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Research on the Temporal-Spatial Evolution and Influencing Factors of China's New Quality Productive Forces

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Abstract

New quality productive forces represent the direction of evolution of advanced productive forces, emerging from revolutionary technological breakthroughs, innovative allocation of production factors, and deep transformation and upgrading of industries. This paper employs entropy method, time series analysis, and spatial analysis to explore the comprehensive evaluation and temporal-spatial evolution characteristics of the new quality productive forces in 30 provinces (regions, municipalities) of China from 2013 to 2022, and utilizes a fixed effects model to identify the influencing factors of the new quality productive forces. The results reveal that: (1) From 2013 to 2022, the level of new quality productive forces in China has shown a stable growth trend, with slight fluctuations in the past three years; (2) The level of new quality productive forces in China exhibits a distribution pattern of "east > central > west," with the highest in the east, followed by the central region, and the lowest in the west; (3) The hotspots of new quality productive forces are mainly distributed in the southeastern coastal areas, showing a trend of moving southward, while the cold spots are mainly in the northwest region, with relatively stable distribution; (4) The analysis of influencing factors indicates that factors such as economic development level, fiscal inclination towards science and technology, environmental regulation intensity, and financial development level can significantly enhance the development level of new quality productive forces. This paper systematically analyzes the temporal-spatial evolution and influencing factors of China's new quality productive forces, which is of significant theoretical and practical importance for clarifying the development patterns of new quality productive forces and improving local levels of new quality productive forces.

Keywords

New Quality Productive Forces; Comprehensive Evaluation; Temporal-Spatial Evolution; Influencing Factors; Regional Differences.

1. Introduction

In 2023, the symposium on promoting the comprehensive revitalization of the Northeast in the new era pointed out the importance of nurturing strategic emerging industries for driving the comprehensive economic revitalization. It explained that it is necessary to focus on developing strategic emerging industries such as new energy, new materials, advanced manufacturing, and electronic information. Additionally, it advocated for accelerating the cultivation of future industries to form new productive forces, thereby enhancing the new momentum for economic development.

Currently, in academic research, some scholars have explored the connotations and constituent elements of new quality productive forces, elucidating their significance and pathways from various perspectives. Firstly, Cheng and Chen (2023) argue that the General Secretary's

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important discourse on developing new quality productive forces represents an inheritance and development of Marxist and its Sinicized theories regarding the idea of technological productive forces[1]. This perspective highlights the theoretical value and guiding significance of new quality productive forces in contemporary economic development. Zhao and Ji (2024) suggest that new quality productive forces are the productive forces formed by the new round of industrial technological revolution and the clustering of strategic emerging industries[2]. This highlights the intrinsic connection between new quality productive forces and technological innovation, as well as industrial upgrading, emphasizing the crucial role of the rise of emerging industries in enhancing the level of productive forces. Yu and Ma (2023) believe that the core essence of new quality productive forces is to drive high-quality development through innovation, with key components being new scientific and technological advancements, new modes of production, new industrial forms, and new factor supplies[3]. Dai(2023) summarizes from the dimensions of "new," "quality," and "force" that to form and develop new quality productive forces, it is necessary to accelerate the innovation and development of digital technologies and focus on promoting the intelligent and digital transformation of production methods[4].

Existing research has primarily focused on qualitative analysis of new quality productive forces, but further investigation is needed to assess the current levels of these forces. The objective of this paper is to conduct a quantitative analysis to establish a comprehensive evaluation index system for new quality productive forces at the provincial level in China, revealing their temporal-spatial evolution and specific influencing factors. Specifically, this paper aims to construct a comprehensive evaluation index system for new quality productive forces from four dimensions: technological productive forces, green productive forces, digital productive forces, and the development environment of productive forces. Using the entropy method, we will measure the development level of new quality productive forces in 30 provinces (regions, municipalities) of China from 2013 to 2022. Spatial analysis will be employed to deeply examine the temporal-spatial evolution characteristics, and a fixed effects model will be used to identify specific influencing factors of new quality productive forces.

The research conducted in this paper not only helps to understand the development status of new quality productive forces in China but also provides insights for improving the level of new quality productive forces in various regions and promoting high-quality economic development. Through comprehensive evaluation and analysis of the temporal-spatial evolution characteristics of new quality productive forces, we can more accurately grasp the trajectory and trends of China's economic development, providing a scientific basis for formulating corresponding policies and development strategies. Research on the influencing factors of new quality productive forces enables us to better identify which factors are most significant and have the largest contribution in different regions, thereby facilitating the development of new quality productive forces in a region-specific manner.

2. Literature Review

The introduction of the concept of new quality productive forces signifies a shift in traditional notions of productivity, emphasizing the importance of pursuing advancement and continuous innovation. This concept is characterized by its forward-looking, revolutionary, and high-quality nature, and has become a significant driving force for China's modernization. Currently, the academic community has conducted analyses on the connotations, significance, and manifestations of new quality productive forces. Li and Cui (2024) suggest that new quality productive forces are a more advanced form of productivity that emerges from the continuous improvement in the quality of its constituent elements[5]. Gao(2023) focuses on the importance and development paths of new quality productive forces, highlighting their crucial role in the

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construction of China's modernization and the inherent need for promoting high-quality development[6]. Hong (2024) summarizes new quality productive forces from a macro perspective as three major sectors: new technologies, new energy, and the digital economy[7]. Lu et al. (2024) construct a comprehensive evaluation system for new quality productive forces from three dimensions: technological productivity, green productivity, and digital productivity[8]. The concept of new quality productive forces implies the need to continuously drive technological innovation and industrial upgrading, and to explore new development paths and models. In the current context of economic globalization and technological advancement, traditional industries are under pressure to transform and upgrade, and the cultivation of new quality productive forces provides a new source of momentum for the sustainable development of China's economy. Although new quality productive forces have been recognized as a key driving force for high-quality economic development, their connotation analysis and statistical research are still in the initial stages. As can be seen, most studies focus on qualitative analysis of new quality productive forces, with fewer addressing the measurement of their levels. Through a comprehensive analysis based on existing research, we can summarize the manifestations of new quality productive forces into the following four aspects.

