Industries			Proportion of Emerging Strategic Industries
	Future Industries			Robot Installation Density
	Ecological Environment		Green Ecology	Green Resources Intensity of Environmental Protection
			Green Production	Quality of Pollution Control
				Green Invention Achievements
	Means of Labor	Material Means of Labor	Infrastructure	Traditional Infrastructure Digital Infrastructure
			Energy Utilization Level	Energy Intensity Green Energy Consumption Level
		Energy Utilization Potential	Pollution Control Potential	

	Intangible Means of Labor	STI Level	Per Capita Number of Patents
			Economic Investment in New Products
		Digitalization Level	Digital Economy
			Enterprise Digitalization

Independent Variable: This study develops an evaluation index system for artificial intelligence. The entropy weight method is used to evaluate this system, and the resulting comprehensive score is taken as the artificial intelligence index, which serves as the independent variable of the study.

**Table 2:** The Indicators System of Artificial Intelligence

Criterion Layer	Indicators Layer
AI	Internet Infrastructure: Provincial Optical Cable Investment Area
	Intelligent Equipment Investment: Fixed Asset Investment in Information Transmission Software Service Industry
	Intelligent Fund Investment: Internal R&D Expenditure of High-Tech Industry (10,000 yuan)
	Intelligent Talent Investment: R&D Personnel in High-Tech Manufacturing Industry
	Main Business Income of Industrial Enterprises
	Software Development and Application
	Intelligent Product Development
	Intelligent Enterprise Development
	New Product Production
	Innovation Efficiency
	Market Profit
	Economic Benefits
	Social Benefits

Control Variables: In this study, transportation (TRAF), opening-up (OPEN), aging population (OLD), and resource allocation (SET) are selected as control variables.

Mediating Variable: STI is the core engine driving the progress of human society and the source of emerging industries. It is adopted as the mediating variable of this study.

**3.4.2 Data Sources**

This study uses data from 30 provinces in China covering the period 2012–2022. The data are primarily sourced from the \*China Statistical Yearbook\*, government work reports, and provincial statistical yearbooks. It is noted that, for the purpose of quantitative analysis, the original data were cleaned, and

logarithmically transformed data were used for the empirical study. In addition, because some provinces had missing values in certain years, this study employs interpolation methods to supplement the data in a scientifically appropriate manner. Table 3 presents the results of the descriptive statistics.

**Table 3:** Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
NQPF	330	0.285	0.13	0.102	0.747
AII	330	2.052	0.719	0.939	5.083
TRAF	330	11.651	0.834	9.501	12.981
OPEN	330	0.265	0.268	0.008	1.354
OLD	330	0.136	0.045	0.054	0.275
SET	330	0.238	0.181	0.002	0.922

## 4. Analysis of Research Results

### 4.1 Benchmark Regression Results

First, as shown in Table 3, the baseline regression model verifies the direct impact of artificial intelligence on China's NQPF. Column 1 reports the direct effect of AI on NQPF without control variables, while Column 2 presents the effect after incorporating control variables. The results indicate that all empirical estimates are statistically significant.

When artificial intelligence increases by one unit, it promotes the improvement of NQPF by 0.092 units. When transportation conditions increase by one unit, NQPF rises by 0.055 units, likely because improved transportation conditions enhance logistics efficiency.

When opening-up increases by one unit, NQPF rises by 0.215 units, likely because greater openness introduces advanced foreign productive forces. The regression coefficient for the aging population is negative, which may be explained by the reduction in the young labor force associated with population aging, a factor that is unfavorable for the improvement of NQPF.

When resource allocation increases by one unit, it promotes the improvement of NQPF by 0.060 units, as more efficient resource allocation supports the effective utilization of limited resources.

The above results verify the validity of Hypothesis 1.

