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# INTERNAL LOGIC AND NEW DEVELOPMENT ADVANTAGES OF NEW-QUALITY PRODUCTIVE FORCES FROM THE PERSPECTIVE OF TOTAL FACTOR PRODUCTIVITY

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**Abstract:** As essentially advanced productive forces, new-quality productive forces take substantial improvement of total factor productivity (TFP) as its core symbol, which is an inevitable choice for China's modernization drive. Against the background of new-growth-driver transformation, this paper interprets the theoretical connotation of TFP, analyzes the internal logic that new-quality productive forces realize growth-driver transformation relying on TFP from the perspective of demographic constraints. The Solow residual method is adopted to measure China's TFP from 2001 to 2025, followed by international comparison. The results show that China's TFP presents phased fluctuation: it maintained high growth after China's accession to WTO, turned stable after the global financial crisis, and suffered short-term shocks during the pandemic. There is still considerable catching-up space for China's TFP compared with developed economies such as the United States. At present, the marginal benefit of economic growth driven by traditional factors is gradually decreasing, and efficiency improvement has become a key path to break through growth bottlenecks. A unified national market, complete industrial system, real-economy-oriented digital economy and booming green low-carbon economy constitute four major advantages for China to improve TFP and foster new-quality productive forces. It provides practical support for quality-oriented economic growth and theoretical reference for central regions to develop new-quality productive forces according to local conditions.
**Keywords:** New-quality productive forces; Total factor productivity; Solow residual; Digital economy; Green and low-carbon economy

## 1 INTRODUCTION

Fostering new-quality productive forces is a key starting point for promoting quality, efficiency and dynamic transformation of China's economy. Marked by substantial improvement in total factor productivity (TFP), new-quality productive forces provide theoretical guidance for China to break the constraints of traditional factors and pursue a high-quality modernization path [1-3]. With the transformation of population structure, the labor-force participation rate and the size of working-age population are gradually declining. The growth model relying on large-scale input of capital and labor is no longer sustainable. Clarifying the intrinsic correlation between new-quality productive forces and TFP and identifying realistic conditions for efficiency improvement carry great practical significance for building an efficiency-driven growth model [4-5].

Domestic academic circles have conducted extensive research on the connotation and formation mechanism of new-quality productive forces, and generally regard TFP as the core criterion for evaluating the development effect of new-quality productive forces [6-8]. Empirically, methods including the Solow residual and DEA-Malmquist are widely adopted to measure China's TFP and make international comparisons, so as to analyze its phased characteristics and catching-up gaps [9-10]. Nevertheless, existing studies mostly focus on conceptual interpretation or pure TFP numerical calculation. Few literatures incorporate demographic constraints into the analytical framework to systematically demonstrate how new-quality productive forces realize growth-driver transformation via TFP, and theoretical refinement of China's realistic development advantages still needs further deepening.

Accordingly, against the backdrop of demographic constraints, this paper interprets the theoretical connotation of TFP, analyzes the internal mechanism through which new-quality productive forces achieve growth-driver transformation, applies the Solow residual method to measure China's TFP from 2001 to 2025 and conducts international comparisons, and summarizes four realistic advantages for China to raise TFP and develop new-quality productive forces. The marginal contributions of this paper are as follows: it brings population-structure changes into theoretical deduction to supplement the internal logic behind efficiency-driven new-quality productive forces; it summarizes development advantages tailored to national conditions based on measurement results, offering theoretical reference for advancing quality-oriented economic growth.

## 2 TOTAL FACTOR PRODUCTIVITY AND INTERNAL LOGIC

### 2.1 Concept of Total Factor Productivity

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Total Factor Productivity (TFP), formally proposed by Solow in 1957, refers to the efficiency gain in additional output under the premise that the input quantity of all production factors such as capital, labor and land remains unchanged. In other words, with the same number of workers, machines and raw materials, if more output is generated, the extra contribution comes from TFP. It also covers the scenario where output stays unchanged while the input of capital, labor, land and other production factors is reduced.