Firstly, science and technology are considered the primary productive forces. Technological innovation not only improves production processes but also optimizes resource allocation, enhancing production efficiency and product quality while reducing production costs. This continuous effort in innovation is not only a transition from quantitative to qualitative changes but also a key to achieving higher quality development. The Central Economic Work Conference in 2023 emphasized the need to "promote industrial innovation through scientific and technological innovation, especially by fostering new industries, new models, and new momentum with disruptive and cutting-edge technologies to develop new quality productive forces." The importance of technological innovation lies not only in improving existing production methods but also in leading the transformation of industrial structures and development paths.

Secondly, adhering to the concept of green development is crucial for promoting the development of new quality productive forces. China has explicitly set the goals of achieving "carbon peak" by 2030 and "carbon neutrality" by 2060. With the establishment of these targets, industries driven by fossil fuels are considered old quality productive forces. Green productivity focuses on the efficient use of resources, the clean utilization of energy, and the reduction of negative environmental impacts, aligning with the requirements of sustainable development. In the current context of increasing global resource scarcity and worsening environmental pollution, developing green productive forces has become an important way to ensure the sustainability of China. By introducing green technologies and industries, we can achieve resource recycling in the production process, reduce energy consumption and emissions, thereby lowering production costs and improving production efficiency. This not only helps to alleviate environmental pressures but also promotes the transformation and upgrading of related industries, fostering new economic growth points[9].

Furthermore, the full utilization of digital technology is another crucial aspect in promoting the development of new quality productive forces. Currently, the digital economy is becoming a representative of new quality productive forces. Integrating digital technologies such as artificial intelligence and big data to cultivate and develop new quality productive forces is key to seizing the historical opportunities of the new scientific and technological revolution and mastering the future. Digital production can help enterprises better understand and utilize resources, and through big data analysis, more precise production planning and resource allocation can be achieved. Digital production can enhance corporate innovation capabilities and is an important means of achieving industrial upgrading. The application of digital

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technologies can improve corporate competitiveness and market position, thereby promoting the development of the entire industry.

Lastly, various external environments that influence and shape the development of new quality productive forces are an important foundation. Firstly, government support and guidance for economic development provide financial support and policy guarantees for the development of new quality productive forces. Secondly, a developed industrial system is usually accompanied by advanced production technologies, efficient production models, and a complete supply chain system, all of which provide significant support for the cultivation and development of new quality productive forces. Additionally, high-quality, innovative talents are an important driving force for the development of new quality productive forces. These talents can bring technological innovation, management innovation, and business model innovation to enterprises, and also cultivate and attract more innovative talents, forming a virtuous innovation ecosystem. Finally, the improvement of marketization can promote the effectiveness of resource allocation and the competitiveness of the economy. Through the role of market mechanisms, resources can be more effectively allocated to efficient production areas, thereby enhancing overall productivity levels and promoting sustainable economic development.

Based on this, this paper will construct a comprehensive evaluation index system for new quality productive forces from four dimensions: technological productivity, green productivity, digital productivity, and the development environment of productive forces. It will use spatial analysis to explore the temporal-spatial evolution characteristics of China's new quality productive forces and further employ a fixed effects model to identify specific influencing factors of new quality productive forces. This provides more effective decision-making references for promoting high-quality economic development in China. Considering the basic connotations of each dimension of new quality productive forces and the external influencing factors of the system comprehensively helps to examine the changes in China's economic structure more fully and can provide certain scientific basis and practical experience for the formulation of future economic policies in various regions.

3. Indicator Construction and Research Methods

3.1. Construction of New Quality Productive Forces Measurement Indicator System

3.1.1. Indicator Construction

New quality productive forces are driven by the deep application of new technologies and are characterized by the rapid emergence of new industries, new business forms, and new models. This leads to the construction of a new type of social production relationship and system. This paper draws on the research of Lu et al. (2024) [10]and Han et al. (2024)[11], and constructs a measurement indicator system for new quality productive forces from four dimensions: technological productivity, green productivity, digital productivity, and the development environment of productive forces. Twenty specific indicators are selected for this purpose, as detailed in Table 1.

