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Measurement, Evaluation and Research on the New Quality Productivity of Chinese Provinces

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Abstract

The development of new quality productivity is crucial for advancing China's economic transformation and realizing high-quality development. Based on this, this paper measures the new quality productivity of 30 Chinese provinces from 2011 to 2022, and analyzes its development trends and regional differences. The results show that: first, China's new quality productivity maintains a sound development momentum with great potential; second, there are significant disparities in the development of new quality productivity among provinces, with the eastern region outperforming the central and western regions. In view of this, all provinces in China should further accelerate talent cultivation, promote technological innovation, and strengthen digital infrastructure construction.

Keywords

New Quality Productivity; Technological Innovation; TOPSIS-Entropy Weight Method

1. Introduction

Nowadays, traditional production methods are no longer sufficient to meet the needs of the rapidly evolving era of science and technology, and production models are undergoing profound transformations. General Secretary Xi Jinping first put forward the concept of "new quality productive forces" during his inspection tour of Heilongjiang, emphasizing the need to "vigorously cultivate strategic emerging industries such as new energy, new materials, advanced manufacturing, and electronic information, actively foster future industries, and accelerate the development of new quality productive forces". The rise of new quality productive forces not only subverts traditional industries but also imposes brand-new requirements on innovation capacity, intelligentization, and sustainable development. In this crucial period full of opportunities and challenges, it is essential to conduct in-depth reflections and take proactive actions to promote the development of new quality productive forces, thereby addressing the increasingly fierce global competition and driving high-quality economic development. Then,

how can new quality productive forces be measured quantitatively? What is the current state of the development of new quality productive forces in China? Focusing on these two questions, this paper analyzes and explores new quality productive forces based on the panel data of 30 Chinese provinces from 2011 to 2022.

2. Literature Review

2.1. Connotation and Concept of New Quality Productive Forces

Regarding productivity, Marx and Engels stated in The German Ideology: "A certain mode of production or stage of industrial development is always bound up with a certain mode of co-operation, or a certain stage of social development; and this mode of co-operation itself is a productive force." Later, in Letter to Pavel Vasilyevich Annenkov, Marx pointed out that "productivity is the result of people's practical capabilities..." From the perspective of Marxist historical materialism, it is productivity that drives the transformation of production relations. In short, productivity refers to people's ability to produce the material means of subsistence they need, and this ability exists objectively in the means of production, which are the objectified results of people's practical activities (Lin, 2005)[1].

However, the development of productivity is not static but dynamic. Productivity has become the most revolutionary and dynamic factor driving social progress. Qualitative changes in key and core technologies will disrupt the old productive forces and become the core elements of new productive forces. As the decisive force behind the changes in social systems and the development of human society, China's productivity has undergone long-term gestation and development, and qualitative changes have taken place in the process of deepening reforms, evolving into advanced productive forces. In September 2023, General Secretary Xi Jinping put forward the concept of "new quality productive forces", which provides important guidance for China to build a new engine for economic development, enhance new drivers of growth, and establish new national advantages in the new development stage. Distinct from traditional productivity, new quality productive forces represent the evolutionary direction of advanced productivity, characterized by high technology, high efficiency, and high quality. They are an advanced form of productivity fostered by revolutionary technological breakthroughs, innovative allocation of production factors, and in-depth transformation and upgrading of industries. With the upgrading of laborers, means of labor, objects of labor, and their optimal combination as its basic connotation, new quality productive forces possess strong momentum for development. From the perspective of the three elements of productivity, means of labor with higher technological content serve as the source of momentum for new quality productive forces; objects of labor covering a wider range form the material foundation; and laborers with higher qualities are the primary element of new quality productive forces.

2.2. Research Status of New Quality Productive Forces

At present, most scholars focus on studying the connotation and characteristics of new quality productive forces. The "new quality" refers to the new form derived from scientific and technological innovation, industrial transformation and upgrading, etc., as traditional productive forces are continuously impacted by intelligentization and informatization. Among them, the "new" denotes new forms such as new technologies, new industries, and new drivers of growth, while the "quality" refers to the leaping development in terms of substance, quality, and essence, which is a form of productivity that meets the requirements of Chinese path to modernization (Liu & Ren, 2024)[2]. Qi et al. (2024)[3] explored the generative logic of new quality productive forces from historical, realistic, and theoretical perspectives, concluding that essentially, new quality productive forces constitute a Schumpeterian process of continuous innovation, involving new combinations of new production factors.