**Table 4:** The Results of Direct Regression

Variables	NEWP(1)	NEWP(2)
AI	0.133*** (0.007)	0.092*** (0.007)
TRAF		0.055*** (0.004)
OPEN		0.215***

		(0.015)
OLD		-0.548*** (0.096)
SET		0.060*** (0.014)
Constant	0.011 (0.015)	-0.556*** (0.048)
R <sup>2</sup>	0.541	0.786
F-value	388.19	242.53
N	330	

#### 4.2 Robustness Test

To ensure the accuracy and robustness of the regression results, this study conducts robustness checks by reducing the sample size and by lagging the independent variable by one period. First, the sample size is reduced by narrowing the sample period to 2017–2022 and excluding the four municipalities (Beijing, Shanghai, Tianjin, and Chongqing). Second, the independent variable (AI) is lagged by one period (denoted as LAI), reflecting the fact that the effects of macro-level policy implementation often exhibit time-lag characteristics. As shown in Table 4, Columns 1 and 2 report the regression results after reducing the sample size and lagging the independent variable, respectively. The coefficients remain significant, indicating that the empirical results of this study are highly robust.

**Table 5: The Results of Robustness Test**

Variables	NEWP(1)	NEWP(2)
AI	0.081*** (0.010)	
LAI		0.096*** (0.008)
TRAF	0.034*** (0.007)	0.055*** (0.005)
OPEN	0.395*** (0.043)	0.215*** (0.018)
OLD	-0.227** (0.116)	-0.552*** (0.104)
SET	-0.003 (0.020)	0.051*** (0.016)
Constant	-0.355*** (0.071)	-0.543*** (0.053)
R <sup>2</sup>	0.851	0.765
F-value	178.25	196.12
N	156	300

### 4.3 Mediating Effect

Table 5 presents the results of the mediating effect test based on the Bootstrap method. The coefficient of the direct effect ( $\beta_2$ ) of artificial intelligence on China's NQPF is 0.078, and its confidence interval does not include 0. The coefficient of the indirect effect ( $\beta_1$ ) mediated through STI is 0.014, and its confidence interval likewise does not include 0. These results indicate that both the direct effect and the mediating effect are significant, demonstrating that artificial intelligence enhances China's NQPF in part through the mechanism of STI. Therefore, Hypothesis 2 is verified.

**Table 6: Results of the Mediating Effect Test Based on the Bootstrap Method**

	Observed coefficient	Bootstrap std.err.	z	$P >  z $	Normal-based [95% conf.interval]	
$\beta_1$	0.014	0.004	3.71	0.000	0.007	0.022
$\beta_2$	0.078	0.009	8.95	0.000	0.061	0.095

## 5. Conclusions and Recommendations

### 5.1 The Perspective of AI

First, to advance the “AI + R&D” paradigm revolution. a. Empower basic scientific research: Utilize AI large models to accelerate the discovery of new materials, the development of new drugs, protein structure prediction, and other frontier fields, shifting scientific research from “experimental trial and error” to “computational prediction” and significantly enhancing R&D efficiency. b. Innovate industrial design: Apply generative AI to product design, simulation, and process optimization, shortening design cycles and enabling the creation of new products and solutions that traditional methods cannot achieve.

Second, to deepen the integration of “AI + industry.” a. Intelligent manufacturing: Promote AI-based visual quality inspection, predictive maintenance, and intelligent scheduling, enabling production processes to achieve self-perception, self-decision-making, and self-execution. This supports the development of “lights-out factories” and comprehensively enhances manufacturing efficiency and quality. b. Modern service industry: Develop intelligent customer service systems, personalized recommendation engines, and smart logistics solutions to improve accuracy and efficiency in the service sector, fostering new service models and business formats.

Third, to build an open and collaborative AI innovation ecosystem. a. Break through key bottlenecks: Focus on tackling “chokepoint” technologies such as AI chips, foundational frameworks, and core algorithms to ensure technological independence and controllability. b. Promote data openness and circulation: Under the premise of ensuring security and privacy, promote the open sharing and reuse of high-quality industry datasets to provide essential “fuel” for AI model training. c. Cultivate interdisciplinary talent: Strengthen

interdisciplinary education in “AI + industry” and cultivate innovative professionals who understand both technological principles and practical application scenarios.