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Table 1. Measurement Indicator System for New Quality Productive Forces

Primary Indicator	Secondary Indicator	Indicator Description	Indicator Attribute
technological productivity	Innovative Productivity	Number of domestic patent applications granted (items)	+
		R&D expenditure of large-scale industrial enterprises (billion yuan)	+
	Technological Productivity	Technology market transaction volume (billion yuan)	+
		Full-time equivalent of R&D personnel in large-scale industrial enterprises (person-years)	+
green productivity	Resource-saving Productivity	Energy consumption per unit of regional GDP (tons/10,000 yuan)	-
		Industrial water use per unit of regional GDP (cubic meters/1 yuan)	-
		Electricity consumption per unit of regional GDP (kWh/1 yuan)	-
	Environment-friendly Productivity	Chemical oxygen demand emissions per unit of regional GDP (kg/10,000 yuan)	-
		Sulfur dioxide emissions per unit of regional GDP (kg/10,000 yuan)	-
		Nitrogen oxides emissions per unit of regional GDP (kg/10,000 yuan)	-
digital productivity	Digital Industry Productivity	Total volume of telecommunications services (billion yuan)	+
		Software service revenue (billion yuan)	+
		Number of enterprises in the information transmission, software, and information technology industry (units)	+
	Industrial Digitalization Productivity	Proportion of enterprises with e-commerce transactions (%)	+
		E-commerce sales (billion yuan)	+
		Digital inclusive finance index (-)	+
development environment of productive forces	External Environment	Local general budget expenditure per unit of regional GDP (ratio)	+
		Industrial added value per unit of regional GDP (ratio)	+
		Average number of students per 100,000 population in higher education institutions (people)	+
		Marketization index (-)	+

Note: "+" represents a positive indicator, and "-" represents a negative indicator.

3.1.2. Data Sources

Based on the rationality and availability of indicator data, the research sample data selected for this study are panel data from 2013 to 2022 for 30 provinces (regions, municipalities) in China, excluding Tibet and the Hong Kong, Macao, and Taiwan regions. The sample data are primarily sourced from the National Bureau of Statistics, statistical yearbooks of various provinces (regions, municipalities), and the Wind database.

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3.2. Research Methods

3.2.1. Entropy Method

To ensure the objectivity and accuracy of the research results, the entropy method is employed to weight the evaluation indicators of new quality productive forces. The calculation steps of the entropy method are as follows:

Step 1: Standardize each indicator X_{ij} in the new quality productive forces measurement indicator system using the range method. This step eliminates the effects caused by inconsistencies in the magnitude and dimensions of different indicators.

(1) For positive indicators:

$$Y_{ij} = \frac{x_{ij} - min(x_{ij})}{max(x_{ij}) - min(x_{ij})}$$

(2) For negative indicators:

$$Y_{ij} = \frac{\max(x_{ij)} - x_{ij}}{max(x_{ij}) - min(x_{ij})}$$

Step 2: Calculate the information entropy E_j of Y_{ij} in the new quality productive forces measurement indicator system.

$$E_j = \ln\frac{1}{n}\sum_{i=1}^{n}\left[\left({Y_{ij}}/{\sum_{i=1}^{n} Y_{ij}}\right)\ln\left({Y_{ij}}/{\sum_{i=1}^{n} Y_{ij}}\right)\right]$$

Step 3: Calculate the weight W_j of Y_{ij} in the new quality productive forces measurement indicator system.

$$W_j = {(1 - E_j)}/{\sum_{j=1}^{m}(1 - E_j)}$$

Step 4: Calculate the comprehensive score of new quality productive forces.

$$S_i = \sum_{j=1}^{m}(W_j \times Y_{ij})$$

3.2.2. Jenks Natural Breaks Method

The Jenks Natural Breaks method, proposed by George Frederick Jenks, is a map classification algorithm that assumes data has natural breakpoints. These breakpoints can be utilized for classification, with the principle being to minimize within-group variance and maximize between-group variance.

3.2.3. Hotspot Analysis Method

The Hotspot Analysis Method (Getis-Ord Gi*) is an effective approach for identifying local spatial autocorrelation. It not only analyzes the spatial clustering characteristics of local areas

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but also categorizes them into "high-value areas" and "low-value areas," providing significant statistical insights. The calculation formula for the hotspot analysis index is as follows:

$$Gi^* = \frac{\sum_j^n w_{ij}(d)x_i}{\sum_j^n x_j}$$

Subsequently, the Gi*(d) is standardized using the following formula:

$$Z(Gi^*) = \frac{Gi^* - E(Gi^*)}{\sqrt{Var(Gi^*)}}$$

Here, W_{ij} represents the spatial weight within distance d, taking a value of 1 if spatial units i and j are adjacent, and 0 otherwise. $E(Gi^*)$ and $\mathrm{Var}(Gi^*)$ are the mean and variance of Gi^*, respectively. $Z(Gi^*)$ is the Z-score obtained after standardizing the hotspot analysis index. If $Z(Gi^*)$ is less than 0, the area is a low-value spatial cluster, i.e., a cold spot area. If $Z(Gi^*)$ is close to 0, the area has no significant spatial clustering, i.e., a random distribution area. If $Z(Gi^*)$ is greater than 0, the area is a high-value spatial cluster, i.e., a hotspot area[12].

4. Analysis of Temporal-Spatial Evolution Characteristics of New Quality Productive Forces

4.1. Overall Characteristics of New Quality Productive Forces Measurement

Based on the calculation of the new quality productive forces index for 30 provinces (regions, municipalities) from 2013 to 2022, the overall characteristics of China's new quality productive forces development level are summarized as follows. Firstly, the overall level of China's new quality productive forces is not high. Excluding the highest and lowest values, the index range is 0.0426 to 0.5346, indicating significant room for improvement in the future. Secondly, there is a considerable disparity in the new quality productive forces levels among the provinces (regions, municipalities). The range of the new quality productive forces index in China was 0.2204 in 2013, 0.2811 in 2016, 0.5497 in 2019, and 0.6789 in 2022, with the 2022 range being approximately three times that of 2013. Thirdly, from 2013 to 2022, the new quality productive forces levels in all provinces (regions, municipalities) showed a stable growth trend. Although some provinces (regions, municipalities) exhibited fluctuations, the overall trend was upward. Fourthly, the new quality productive forces levels in China's three major economic regions follow a distribution pattern of "east > central > west," with the eastern region performing the best, followed by the central region, and the western region being the lowest[13].