Meanwhile, numerous scholars have conducted research on the practical paths for the generation and functioning of new quality productive forces. Li, Guo et al. (2024)[4] argued that new quality productive forces are an inevitable manifestation of the continuous development of the socioeconomic structure. Their emergence stems from revolutionary technological breakthroughs, a profound understanding and practice of the innovative allocation of production factors, and the in-depth transformation and upgrading of industries. By analyzing the inherent logic of new quality productive forces empowering high-quality development, Xu et al. (2023)[5] found that accelerating the development of new quality productive forces can help achieve development goals, improve the development structure, strengthen development momentum, expand development content, and optimize development factors. From the perspectives that high-quality development of financial management is a development model led by new quality productive forces and the enabling methods of new quality productive forces for high-quality financial management development, Wang et al. (2024)[6] analyzed the enabling mechanism of new quality productive forces for high-quality financial management development and finally proposed six implementation paths for such empowerment.

In addition, some scholars have mainly focused on researching the measurement of new quality productive forces. When studying the impact and mechanism of new quality productive forces on resource allocation efficiency, Xu et al. (2024)[7] established an evaluation index system for new quality productive forces from three dimensions: new-quality laborers, new-quality means of labor, and new-quality objects of labor, and measured the level of new quality productive forces in a scientific, objective, and comprehensive manner. Based on the two-factor theory of labor, Song et al. (2024)[8] constructed an evaluation index system to measure the level of new quality productive forces at the provincial level.

3. Indicator System and Model Construction

3.1. Construction of the Measurement Indicator System for New Quality Productive Forces

Drawing on the indicator system construction methods proposed by Qi et al. (2024)[3] and Xu et al. (2024)[7], this paper constructs a measurement system for new quality productive forces in accordance with the principles of scientificity, systematicity, and feasibility, as well as the three-factor theory of labor. The system is designed from three dimensions, namely new-quality laborers, new-quality objects of labor, and new-quality means of labor. It selects 9 primary indicators and 20 secondary indicators to conduct a scientific and comprehensive measurement and evaluation of new quality productive forces, with the specific indicator system presented in Table 1.

Table 1. Evaluation Index System of New Quality Productive Forces

Dimension LayerPrimary IndicatorSecondary Indicator	Dimension LayerPrimary IndicatorSecondary Indicator	Dimension LayerPrimary IndicatorSecondary Indicator	Indicator Attribute
New-quality Laborers	Laborer Quality	Average years of education per capita (years)	+
		Proportion of students in institutions of higher education (%)	+
	Employment Structure	Proportion of employees in computer services and software industry (%)	+
		Proportion of full-time R&D personnel (%)）	+
New-quality Objects of Labor	New-quality Industries	Per capita total telecom business volume (yuan)	+
	Ecological Governance	Forest coverage rate (%)	+
	Environmental Protection Efforts	Proportion of environmental protection expenditure (%)	+
	Pollutant Emissions	Sulfur dioxide emissions (10,000 tons)	−
		Industrial solid waste emissions (10,000 tons)	−
		Wastewater COD emissions (10,000 tons)	−
		Carbon dioxide emissions (1,000,000 tons)	−
New-quality Means of Labor	Tangible Means of Labor	Highway mileage (km)	+
		Railway mileage (km)	+
		Optical fiber length (km)	+
		Per capita number of internet broadband access ports (unit)	+
		Number of internet broadband access users per 100 people (user)	+
		Total energy consumption (10,000 tons of standard coal)	−
		Number of mobile phones owned per 100 people (unit)	+
	Intangible Means of Labor	Number of valid invention patents of industrial enterprises above designated size (unit)	+
		R&D expenditure of industrial enterprises above designated size (10,000 yuan)	+

3.2. Data Sources

To maintain the balance of panel data and reduce the impact of missing values, this paper selects the panel data of 30 provinces in China (excluding Tibet, Hong Kong, Taiwan, and Macao) from 2011 to 2022 as the research sample. The analytical data are derived from China Statistical Yearbook, the EPS Database, and the statistical yearbooks of various provinces. Among them, the data on carbon dioxide emissions are obtained from the CEADs (China Emission Accounts and Datasets). In addition,

for a small number of missing data in individual years, this paper employs the linear interpolation method to supplement them.