Fourth, to establish a scenario-enabled empowerment mechanism and promote the deep implementation of AI. a. Create a unified national system for cataloging AI application scenarios, focusing on key fields such as manufacturing, agriculture, healthcare, and elderly care. Release high-value scenario demands to guide precise matching between technological supply and actual needs. b. Promote mechanisms such as “scenario-based proposal solicitation” and “on-site model deployment,” encouraging enterprises to present real production pain points and enabling AI companies to deliver targeted solutions, thereby strengthening the closed-loop process of “problem identification → scenario adaptation → engineering implementation.” c. Support the development of industry-level AI datasets, promote data sharing in areas such as industrial production, agricultural cultivation, and medical diagnosis, and provide high-quality data resources for model training.

Fifth, improve the factor guarantee system and strengthen development support. a. Build a comprehensive talent training system: universities should establish interdisciplinary “AI + industry” programs, enterprises should provide systematic on-the-job training, and talent evaluation mechanisms should be optimized to attract high-level talent both domestically and internationally. b. Establish a classified and hierarchical data property rights system, clarify the boundaries between data ownership and usage rights, standardize data circulation rules, and ensure the safe and orderly flow of data as a production factor. c. Introduce inclusive support policies and, through measures such as “intelligent computing vouchers” and “AI-as-a-Service” platforms, reduce AI adoption costs for small and medium-sized enterprises, promoting the widespread diffusion of intelligent benefits across the entire industry.

## **5.2 The Perspective of Transportation**

First, to develop “smart transportation” and enhance logistics efficiency. a. Build a digital supply chain: Use big data, the Internet of Things (IoT), and artificial intelligence to construct an end-to-end, fully visualized, and controllable smart logistics system, significantly reducing overall logistics costs. b. Promote autonomous freight transportation: Take the lead in deploying driverless trucks in scenarios such as ports and highways to achieve 24/7 uninterrupted transport operations and improve the efficiency of trunk-line logistics.

Second, to build a “comprehensive three-dimensional transportation network” and optimize spatial layout. a. Strengthen connections among hub cities: Use high-speed railways, intercity railways, and aviation networks to enhance the interconnectivity of innovation hubs, promoting the rapid flow and clustering of innovative factors. b. Improve the “last mile”: Develop drone delivery, autonomous vehicle delivery, and other terminal logistics solutions to address urban–rural distribution challenges, enabling the outcomes of NQPF to efficiently reach a wider market.

Third, to make forward-looking plans for “future transportation” infrastructure. a. Support the development of the low-altitude economy: Plan and build urban air mobility (UAM) takeoff and landing sites, drone air routes, and related infrastructure to lay the foundation for emerging industries such as future

low-altitude logistics and manned aerial mobility. b. Explore cutting-edge technologies such as the hyperloop: Reserve R&D and testing space for next-generation ultra-high-speed rail transit technologies to further reduce time–space distances.

Fourth, to improve the policy guarantee system and optimize the development environment. a. Establish a dedicated NQPF development fund for the transportation sector, focusing on supporting R&D in smart and green transportation technologies, advancing infrastructure construction, and providing financing and interest subsidies for small and medium-sized enterprises. b. Build an inter-departmental coordination mechanism to integrate policy resources across transportation, science and technology, industry, and environmental protection, addressing challenges such as inconsistent technical standards and barriers to data sharing. c. Develop a comprehensive talent training system: universities should establish interdisciplinary programs such as “Transportation + Digital Technology” and “Transportation + Low-Carbon Engineering,” while enterprises and research institutions should jointly build training bases to cultivate professional technical talent.

### **5.3 The Perspective of Opening-Up**

First, to proactively align with high-standard international economic and trade rules. a. Join high-level free trade agreements: Actively work toward joining CPTPP, DEPA, and other high-standard agreements, promoting the alignment of domestic rules, regulations, management, and standards with international practices and enhancing the global adaptability and competitiveness of Chinese enterprises. b. Promote “institutional opening-up”: Shift from the earlier model of “opening focused on commodity and factor flows” to one centered on “rules and standards,” creating a stable, transparent, and predictable business environment.