4.2. Temporal Evolution Characteristics of New Quality Productive Forces Level

The entropy method was employed to calculate the new quality productive forces index for 30 provinces (regions, municipalities) in China from 2013 to 2022. To further characterize the temporal evolution of the new quality productive forces levels across these provinces (regions, municipalities), we computed the average new quality productive forces index for the national level and the three major economic regions from 2013 to 2022 and conducted a comparative analysis. The specific results are depicted in Figure 1.

As illustrated in Figure 1, the new quality productive forces level in China showed a significant upward trend from 2013 to 2022, with only minor fluctuations in the last three years. On a national scale, driven by the rapid economic development, the average new quality productive

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forces index increased from 0.0942 in 2013 to 0.1845 in 2019, with an average annual growth rate of 15.98%. From 2020 to 2022, the average index rose from 0.2092 to 0.2297, but the average annual growth rate slowed to 4.90%, primarily due to the impact of the COVID-19 pandemic. When examining the three major economic regions, the eastern region's average new quality productive forces index grew from 0.1366 in 2013 to 0.2679 in 2019, at an average annual growth rate of 16.02%. The central region's index increased from 0.0851 to 0.1637, with an average annual growth rate of 15.39%. The western region's index rose from 0.0586 to 0.1162, with an average annual growth rate of 16.28%. However, from 2020 to 2022, the average growth rates in the eastern, central, and western regions all experienced a significant decline, with average annual growth rates of 6.20%, 5.94%, and 0.07%, respectively.

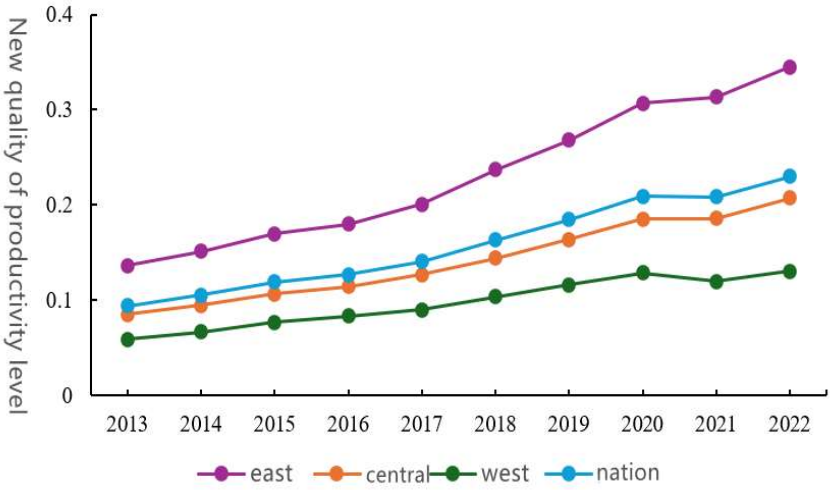

Figure 1. Temporal Evolution of New Quality Productive Forces Level in China (2013-2022)

4.3. Spatial Evolution Characteristics of New Quality Productive Forces Level

4.3.1. Spatial Differentiation Pattern

To explore the spatial differentiation pattern of China's new quality productive forces level, this study utilized ArcGIS 10.8 software to visualize the new quality productive forces levels of 30 provinces (regions, municipalities) in China for the years 2013, 2016, 2019, and 2022. The Jenks natural breaks method was employed to categorize the new quality productive forces levels into five classes: Class I, Class II, Class III, Class IV, and Class V, with higher classes indicating higher levels of new quality productive forces.

Figure 2 presents the spatial differentiation pattern of new quality productive forces. In 2013, the overall level of new quality productive forces in China was relatively low, with the largest number of regions in Class I and Class III, totaling 8 and 10, respectively, while Class IV and above regions numbered only 7, including Guangdong Province, Beijing, Zhejiang Province, Jiangsu Province, Jiangxi Province, Shanghai, and Shandong Province (ranked by index value from highest to lowest, same below). By 2016, there was a noticeable increase in the level of new quality productive forces, with the number of Class IV and above regions increasing to 11, with additional regions being Hubei Province, Tianjin, and Sichuan Province, while Class I regions decreased to 3. In 2019, the regional gap in new quality productive forces levels became more pronounced, with only Guangdong Province in Class V, and Beijing, Zhejiang Province, Jiangsu Province, Shandong Province, Jiangxi Province, and Shanghai in Class IV, with Class I regions increasing to 7. By 2022, the regional gap in new quality productive forces levels further widened, with the number of Class IV and Class V regions remaining unchanged, while Class I regions increased to 8. Overall, from 2013 to 2022, the regional gap in China's new quality productive forces levels showed a significant upward trend, with the number of regions above

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the average level never exceeding 50%, and the high-value areas of new quality productive forces mainly concentrated in the eastern coastal regions.