### 2.2 Production Function of Total Factor Productivity

$$GDP \equiv Y = AK^{\alpha}L^{\beta} \tag{1}$$

where Y denotes total output, K is capital stock, L represents labor input, A stands for TFP, α is the output elasticity of capital, and β is the output elasticity of labor. Under constant returns to scale, α + β = 1. The Solow residual formula for total factor productivity is written as:

$$TFP \equiv g_A = g_Y - \alpha g_K - \beta g_L \tag{2}$$

where $g_Y$ is the growth rate of total output, $g_A$ is the growth rate of TFP, $g_K$ is the growth rate of capital, and $g_L$ is the growth rate of labor.

Its economic implication: after deducting the contribution from capital and labor input to economic growth, the remaining source of growth corresponds to the growth rate of total factor productivity. The growth of TFP reflects efficiency improvement driven by the combined effects of technological innovation, industrial upgrading, optimized resource allocation and institutional innovation.

### 2.3 The Internal Logic of New-Quality Productive Forces

According to macroeconomic principles, gross domestic product Y is largely affected by labor productivity and the size of labor force, as expressed below:

$$GDP \equiv Y = \frac{Y}{L} \cdot \frac{L}{P_L} \cdot P_L \tag{3}$$

In Equation (3), L represents the number of employed workers, and $P_L$ denotes the population aged from 16 to 59 in the working-age group. Take logarithms and derivatives on both sides of Equation (3) to obtain the growth rate identity:

$$g_Y = g_{\frac{Y}{L}} + g_{\frac{L}{P_L}} + g_{P_L} \tag{4}$$

Equation (4) shows that the growth rate of total output consists of three components: the growth rate of labor productivity, the growth rate of labor participation rate, and the growth rate of working-age population. In terms of labor participation rate, data from China Economic Database indicates that China's labor participation rate continuously declined from 1990 to 2025 and reached the minimum value of 64.6% in 2025. In terms of the growth rate of working-age population, data released by the National Bureau of Statistics shows that the proportion of China's population aged 16–59 dropped to 60.6% in 2025, a decrease of 1.9 percentage points compared with 2021, with a cumulative reduction of 30.86 million people within five years. Therefore, considering the current demographic changes in China, improving labor productivity is the optimal solution to achieve sustained and stable economic growth. Based on the Cobb-Douglas production function, this paper has:

$$Y = AK^{\alpha}L^{1-\alpha} \tag{5}$$

Then this paper can derive:

$$y = \frac{Y}{L} = A\left(\frac{K}{L}\right)^{\alpha} = Ak^{\alpha} \tag{6}$$

Take logarithms and derivatives on both sides of Equation (6):

$$g_{\frac{Y}{L}} = g_A + \alpha g_{\frac{K}{L}} \tag{7}$$

In Equation (7), $g_{\frac{K}{L}}$ refers to the growth rate of capital per capita. It demonstrates that the growth of labor productivity depends on the growth rate of total factor productivity and the growth rate of capital per capita. Further analysis: according to Harrod-neutral definition, when the capital-output ratio K/Y remains constant, the marginal product of capital $MP_K$ stays unchanged, i.e.

$$Y = F(K, AL) \tag{8}$$

$$MP_K = \frac{\partial Y}{\partial K} \tag{9}$$

Assume the production function satisfies Harrod-neutral technological progress, and the production function can be expressed as:

$$Y = K^{\alpha}(AL)^{1-\alpha} \tag{10}$$

Then this paper gets:

$$MP_K = \frac{\partial Y}{\partial K} = \alpha K^{\alpha-1}(AL)^{1-\alpha} \tag{11}$$

Take logarithms and derivatives on both sides:

$$g_{MP_K} = (1-\alpha)[g_A + g_L - g_K] \tag{12}$$

Equation (12) further reveals that under the downward trend of $g_L$, there are two ways to raise the growth rate of marginal return on capital: one is the substantial improvement of total factor productivity, and the other is the sharp decline of capital input. Obviously, raising the marginal return of capital by drastically cutting capital input is

economically meaningless. Meanwhile, the rise of capital input will lead to the decline of $g_{\frac{K}{L}}$. Therefore, Equation (7) can only improve labor productivity through the substantial rise of $g_A$ (TFP), so as to achieve the high-quality development goal of increasing total output.