Second, to optimize the level and structure of opening-up. a. Upgrade “bringing in”: Shift from simply “attracting capital” to “attracting talent” and “attracting technology,” encouraging foreign enterprises to establish R&D centers in China, participate in major national science and technology projects, and introduce advanced technological capabilities and management experience. b. Improve the quality of “going out”: Support competitive industries—such as new energy, new energy vehicles, and the digital economy—in expanding globally, enabling continuous iteration and upgrading through participation in international competition, and fostering the development of world-class Chinese brands and industrial chains.

Third, to deepen participation in the global innovation network. a. Take the lead in organizing major international scientific programs: Proactively shape agendas and lead global scientific cooperation on key issues such as artificial intelligence, climate change, and life and health, thereby securing advantageous positions at the forefront of global innovation. b. Attract top global talent: Improve visa, residency, and taxation policies to draw and retain strategic scientists, leading technological experts, and high-level innovation teams from around the world.

Fourth, to deepen science and technology cooperation under the Belt and Road Initiative by implementing the Belt and Road Science, Technology and Innovation Cooperation Action Plan and establishing overseas innovation centers in partner countries along the routes. Efforts should focus on advancing multilateral

cooperation in areas such as green energy, artificial intelligence, and digital infrastructure, building an integrated land–sea–air–cyberspace connectivity network, promoting the outward transfer of industrial standards and technological solutions related to China’s NQPF, and simultaneously absorbing unique resources and technologies from partner countries along the routes.

#### **5.4 The Perspective of Aging**

First, to address labor shortages through technological innovation. a. Vigorously promote “machine substitution for labor”: In labor-shortage industries such as elderly care, housekeeping, and manufacturing, accelerate the R&D and deployment of nursing robots, service robots, and industrial robots—creating major new opportunities for the high-end equipment manufacturing industry itself. b. Extend the “human capital” of the elderly: Use wearable devices, telemedicine, and other technologies to help older adults maintain health, prolong their effective working years, and transform the “silver-haired generation” into a “dynamic generation” and a valuable source of experience.

Second, cultivate and expand new formats of the “silver economy.” a. Smart health and elderly care: Use AI, big data, and IoT to develop products and services such as chronic disease management, remote monitoring, and smart home aging-adaptation solutions, fostering the growth of a trillion-level health and elderly care industry. b. Develop new markets for elderly consumption: Target emerging needs in areas such as elderly tourism, lifelong learning, elderly finance, and senior-friendly entertainment, creating marketable products and services and forming new drivers of economic growth.

Third, promote the transformation from a “demographic dividend” to a “talent dividend.” a. Strengthen lifelong vocational skills training: Use online education, virtual reality, and other technologies to provide convenient and efficient pathways for workers of all ages—especially older workers—to upgrade their skills and meet the talent requirements of NQPF. b. Optimize the population development strategy: While encouraging childbirth, place greater emphasis on improving population quality by increasing investment in cultivating the scientific literacy and innovation capability of children and adolescents, thereby reserving core talent for the future development of NQPF.

#### **5.5 The Perspective of Resource Allocation Efficiency**

First, to let the market play a decisive role in resource allocation. a. Promote factor marketization reform: Deepen the market-oriented reform of data, technology, and intellectual property allocation, and establish unified and standardized trading markets and pricing mechanisms to ensure that new production factors flow to the most innovative entities. b. Break hidden barriers: Eliminate policies that hinder a unified market and fair competition, ensuring that private enterprises and small and medium-sized firms can access talent, capital, data, and other resources on an equal footing with state-owned enterprises.

Second, to better play the role of the government. a. Implement “innovation-friendly” regulation: Adopt regulatory sandboxes for emerging technologies and new business models—such as autonomous driving and the low-altitude economy—to provide sufficient room for development while maintaining necessary safety safeguards. b. Optimize the direction of fiscal investment: Redirect more government funds from

traditional infrastructure and general subsidies toward supporting basic research, cutting-edge technological breakthroughs, and “specialized, refined, distinctive, and innovative” enterprises. c. Improve the innovation incentive mechanism: Strengthen intellectual property protection, crack down firmly on infringement, and ensure that innovators can genuinely obtain excess returns from their innovations.