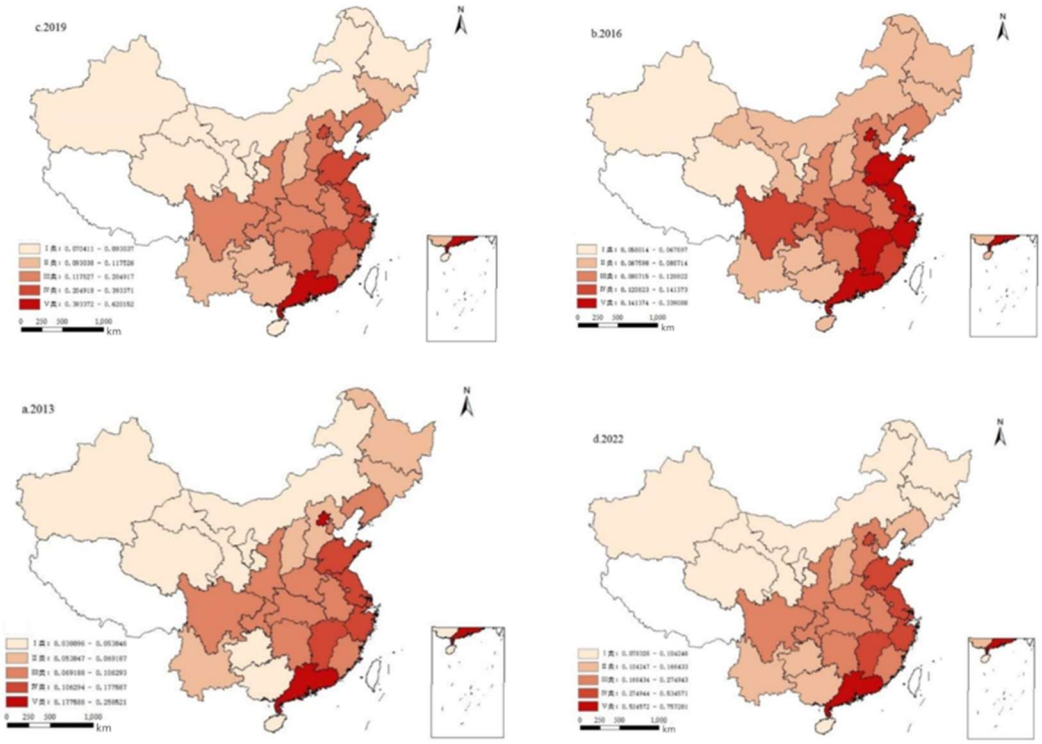

Figure 2. Spatial Differentiation Pattern of New Quality Productive Forces in 30 Provinces (Regions, Municipalities) of China (2013-2022)

Note: This map was created based on the Chinese standard map with the review number GS (2023) 2767, and the boundaries of the base map have not been modified.

4.3.2. Cold and Hot Spot Distribution Pattern

To further analyze the cold and hot spot distribution pattern of China's new quality productive forces level, this study utilized the hotspot analysis module of ArcGIS 10.8 software to calculate the cold and hot spots for the new quality productive forces levels of 30 provinces (regions, municipalities) in China for the years 2013, 2016, 2019, and 2022. The Jenks natural breaks method was employed to categorize the Z-values into five types: cold spot areas, secondary cold spot areas, random distribution areas, secondary hot spot areas, and hot spot areas.

From the cold and hot spot distribution pattern of new quality productive forces shown in Figure 3, the following observations can be made: (1) From 2013 to 2022, the hot spot areas of China's new quality productive forces level consistently remained in the southeastern coastal regions, such as Shanghai, Zhejiang Province, Jiangsu Province, and Fujian Province, with a trend of expanding southward. (2) The distribution of secondary hot spot areas was relatively stable, always surrounding the hot spot areas and in the Beijing-Tianjin region. (3) The random distribution areas were located in the central regions, consistently forming a transitional zone between the hot spot and cold spot areas. (4) The cold spot areas were consistently distributed in the northwestern regions, with their distribution range gradually shrinking; the secondary cold spot areas were always around the cold spot areas, with their distribution range gradually expanding. (5) At the four time points of 2013, 2016, 2019, and 2022, the distribution of China's new quality productive forces level exhibited characteristics of "hot spots remain hot," "high values remain high," "cold spots remain cold," and "low values remain low."

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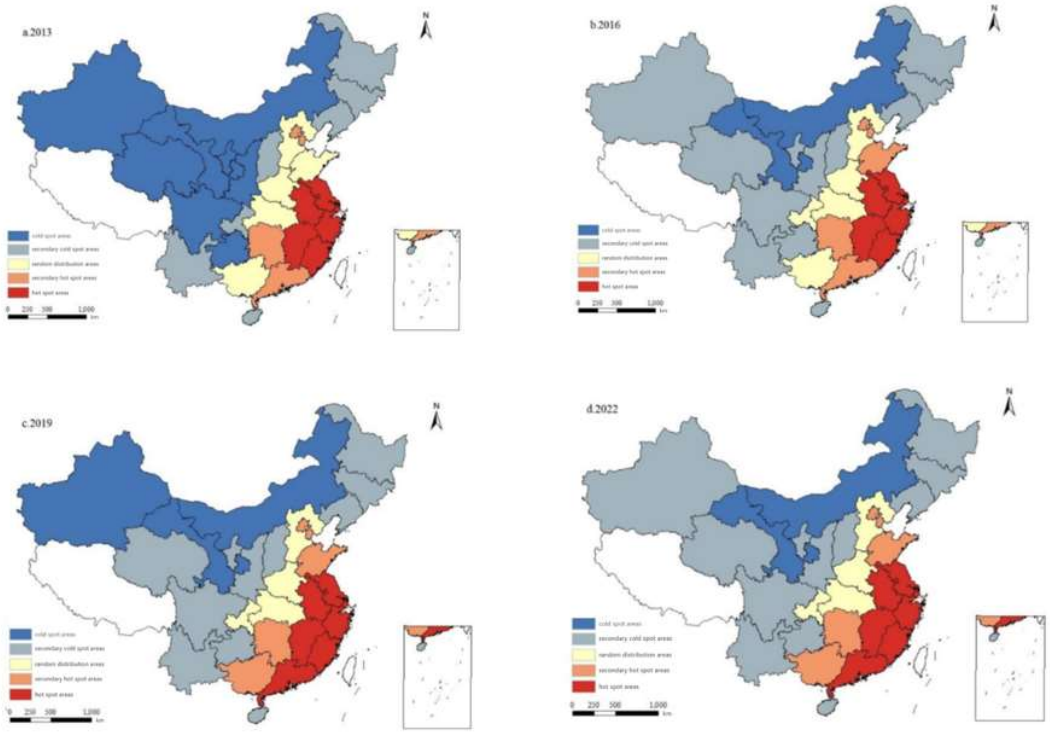