## 3 MEASUREMENT OF CHINA'S TOTAL FACTOR PRODUCTIVITY

Abundant domestic and international studies have focused on TFP measurement. Domestic research mainly adopts the Solow residual method (growth accounting method), Cobb-Douglas (C-D) production function and DEA-Malmquist index method, with time spans mostly starting from 1952. Some international institutions build databases to measure TFP of major global countries annually.

Based on the above analysis, this paper applies the Solow residual method (growth accounting method), takes the year 2000 as the base period, and calculates China's total factor productivity from 2001 to 2025.

### 3.1 Main Parameters and Data Sources

Total Output: The total output adopts official GDP data from the China Statistical Yearbook, adjusted at constant prices with the year 2000 as the base period.

Labor Input: Labor input is represented by the number of employed persons in corresponding years nationwide. The output elasticity of labor β is set to 0.6. Capital Input: The perpetual inventory method is used to calculate fixed capital stock, and the formula is:

$$K_{it}=K_{i,t-1}(1-\delta)+I_{it} \tag{13}$$

where $I_{it}$ denotes the newly increased fixed asset investment in year t, $K_{it}$ is the fixed capital stock in year t, and δ represents the depreciation rate.

### 3.2 Results of China's Total Factor Productivity Measurement

1. Changes in TFP Growth Rate: As shown in Figure 1, China's average TFP growth rate reached 2.60% from 2001 to 2024. A high growth rate was maintained during 2001–2007, with a peak value of 5.75%, mainly attributed to the TFP improvement brought by the early dividend after China's accession to the WTO. After 2008, affected by the global financial crisis and China's entry into the new normal stage, TFP entered a stable growth period. From 2020 to 2024, economic fluctuations intensified due to the pandemic, and TFP changed accordingly, which has gradually returned to normal levels. For reference, the research group of the Institute of Economics, Chinese Academy of Social Sciences (2024) adopted the non-parametric DEA-Malmquist index method to study China's TFP growth from 1978 to 2023. The peak value was 6.2% in 2007, while it remained at around 1% from 2008 to 2023. Meanwhile, according to the latest Penn World Table 11.0 calculated by the University of Groningen GGDC in October 2025, China's TFP growth rate was 2.98% from 2001 to 2023, with the highest value of 10.58% in 2007. It can be seen that the change of TFP growth rate is closely related to the level of economic development.