3.3. Construction of the Measurement Model for New Quality Productive Forces

This paper adopts the TOPSIS entropy weight method to measure the level of new quality productive forces. The calculation steps are as follows:

(1) Data Standardization

First of all, standardization processing is performed on all indicators, and different types of indicators require separate standardization methods.

$$y_{ij} = \begin{cases} \frac{x_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)}, & \text{if } X_{ij} \text{ is a positive indicator} \\ \frac{\max(X_j) - x_{ij}}{\max(X_j) - \min(X_m)}, & \text{if } X_{ij} \text{ is a negative indicator} \end{cases} \quad (1)$$

The original indicators $\{X_1, X_2, \ldots, X_m\}$ are converted into standardized indicators $\{Y_1, Y_2, \ldots, Y_m\}$, where y_{ij} represents the value of the j-th indicator of the i-th sample after standardization:

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{pmatrix} \rightarrow \quad Y = \begin{pmatrix} y_{11} & \cdots & y_{1m} \\ \vdots & \ddots & \vdots \\ y_{n1} & \cdots & y_{nm} \end{pmatrix} \quad (2)$$

(2) Calculation of Indicator Weights

Calculate the proportion of the i-th ample under a given indicator X_j, where ρ_{ij} denotes the proportion of the i-th sample in the j-th indicator.

$$\rho_{ij} = \frac{y_{ij}}{\sum_i^n y_{ij}}, \quad i = 1,2,\ldots,n; \quad j = 1,2,\ldots,m \quad (3)$$

(3) Calculation of Information Entropy

Calculate the entropy value of a given indicator X_j:

$$E_J = -\frac{1}{\ln(n)} \sum_{i=1}^n \rho_{ij} \ln(\rho_{ij}) \quad (4)$$

where n is the number of samples, and generally $0 \leq E_j \leq 1$

(4) Determination of Indicator Weights

Based on the information entropy calculation formula, the information entropy values of each indicator are obtained as $E_1, E_2, \ldots, E_m$. Then, the weight of each indicator is determined through the information entropy values:

$$W_j = \frac{1 - E_j}{m - \sum E_j} \quad (j = 1,2,\ldots,m) \quad (5)$$

(5) Calculation of Comprehensive Scores

$$Score_{ij} = \sum_{j=1}^m W_j . y_{ij} \quad y(i = 1,2,\ldots,n) \quad (6)$$

4. Calculation Results and Analysis of New Quality Productive Forces

4.1. Entropy Values and Weights of the Indicator Evaluation System

As shown in Table 2, based on the formulas mentioned above, this paper calculates

the entropy values and weights of the indicator evaluation system for new quality productive forces in 30 Chinese provinces from 2011 to 2022. In the process of measuring the research objects by the entropy weight method, the calculated entropy value (information entropy value) represents the amount of information carried by the corresponding indicator and the degree of system disorder. The more information an indicator carries, the smaller its entropy value, and the more effective the selected indicator will be. It can be seen from Table 2 that among the secondary indicators, the "number of valid invention patents of industrial enterprises above designated size" has the strongest effectiveness, with an entropy value of 0.0180.

In terms of weights, the process of calculating weights by the entropy weight method needs to determine the amount of information contained in each value, which can reflect the utility value of the indicator's information entropy, eliminate human factors, avoid the non-objectivity caused by the subjective weighting method, and make the results more convincing. That is to say, the greater the role played by the information entropy of the corresponding indicator in the measurement process, the larger the weight should be assigned; otherwise, a smaller weight should be assigned. As can be seen from Table 2, among the secondary indicators, the "proportion of employees in computer services and software industry" and the "number of valid invention patents of industrial enterprises above designated size" have the highest weights, accounting for 16.29% and 16.51% respectively. At the dimension level, the "new-quality means of labor" has the highest weight, reaching 48.66%, which proves that new-quality means of labor play a significant role in the measurement of new quality productive forces.