Figure 3. Cold and Hot Spot Distribution Pattern of New Quality Productive Forces in 30 Provinces (Regions, Municipalities) of China (2013-2022)

Note: This map was created based on the Chinese standard map with the review number GS (2023) 2767, and the boundaries of the base map have not been modified.

5. Analysis of Influencing Factors of New Quality Productive Forces Level

5.1. Variable Selection and Model Specification

5.1.1. Variable Selection

Starting from the basic connotations of new quality productive forces and combining the measurement results, this paper intends to explore the influencing factors of new quality productive forces(Npro) from aspects such as economic development level (Pgdp), fiscal inclination towards science and technology (Se), fiscal inclination towards education (Edu), environmental regulation intensity (Er), financial development level (Fd), and degree of openness to the outside world (Op). Specifically, the economic development level is measured by per capita GDP (in ten thousand yuan), fiscal inclination towards science and technology is measured by the proportion of fiscal expenditure on science and technology in total expenditure, fiscal inclination towards education is measured by the proportion of fiscal expenditure on education in total expenditure, environmental regulation intensity is measured by the proportion of investment in industrial pollution control in the added value of the secondary industry, and the degree of openness to the outside world is measured by the proportion of total imports and exports in regional GDP. Descriptive statistics for each variable are presented in Table 2. Additionally, the results of the multicollinearity test for the variables in Table 3 indicate that all VIF values are significantly less than 10, suggesting that there is no severe multicollinearity among the variables.

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Table 2. Descriptive Statistics of Main Variables

Variable Symbol	Observations	Mean	Standard Deviation	Maximum	Minimum
Npro	300	0.158	0.114	0.038	0.757
Pgdp	300	6.271	3.112	2.209	19.031
Se	300	0.022	0.015	0.005	0.068
Edu	300	0.161	0.026	0.989	0.217
Er	300	0.003	0.003	0.000	0.025
Fd	300	1.570	0.429	0.743	2.774
Op	300	0.259	0.257	0.008	1.257

Table 3. Multicollinearity Test Results for Variables

Variable	Pgdp	Se	Edu	Er	Fd	Op
VIF	3.03	3.25	1.40	1.18	1.48	2.95
1/VIF	0.3302	0.3073	0.7134	0.8443	0.6770	0.3389

5.1.2. Model Specification

Drawing on relevant literature and combining the measurement results of new quality productive forces, this paper employs a fixed effects model to identify the specific influencing factors of the new quality productive forces level. The fixed effects model is constructed as follows:

$$Npro_{it} = \alpha_0 + \alpha_1 Pgpd_{it} + \alpha_2 Se_{it} + \alpha_3 Edu_{it} + \alpha_4 Er_{it} + \alpha_5 Fd_{it} + \alpha_6 Op_{it} + \mu_i + \delta_t + \varepsilon_{it}$$

In the model, $Npro_{it}$ is the dependent variable representing new quality productive forces. $Pgpd_{it}$, Se_{it}, Edu_{it}, Er_{it}, Fd_{it} , and Op_{it} are the respective influencing factors, namely, economic development level, fiscal inclination towards science and technology, fiscal inclination towards education, environmental regulation intensity, financial development level, and degree of openness to the outside world. ε_{it} represents the random disturbance term, while μ_i and δ_t denote the fixed effects for provinces and years, respectively.

5.2. Empirical Test Results Analysis

5.2.1. Baseline Regression Results Analysis

Table 4 presents the baseline regression results. Columns (1) to (3) in Table 4 show the regression results without fixed effects, with only provincial fixed effects, and with both spatial and temporal fixed effects, respectively. Among the explanatory variables, economic development level, fiscal inclination towards science and technology, environmental regulation intensity, and financial development level all have a positive and significant impact on the new quality productive forces index at least at the 5% level, while the degree of openness to the outside world and fiscal inclination towards education are no longer significant after the inclusion of fixed effects.