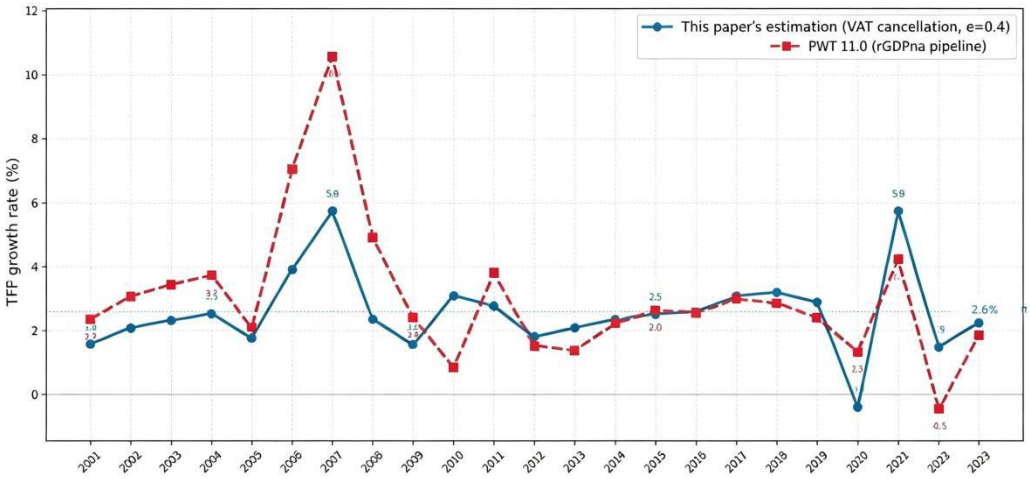



**Figure 1** China's TFP Growth Rate

2. Contribution Rate of TFP to Economy: The measurement results show that the average contribution rate of China's TFP to economic growth was 15.2% from 2001 to 2024. The research group of the Institute of Economics, Chinese Academy of Social Sciences (2024) used the DEA-Malmquist index method and obtained an average annual contribution rate of 15.8%.

According to the measurement results, on the one hand, the contribution rate of TFP to economy, similar to TFP growth rate, is closely associated with economic development level in most cases. On the other hand, it is also affected by the quality of economic development. As shown in Figure 2, TFP growth rate rose from 2022 to 2023, while its economic contribution rate declined instead. This may be because China increased capital investment to recover economy in the

short run, and the growth rate of total output driven by capital input temporarily exceeded the TFP growth rate, which is a special short-term phenomenon.

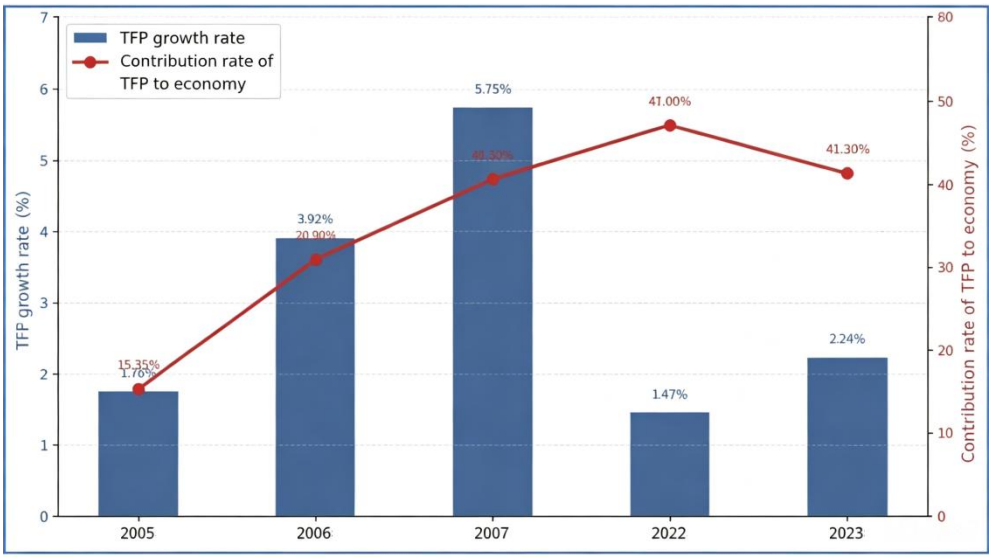



**Figure 2** TFP Growth Rate and Its Economic Contribution Rate in Selected Years

3. International Comparison of TFP: To objectively understand the status of China's total factor productivity in the global context, this paper draws on the data of relative total factor productivity of major countries worldwide relative to the United States measured by Penn World Table 11.0. Horizontal comparison is conducted using data of seven countries including Germany, France, Japan, South Korea, Brazil, India and China in 2000 and 2023 (see Figure 3).
It can be observed that China's TFP relative to the United States increased from 30.78% to 43.94% between 2000 and 2023, rising by 13.16 percentage points, which represents the largest increase. India's value rose from 29.33% to 38.25%, an increase of 8.92 percentage points, also achieving catch-up. The indicators of other countries all declined. Of course, China's TFP was still less than 45% of that of the United States in 2023 and relatively low compared with other countries. There remains remarkable room for catch-up alongside persistent gaps. The current status and evolving trends of total factor productivity (TFP) in major economies relative to the United States are illustrated in Figure 3.

