Original Research Article

# Efficiency measurement, regional differences, and convergence of financial development driving new quality productive forces

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***Abstract:*** Developing new quality productive forces is a core focus of China's high-quality development. This paper treats financial development as an input and new quality productive forces as an output, and measures the conversion efficiency and its regional differences and convergence using panel data of 30 Chinese provinces from 2012 to 2024. An SBM-DEA model with undesirable outputs is used, combined with Dagum Gini coefficient decomposition, spatial Markov chains, and beta convergence models. The results show that interprovincial conversion efficiency is generally at an upper-middle level; most eastern provinces remain near the efficient frontier, while central and western provinces fluctuate sharply and lack sustained improvement. The regional difference pattern has shifted from cross-overlapping to gradient differentiation, with between-subgroup differences becoming dominant. The spatial Markov chain confirms a high-neighbor enhancement effect, but hierarchical rigidity remains. Beta convergence is significant, although the high convergence speed partly reflects mean reversion of super-efficiency values rather than steady-state catch-up.

***Keywords:*** financial development; new quality productive forces; SBM-DEA model; Dagum Gini coefficient; spatial Markov chain

## 1. Introduction

The 2026 "Financial Powerhouse 15th Five-Year Plan" emphasizes enriching financial market formats, increasing direct financing, and better supporting new quality productive forces. The financial system can diversify risks and guide patient capital toward new factors and industries, making it an important engine for cultivating new quality productive forces. Therefore, measuring the efficiency of financial development in driving new quality productive forces, and examining its regional differences and convergence, is of practical importance for optimizing financial resource allocation and promoting coordinated regional development.

Existing research has gradually moved from single financial scale indicators, such as M2/GDP, to multidimensional systems of "scale–efficiency–structure." Studies have confirmed that financial efficiency and financial structure matter more than simple scale expansion for productivity growth. Research on new quality productive forces has also developed rapidly, covering theoretical connotation, measurement systems, regional differences, and spatial spillovers. However, most studies examine the finance–new quality productive forces relationship through marginal effect regressions or level measurement. Systematic analysis from the perspective of conversion efficiency—Treating financial development as input and new quality productive forces as output—Remains insufficient.

This paper makes three main contributions. First, it advances the relationship from correlation to efficiency measurement by using an SBM-DEA model to measure how provinces convert financial resources into new quality productive forces. Second, it constructs an input–output framework: Financial development is the input side, covering financial scale, structure, and efficiency; new quality productive forces are the output side, covering five dimensions. Third, it integrates SBM-DEA, Dagum Gini decomposition, spatial Markov chains, and beta convergence into a unified analytical chain of efficiency measurement, difference decomposition, dynamic evolution, and convergence judgment.

# 2. Model construction

## 2.1. Data preprocessing

The data cover 30 Chinese provinces from 2012 to 2024. Original indicators are first Box-Cox transformed to reduce skewness and avoid negative or zero values. Following Ma Zhanxin (2013), the transformed data are adjusted as:

$$s_i^{(t)} = 0.9 s_i^{(bc)} + 0.1 \left| \max s_i^{(bc)} - \min s_i^{(bc)} \right|, \quad s_i^{(bc)} = \begin{cases} \dfrac{s_i^{\lambda} - 1}{\lambda}, & \lambda \neq 0 \\ \ln s_i, & \lambda = 0 \end{cases}$$

The entropy method is then used to objectively weight indicators and synthesize dimension scores, which serve as input and output variables for the SBM-DEA model.

## 2.2. SBM-DEA model with undesirable outputs

Assume $N$ DMUs, $m$ inputs, $q_1$ desirable outputs, and $q_2$ undesirable outputs. For $DMU_k$, the super-efficiency SBM-DEA model is:

$$\min \rho_k^* = \frac{1 + \frac{1}{m} \sum_{i=1}^{m} s_i^- / x_{ik}}{1 - \frac{1}{q_1 + q_2} \left( \sum_{r=1}^{q_1} s_r^+ / y_{rk} + \sum_{t=1}^{q_2} s_t^{b-} / b_{tk} \right)}$$

subject to input, desirable output, and undesirable output constraints. The slack variables $s^-$, $s^+$, and $s^{b-}$ represent input savings, desirable output excess, and undesirable output reduction, respectively. Solving the model yields the conversion efficiency of each province.

## 2.3. Dagum Gini coefficient

The overall Gini coefficient $G$ is decomposed into within-subgroup, between-subgroup, and hyper-variability components:

$$G = \frac{\sum_{j=1}^{k} \sum_{h=1}^{k} \sum_{r=1}^{n_j} \sum_{l=1}^{n_h} |y_{jr} - y_{hl}|}{2 \mu n^2}, \quad G = G_w + G_{nb} + G_t$$

where $y_{jr}$ is the efficiency value of province $r$ in group $j$, $\mu$ is the weighted average, $n$ is the number of provinces, and $k$ is the number of regional groups.