Specifically, the economic development level plays a crucial supportive role in the development of new quality productive forces. Regions with higher economic levels have greater capacity to provide the necessary resources and conditions to support the development of new quality productive forces. Therefore, improvements in economic development level and financial development level can significantly and positively promote the enhancement of new quality productive forces. The significant positive impact of fiscal inclination towards science and technology stems from the fact that the higher the government's emphasis on science and technology, the larger the dedicated funding for its development, which aligns with the objective requirements for the development of new quality productive forces. Moderate

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environmental regulation intensity helps to stimulate enterprises to innovate in green and efficient technologies, encouraging them to actively adjust their industrial structures. At the current level, the higher the government's regulatory intensity on the environment during industrial development, the more it reflects the requirements of green and low-carbon industrial development, making the direction of industrial development more consistent with that of new quality productive forces. Thus, the enhancement of environmental regulation intensity also positively affects the level of new quality productive forces. The degree of openness to the outside world only shows a 5% significant effect in the model without fixed effects, with a negative coefficient, indicating that at the current stage, the overall level of openness does not promote the enhancement of new quality productive forces. This may be related to the low quality of openness and the inconsistent impact of this factor on different regions. Although fiscal inclination towards education has a positive impact, it does not reach a significant level, possibly due to the large differences in the impact of this factor across different regions, preventing an overall significant effect.

Table 4. Baseline Regression Results

Variable	(1)	(2)	(3)
Pgdp	0.023***	0.023***	0.026***
	(0.002)	(0.003)	(0.008)
Se	2.946***	2.578***	2.568***
	(0.889)	(0.741)	(0.740)
Edu	0.878	0.649	0.638
	(0.592)	(0.676)	(0.658)
Er	2.185**	2.950***	2.435**
	(0.913)	(0.794)	(0.910)
Fd	0.071***	0.088***	0.102***
	(0.025)	(0.029)	(0.032)
Op	-0.153**	-0.155	-0.176
	(0.060)	(0.139)	(0.189)
Constant	-0.273**	-0.256**	-0.267**
	(0.122)	(0.123)	(0.100)
Province FE	NO	YES	YES
Year FE	NO	NO	YES
N	300	300	300
R2	0.775	0.779	0.798

Note: The values in parentheses are robust standard errors. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Unless otherwise specified, the same applies below.

5.2.2. Heterogeneity Analysis

Due to significant differences in economic and financial development levels across various regions in China, this study divides the sample data into three parts: eastern, central, and western, to explore the regional heterogeneity of the impact of each variable on new quality productive forces. The regression results are shown in Table 5.

In the eastern region, when the economic development level reaches a certain threshold, the positive effect of economic development level is no longer significant. The significant factors at this level include fiscal inclination towards science and technology, environmental regulation intensity, financial development level, and fiscal inclination towards education. This indicates that economically developed regions are advancing the development of new quality productive forces through multiple pathways.

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In the central region, the impact coefficients of economic development level and financial development level are significantly positive at the 1% level, suggesting that the central region still needs to focus on economic development as a support to better enhance its level of new quality productive forces. The impact coefficient of fiscal inclination towards science and technology is significantly positive at the 5% level, indicating that fiscal expenditure on science and technology plays an important role as a driving force for the development of new quality productive forces in the central region. Unlike the baseline regression, the impact coefficient of the degree of openness to the outside world is significantly positive at the 5% level, suggesting that opening up to the outside world is also a viable path for the development of new quality productive forces in the central region.

In the western region, all factors show varying degrees of significant impact, except for fiscal expenditure on education, which does not align with expectations. This suggests that as an economically underdeveloped region, the western region's starting points for various development paths are relatively low. The region still needs to rely on economic development as a support, while appropriately improving technology levels, increasing environmental regulation intensity, and enhancing the degree of openness to the outside world to complement economic development and thereby improve the level of new quality productive forces. Unlike the baseline regression, fiscal expenditure on education is significantly negative at the 1% level, which may be related to the longer time required for education expenditure to take effect and the potential impact of increased fiscal funds for education on the growth of other development paths.

Table 5. Heterogeneity Analysis Results

Variable	(1)east	(2)central	(3)west
Pgdp	0.016	0.040***	0.017*
	(0.010)	(0.008)	(0.008)
Se	4.374***	0.951**	1.891*
	(0.749)	(0.327)	(0.863)
Edu	1.778*	-0.148	-0.456***
	(0.894)	(0.228)	(0.119)
Er	6.489**	0.897	2.012**
	(2.368)	(0.801)	(0.770)
Fd	0.180**	0.127***	0.022**
	(0.058)	(0.032)	(0.009)
Op	-0.239	0.312**	0.158***
	(0.155)	(0.102)	(0.046)
Constant	-0.560**	-0.207***	-0.009
	(0.191)	(0.044)	(0.025)
Province FE	YES	YES	YES
Year FE	YES	YES	YES
N	110	80	110
R2	0.853	0.968	0.915

5.2.3. Contribution Analysis of Different Influencing Factors

The previous sections examined the influencing factors of the new quality productive forces level. This section further estimates the relative importance of these factors, specifically their contributions to changes in the new quality productive forces level. This paper employs the Shapley value decomposition method proposed by Shorrocks (2013) [14]to analyze the contributions of each variable in the eastern, central, and western regions.

Based on Table 6, it can be concluded that in the eastern region, fiscal inclination towards science and technology contributes 44.79%, playing a dominant role. The contributions of other factors (except for financial development level) range between 10% and 18%, while the

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financial development level has the lowest contribution at only 2.18%. In the central region, the main contributor is the economic development level, accounting for 33.69%, followed by fiscal inclination towards science and technology at 19.43%. Environmental regulation intensity, openness to the outside world, and fiscal inclination towards education also contribute more than 10%, while the financial development level has the lowest contribution at 3.42%. In the western region, the economic development level is the dominant factor, accounting for 41.10%, followed by environmental regulation intensity at 24.92%. Both financial development level and fiscal inclination towards education contribute less than 10%.