Third, to improve the utilization efficiency of traditional material resources in support of green transformation. a. Promote the green transformation of energy resources: Accelerate the development of clean and renewable energy industries, reduce the production and usage costs of wind, solar, and other renewable energy sources through technological innovation, and enhance their market competitiveness. At the same time, optimize the energy allocation mechanism by directing energy resources toward NQPF-related fields such as green manufacturing and low-carbon industries, reducing resource occupation by high-energy-consuming sectors, and supporting the low-carbon upgrading of industry. b. Promote circular and efficient resource utilization: Establish a resource recycling system and advance the collection, processing, and reuse of renewable materials such as industrial waste and agricultural residues, thereby expanding the scope of labor objects. For example, support enterprises in improving resource utilization efficiency through technological transformation and converting renewable resources into new production inputs. This not only lowers production costs but also provides green, low-carbon material support for the development of NQPF.

## **5.6 The Perspective of STI**

First, to strengthen the source of STI and consolidate the foundation for support. a. Advance frontier exploration and innovate scientific research paradigms: It is recommended to focus on supporting interdisciplinary research that integrates artificial intelligence with basic sciences such as physics, biology, and materials, promoting a new paradigm of “AI-driven scientific research.” This includes accelerating the development and application of scientific large models, promoting the intelligent upgrading of major scientific research infrastructure, and building open and shared high-quality scientific datasets to provide “high-quality fuel” for AI-enabled scientific discovery.

Second, to optimize the STI environment and bridge development gaps. a. Implement regionally differentiated strategies: In eastern and coastal regions with strong foundations, encourage efforts to pursue cutting-edge technologies and original innovation. In central, western, and inland regions, policy priorities should focus on improving top-level design and institutional support, while strengthening financial and policy assistance for the intelligent upgrading of infrastructure. b. Cultivate talent and optimize the business environment: Strongly support AI skills training, integrate AI into the full process of education and teaching, and innovate human–machine collaborative education models.

Third, to innovate policy tools that guide the flow of production factors. a. Establish special reward and subsidy mechanisms: Drawing on practices in Shandong and other regions, implement diversified reward and subsidy policies such as “computing-power vouchers,” “model vouchers,” “corpus vouchers,” and “innovation vouchers” to precisely reduce the core factor costs faced by enterprises. b. Strengthen targeted financial support: Make full use of new policy-oriented financial tools to ensure that funds are directed

toward key areas such as artificial intelligence and the digital economy. At the same time, guide venture capital to invest in AI start-ups and encourage the development of sci-tech financial products that support innovation in the AI industry.

Fourth, to activate the vitality of enterprises as the main actors and deepen collaboration among industry, universities, and research institutions. Establish an enterprise-led mechanism for the approval of science and technology projects, clarify the leading role of enterprises in major sci-tech initiatives, and ensure that R&D directions align with actual industry needs. Promote the consortium model jointly formed by “enterprises + universities + research institutions,” and encourage enterprises to invest in generic technology R&D and the construction of pilot-scale testing platforms through policies such as tax incentives and additional deductions for R&D expenses. Improve the reform of rights related to job-related scientific and technological achievements by clarifying ownership, disposal rights, and benefit rights, allowing researchers to share in commercialization benefits proportionally and stimulating enthusiasm for achievement transformation. Build public service platforms such as concept-verification centers and pilot-scale testing bases to provide financial, equipment, and technical support for transforming scientific and technological achievements from laboratories to production lines, effectively overcoming the “valley of death.” Establish a “patient capital” support system by guiding venture capital funds and industrial funds to favor early- and mid-stage sci-tech enterprises, ensuring long-term financing support for achievement transformation. Create regional alliances for the transformation of scientific and technological achievements, eliminate market segmentation and data barriers, and promote the free cross-regional flow of key factors such as technology, talent, and data.

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