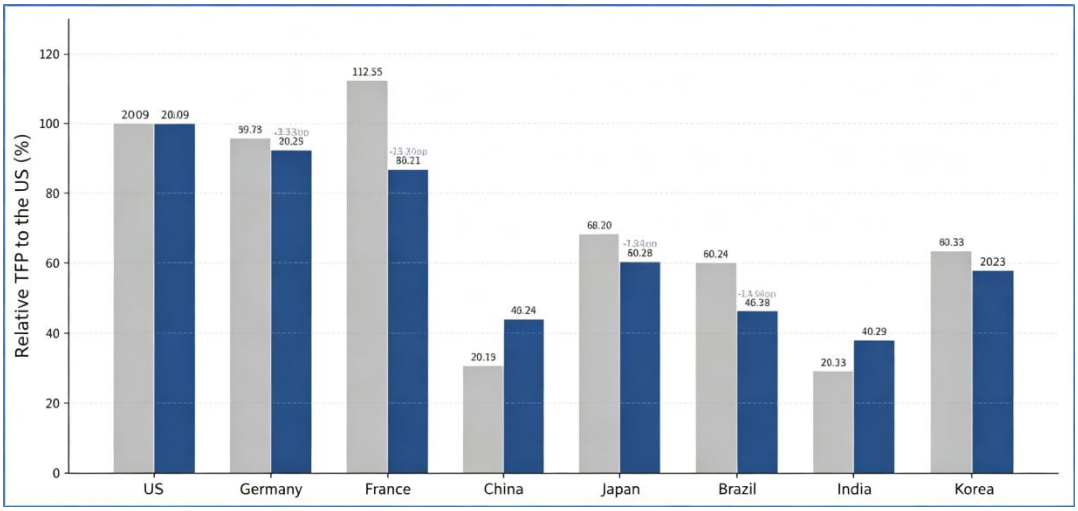



**Figure 3** Status and Changes of Total Factor Productivity of Major Countries Relative to the United States

## 4 NEW ADVANTAGES OF BOOSTING NEW-QUALITY PRODUCTIVE FORCES THROUGH HIGHER TOTAL FACTOR PRODUCTIVITY

Existing studies indicate that from the perspective of TFP's impact on economic growth and its relative development level, there remains considerable room for improvement whether considering China's absolute level or its position relative to other major economies. Meanwhile, as advanced productive forces, the improvement of TFP relies not only on innovative allocation and optimized combination of production factors, but also on external environments such as adapted production relations. Based on China's current objective conditions, the country possesses new advantages to greatly raise total factor productivity, mainly reflected in the following aspects:

### 4.1 The Unique Unified National Large Market

Market is the scarcest resource, and the ultra-large-scale market constitutes China's core advantage. China's large population base, wide middle-income group, and huge potential of stock and incremental consumer markets form the important foundation of the unified national large market. The unified national large market embodies the internal unity of an effective market and a capable government. It enables smoother economic circulation, freer flow of people, goods, capital and information, realizes efficient resource allocation on a larger scale, and continuously demonstrates scale effect and agglomeration effect, which helps greatly improve total factor productivity.

### 4.2 Industrial System Covering All Industrial Sectors

China is the only country in the world that possesses all industrial categories in the UN industrial classification system. The full coverage of industrial sectors, ranging from mining, basic raw materials, low-end processing, high-end equipment, electronic information, biomedicine to aerospace, guarantees China's economic resilience and supply chain security to a certain extent. It helps reduce industrial collaboration costs, promote industrial upgrading, foster and build a modern industrial system, thereby improving total factor productivity and developing new-quality productive forces with high quality.

### 4.3 Digital Economy Rooted in the Real Economy

Digital economy represents the embodiment of new-quality productive forces. During the 14th Five-Year Plan period, China's digital economy has entered a comprehensive expansion stage.