Therefore, based on the contributions of different influencing factors in different regions, it can be inferred that, except for the economically developed eastern region, the improvement of new quality productive forces levels in the central and western regions mainly relies on increasing economic levels. In the eastern region, fiscal inclination towards science and technology is the primary contributor. Among the three regions, the financial development level does not play a significant role.

Table 6. Shapley Value Decomposition Results

Variable	east		central		west	
	Contribution (%)	Rank	Contribution (%)	Rank	Contribution(%)	Rank
Pgdp	17.29	2	33.69	1	41.10	1
Se	44.49	1	19.43	2	16.66	3
Er	11.69	5	15.52	4	24.92	2
Fd	2.18	6	3.42	6	1.60	6
Op	11.82	4	10.02	5	10.16	4
Edu	12.23	3	17.92	3	5.56	5
Total	100.00		100.00		100.00	

5.2.4. Robustness Tests

Table 7. Robustness Test Results

Variable	(1)	(2)	(3)
	Data Trimming	Exclusion of Municipalities	Lagged Variables
Pgdp	0.026***	0.031***	0.024**
	(0.008)	(0.011)	(0.009)
Se	2.568***	2.039***	3.581***
	(0.740)	(0.467)	(0.998)
Er	2.435**	3.100***	3.213***
	(0.910)	(1.024)	(1.090)
Fd	0.102***	0.112***	0.077**
	(0.032)	(0.030)	(0.030)
Op	-0.176	-0.338	-0.202
	(0.189)	(0.214)	(0.170)
Edu	0.638	0.559	0.491
	(0.658)	(0.681)	(0.578)
Constant	-0.204**	-0.234*	-0.009
	(0.085)	(0.120)	(0.025)
Province FE	YES	YES	YES
Year FE	YES	YES	YES
N	300	260	270
R2	0.798	0.809	0.803

To enhance the robustness of the research findings and address potential endogeneity issues in the baseline regression model, the following robustness tests were conducted: (1) Data Trimming, which involves trimming the sample data at the upper and lower 1% levels to

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mitigate the impact of extreme values; (2) Exclusion of Municipalities, where data from the four municipalities directly under the central government-Beijing, Shanghai, Tianjin, and Chongqing-are excluded; (3) Lagged Independent Variables, where the influencing factors are lagged by one period. The results of the robustness tests, as shown in Table 7, are highly consistent with the baseline regression results, indicating that the findings of this study are robust.

6. Conclusion and Recommendations

6.1. Main Conclusion

Based on the exploration and expansion of research on new quality productive forces, this paper uses the entropy method to measure the level of new quality productive forces in 30 provinces (regions, municipalities) of China from 2013 to 2022. It employs time series and spatial analysis methods to investigate the temporal-spatial evolution characteristics of new quality productive forces and further utilizes a fixed effects model to identify the specific influencing factors. The main conclusions are as follows: (1) The temporal evolution characteristics indicate that the national and three major economic regions' levels of new quality productive forces have shown a relatively stable growth trend from 2013 to 2022, with minor fluctuations in the last three years due to the impact of the COVID-19 pandemic; (2) The spatial differentiation pattern shows that the level of new quality productive forces in China follows a distribution pattern of "east > central > west," with regional disparities increasing annually; (3) The cold and hot spot distribution pattern indicates that the hot spots of new quality productive forces in China are mainly located in the southeastern coastal areas, while the cold spots are mainly in the northwestern regions, with the characteristics of "hot spots remain hot" and "high values remain high" becoming increasingly evident; (4) At the national level, economic development level, fiscal inclination towards science and technology, environmental regulation intensity, and financial development level all have a positive promoting effect on the new quality productive forces index, while the impact of openness to the outside world and fiscal inclination towards education is not significant; (5) In terms of regional differences, for the eastern region, the promoting effects of fiscal inclination towards science and technology, environmental regulation intensity, financial development level, and fiscal inclination towards education are more significant; for the central and western regions, economic development level is the main contributing factor, and the contributions of fiscal inclination towards science and technology and openness to the outside world are also substantial.

6.2. Policy Recommendations

First, actively promote technological empowerment and vigorously develop new quality productive forces. Currently, the growth rate of China's new quality productive forces has slowed down. All regions should continuously enhance their level of technological innovation, improve the construction of new infrastructure, build platforms for the development of the digital economy, and establish an environment conducive to scientific and technological innovation. This will encourage various enterprises and research institutions to increase their investment in technological innovation and increase their output, thereby achieving technological empowerment of new quality productive forces and promoting high-quality economic development in China.

Second, implement differentiated policies to orderly promote the development of new quality productive forces. There are significant differences in the development levels of new quality productive forces across various regions in China. Each region needs to adopt differentiated development strategies based on local conditions. The eastern region should play a leading role,

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actively guiding the flow of new quality productive forces resources to the central and western regions; the central and western regions should strengthen cooperation with the eastern region in terms of technological innovation, resource allocation, and talent exchange to comprehensively improve the development level of new quality productive forces.

Third, promote comprehensive economic growth to enhance the development level of new quality productive forces. The eastern region should increase fiscal inclination towards science and technology, raise the intensity of environmental regulation, and promote the stable development of the financial industry while promoting economic growth, to accelerate the formation of new quality productive forces. The central and western regions should focus on promoting economic development, while appropriately strengthening fiscal investment in science and technology and promoting the development of foreign trade, to further develop regional new quality productive forces.

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