Table 2. Calculation Results of Entropy Values and Weights

Dimension LayerPrimary IndicatorSecondary Indicator	Dimension LayerPrimary IndicatorSecondary Indicator	Dimension LayerPrimary IndicatorSecondary Indicator	Entropy Value	Weight (%)	
New-quality Laborers	Laborer Quality	Average years of education per capita (years)	0.9781	1.98	32.79
		Proportion of students in institutions of higher education (%)	0.9829	1.55	
	Employment Structure	Proportion of employees in computer services and software industry (%)	0.8203	16.29	
		Proportion of full-time R&D personnel (%)）	0.8570	12.96	
New-quality Objects of Labor	New-quality Industries	Per capita total telecom business volume (yuan)	0.8844	10.48	18.55
	Ecological Governance	Forest coverage rate (%)	0.9646	3.21	
	Environmental Protection Efforts	Proportion of environmental protection expenditure (%)	0.9785	1.95	
	Pollutant Emissions	Sulfur dioxide emissions (10,000 tons)	0.9929	0.64	
		Industrial solid waste emissions (10,000 tons)	0.9919	0.74	
		Wastewater COD emissions (10,000 tons)	0.9866	1.21	
		Carbon dioxide emissions (1,000,000 tons)	0.9966	0.31	
New-quality Means of Labor	Tangible Means of Labor	Highway mileage (km)	0.9649	3.18	48.66
		Railway mileage (km)	0.9628	3.37	
		Optical fiber length (km)	0.9457	4.93	

		Per capita number of internet broadband access ports (unit)	0.9667	3.02	
		Number of internet broadband access users per 100 people (user)	0.9420	5.26	
		Total energy consumption (10,000 tons of standard coal)	0.9948	0.48	
		Number of mobile phones owned per 100 people (unit)	0.9787	1.93	
	Intangible Means of Labor	Number of valid invention patents of industrial enterprises above designated size (unit)	0.8180	16.51	
		R&D expenditure of industrial enterprises above designated size (10,000 yuan)	0.8898	9.99	

4.2. Specific Calculation and Scoring Results of New Quality Productive Forces

Figure 1 presents the calculation and scoring results of new quality productive forces in 30 Chinese provinces from 2011 to 2022. On the whole, the new quality productive forces of all provinces in China show an upward trend year by year, maintaining a sound development momentum. Especially since 2015, the level of new quality productive forces in all provinces has increased significantly, but it showed a downward trend in 2019.

From the perspective of the connotation of new quality productive forces, improving the level of new quality productive forces requires enhancing the quality of laborers, developing the level of science and technology represented by digitalization, and strengthening the application of new technologies featuring scientization and intelligentization. In recent years, China has steadily promoted economic restructuring, focused on implementing the new development philosophy, improved the efficient allocation of resources, constructed a modern economic system, and firmly grasped high-quality development as the primary task. These efforts have driven the rapid development of high-tech industries, the continuous accumulation of resources driven by high technology, and the steady improvement of total factor productivity, thus leading to a significant rise in the level of new quality productive forces.

Although the COVID-19 pandemic that began in 2019 has hindered the global economic development to a certain extent, resulting in a downward trend in the level of new quality productive forces, China has always strived to move forward towards the goal of high-quality development, and it is believed that the development will gradually improve in the future.

However, there are regional differences in the new quality productive forces among provinces. There is a large development gap between the eastern and western regions of China, and the new quality productive forces show a decreasing trend from the east to the central and western regions. The eastern coastal provinces have a relatively high level of new quality productive forces, while the central and western inland regions are relatively backward with great development potential. From a regional perspective, the Beijing-Tianjin-Hebei region, the Yangtze River

Delta region, the Chengdu-Chongqing region, and the Pearl River Delta region are in the leading position in terms of the level of new quality productive forces. It is not difficult to find that regions with relatively sound development of new quality productive forces all attach great importance to the development of strategic emerging industries and future industries, as well as scientific and technological innovation and digital transformation. Therefore, all provinces need to make more active efforts to enhance the scientific and technological attributes, transform production methods, improve the scientific and technological level of the labor force, and thus elevate the level of new quality productive forces.