In 2024, the scale of China's digital economy reached 59.2 trillion yuan, with the gap with the world's largest economy continuously narrowing. Its year-on-year growth rate of 9.69% was higher than the growth rate of GDP in the same period, accounting for 43.8% of gross domestic product. The digital economy penetration rates of China's primary, secondary and tertiary industries were 10.78%, 25.03% and 45.63% respectively, rising by 0.32, 1.03 and 0.91 percentage points over the previous year. Over the past decade, the driving effect of TFP in the digital economy on economic growth has been increasingly strengthened, and its contribution rate reached 23.75% in 2024. Faced with the volatile and increasingly severe domestic and external environment, the digital economy underpins the transformation and upgrading of industrial digitalization and digital industrialization and acts as a key engine of China's economic growth. Meanwhile, the transformation and upgrading of these industries exert a huge effect on reducing costs and improving efficiency for enterprises. Relevant data shows that every 1 percentage point increase in digital investment can reduce enterprises' main operating costs by 9 percentage points and raise the profit margin of costs and expenses by nearly 7 percentage points. Estimation also shows that digital development is most effective in cutting enterprises' costs in R&D, production and management processes.

China's digital economy, rooted in the real economy and continuously expanding in scale, serves as a strong support for the substantial improvement of total factor productivity and a solid foundation for China's economy to shift from "catch-up" to "parallel development" globally.

### 4.4 Rapidly Developing Green and Low-Carbon Economy

In China, the new development philosophy of green development modes and lifestyles has been well implemented with remarkable achievements. According to data from the National Bureau of Statistics and EIA, China's total power generation reached 9715.88 billion kWh in 2025, and renewable power generation accounted for 35.2%, higher than 25.7% in the United States and the global average level of 33.8%. Among them, hydropower accounted for 13.5%, wind power 10.8%, solar power 5.9%, and nuclear power 5.0%. From 2016 to 2025, China's total power generation increased by 3804.8 billion kWh, and renewable energy accounted for 50.1% of the increment in power generation. Among the increment of renewable power generation, wind power increased the most by 841.8 billion kWh, followed by solar power with an increment of 533.2 billion kWh.

China owns the world's most complete new energy equipment industrial chain, producing approximately 80% of global photovoltaic modules and 60% of wind power equipment. Every minute, 6.8 million kWh of renewable energy power is generated nationwide, and more than 2,000 new energy vehicles roll off the production line every hour. The output value of China's clean energy industry reached 15.4 trillion yuan. From 2021 to 2025, China's exported wind power and photovoltaic products helped other countries reduce carbon emissions by about 4.1 billion tons in total. China's energy consumption per 10,000-yuan GDP has decreased cumulatively by 27.2%, equivalent to saving 1.4 billion tons of standard coal and cutting carbon dioxide emissions by about 3 billion tons. China has become one of the countries with the fastest decline in energy intensity worldwide. Guided by the strategy of "carbon peaking and carbon neutrality", the green and low-carbon economy will also serve as a new advantage for China to substantially improve total factor productivity.

## 5 CONCLUSIONS

This paper sorts out the theoretical connotation of total factor productivity, deduces the internal logical relationship between new-quality productive forces and TFP under demographic constraints, and adopts the Solow residual method to measure China's TFP from 2001 to 2025. The study finds that China's TFP shows obvious phased fluctuation characteristics. Although China has achieved remarkable catch-up progress compared with major global economies,

there is still considerable room for improvement. The unified national large market, complete industrial system, real-economy-oriented digital economy and booming green-low-carbon economy constitute four major realistic advantages for China to boost TFP and foster new-quality productive forces. The analytical framework and empirical ideas in this paper can provide theoretical reference for local governments to formulate policies for developing new-quality productive forces, and offer thinking support for central provinces to promote efficiency-driven high-quality economic growth.

Restricted by data conditions, this paper only carries out national-level overall measurement of TFP without further decomposing provincial-level heterogeneity differences. In addition, the Solow residual method cannot fully separate the influence of institutional factors on efficiency. For future research, regional panel data can be introduced to explore the spatial differentiation of TFP across provinces; more measurement models can be combined to identify the key driving factors of new-quality productive forces, so as to put forward more targeted policy suggestions for different regions.

## COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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