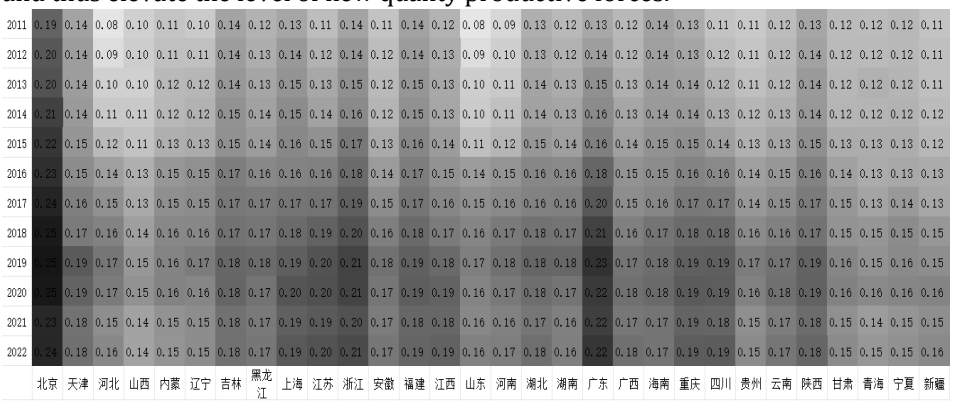

Figure 1. Heatmap of New Quality Productive Forces Measurement Results in 30 Chinese Provinces (2011–2022)

5. Policy Recommendations

Combined with the current development status of China's new quality productive forces and the development requirements of new quality productive forces at the levels of new-quality laborers, new-quality objects of labor, and new-quality means of labor, this paper proposes practical paths to promote the rapid development of China's new quality productive forces on the basis of complying with the laws of productivity development.

5.1. Cultivate Laborers Needed for Strategic Emerging Industries and Future Industries

Cultivate Laborers Needed for Strategic Emerging Industries and Future Industries

The development of new quality productive forces relies on strategic emerging industries and future industries characterized by high innovation and knowledge intensity. These industries are highly dependent on scientific and technological talent resources and have high requirements for the knowledge structure of scientific and technological talents. Therefore, on the basis of consolidating existing talent advantages, efforts should be focused on cultivating new scientific and technological talents represented by artificial intelligence, the Internet of Things, and the Internet, digital technology talents, and talents in "bottleneck" key

technologies represented by chips. Firstly, prioritize supporting talent training in fields related to new quality productive forces, and give certain inclinations in the professional setup, discipline construction, and faculty allocation of relevant majors. Secondly, cultivate talents oriented by industrial needs. Focus on establishing an industry-university-research joint training system, cultivate high-quality talents with both theoretical knowledge and practical experience based on industrial demands, strengthen university-enterprise cooperation and joint talent training, and form a virtuous circle of talent cultivation. Thirdly, vigorously introduce high-quality talents from overseas in related fields. Formulate overseas talent introduction plans and demand lists, establish a global talent introduction network platform, and attract talents in high-tech fields urgently needed in China.

5.2. Upgrade Objects of Labor through Technological Progress and Innovative Development

Firstly, attach importance to promoting breakthrough innovations in underlying generic technologies to form new technological application highlights and breakthrough product highlights. Secondly, increase policy support for basic core technology fields, strengthen the government ' s guiding role in the industrialization of scientific and technological achievements, and adopt comprehensive support measures from R&D to industrialization in key underlying technology fields, including research, training, and infrastructure construction. Thirdly, improve the scientific and technological intermediary service system, give play to its supporting and guaranteeing role in the transfer and diffusion of scientific and technological achievements, and establish new R&D institutions and innovation platforms centered on the industrialization of innovative achievements to promote the transformation of scientific and technological achievements into practical productive forces and accelerate the formation of new quality productive forces.

5.3. Further Tap the Potential of Data Mining

From the supply side, many current institutions do not attach importance to the construction of data resources; most only conduct simple data storage without forming a data processing mechanism, leading to generally poor quality of existing data resources. From the demand side, most production units are still limited to traditional material forms of means of production and have not formed an objective understanding of data resources and their value in human production. Therefore, the following measures should be taken: Firstly, establish unified data standards as soon as possible, implement unified data formats, data standards, and data interfaces for shareable data in the same industry, and build a public data platform with large scale, high quality, and high utilization rate. Secondly, improve relevant laws and regulations, effectively protect the core rights and interests of data owners, and form a safe, reliable, and reasonable data asset protection mechanism. Thirdly,

encourage market entities to explore data asset pricing mechanisms. On the basis of improving laws and regulations, gradually improve the data pricing system. Explore the establishment of a data asset registration system and data asset pricing rules through pilot projects, focus on the construction of a data transaction environment, cultivate standardized data trading platforms and market entities, establish and improve the market operation system, severely crack down on illegal transactions in data trading, and create a safe and orderly market environment.

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