## 2.4. Spatial Markov chain

Efficiency values are discretized into $k$ states. The traditional transition probability is:

$$P_{ij} = \frac{n_{ij}}{n_i}$$

where $n_{ij}$ is the number of provinces moving from state $i$ to state $j$, and $n_i$ is the number of provinces in state $i$. Under a spatial lag condition, the conditional probability $P_{ij|k}$ is calculated, representing the probability that a province moves from state $i$ to state $j$ when its neighborhood is in state $k$. The limiting distribution of the transition matrix gives the long-run steady state.

## 2.5. Beta convergence model

Absolute beta convergence is specified as:

$$\ln \left[ \frac{EE_{i,t+1}}{EE_{i,t}} \right] = \alpha + \beta \ln(EE_{i,t}) + \rho \sum_{j=1}^{n} w_{ij} \ln \left[ \frac{EE_{j,t+1}}{EE_{j,t}} \right] + \mu_i + \mu_j + \epsilon_{it}$$

Conditional beta convergence adds control variables and their spatial lags:

$$\ln \left[ \frac{EE_{i,t+1}}{EE_{i,t}} \right] = \alpha + \beta \ln(EE_{i,t}) + \rho \sum_{j=1}^{n} w_{ij} \ln \left[ \frac{EE_{j,t+1}}{EE_{j,t}} \right] + \delta \ln X_{j,t+1} + \rho \sum_{j=1}^{n} w_{ij} \ln(EE_{j,t}) + \sum_{j=1}^{n} w_{ij} \ln X_{j,t} + \mu_i + \mu_j + \epsilon_{it}$$

# 3. Variables and data

## 3.1. Financial development index

Financial development is measured from three dimensions: Financial scale, financial structure, and financial efficiency. Representative indicators include bank loan balance, premium income, stock market capitalization, total social financing, financial interrelations ratio, social financing ratio, securitization rate, bond financing amount, financial industry structure, marginal output rate of bank credit funds, financing structure, financial labor productivity, savings-investment conversion rate, savings rate, loan-to-deposit ratio, and insurance payout ratio. All are positive indicators. The entropy method is used for weighting.

## 3.2. New quality productive forces index

New quality productive forces are measured from five dimensions: Driving forces, pressure, state, impact, and response. Representative indicators include GDP per capita, GDP growth rate, R&D personnel and expenditure, average years of education, labor productivity, data and ecological factor endowment, forest coverage, industrial robot density, TFP, industrial digitalization, AI enterprise number, internet penetration, regional economic and consumption balance, AI patents, technology incubators, government support, industry-university-research cooperation, higher education investment, intellectual property protection, energy and carbon intensity, pollution intensity, urban-rural income and consumption gaps, and marketization level. Desirable and undesirable outputs are distinguished, with undesirable outputs treated accordingly in the SBM-DEA model.

## 3.3. Control variables and data sources

Control variables include urbanization level, opening-up level, human capital level, tax burden level, industrialization level, informatization level, and transportation infrastructure level. Data come from the *China Statistical Yearbook, China Financial Yearbook, China Science and Technology Statistical Yearbook, China Energy Statistical Yearbook*, Wind database, People's Bank of China statistics, and provincial statistical yearbooks. Missing values are filled by linear interpolation, and value variables are deflated to 2012 prices.

# 4. Empirical results

## 4.1. Efficiency measurement

From 2013 to 2024, the national average conversion efficiency fluctuates between 0.88 and 1.14, with a sample mean of 1.010. This indicates that, given financial inputs, new quality productive forces output is generally close to the efficiency frontier. The time path shows three stages: Narrow fluctuation, oscillating differentiation, and steady recovery. Eastern provinces such as Beijing, Shanghai, Jiangsu, and Zhejiang remain close to the efficient frontier with small fluctuations. In contrast, many central, western, and northeastern provinces, as well as some eastern provinces such as Hainan, show sharp interannual fluctuations. For example, Guizhou rose from 0.490 in 2013 to 1.946 in 2024; Qinghai fell to 0.384 in 2019 but reached 1.906 in 2015. These provinces have catch-up potential, but improvement lacks sustainability and tends to revert quickly.

## 4.2. Regional differences and Gini decomposition

The overall Gini coefficient fluctuates between 0.055 and 0.114. It fell to low points in 2016 and 2020 and peaked in 2017, reflecting the differentiated regional impact of financial deleveraging and subsequent liquidity easing. The source structure evolved in three stages. From 2013 to 2016, hyper-variability dominated, indicating large cross-overlapping among eastern, central, and western regions. From 2017 to 2018, between-subgroup differences rose rapidly to 47%–49%. From 2019 to 2024, between-subgroup differences jumped to 73.36%, cross-regional overlap largely disappeared, and an east-central-west gradient pattern formed. Thereafter, between-subgroup contribution stabilized at 49%–55%.

## 4.3. Spatial Markov chain

Traditional Markov results show that diagonal probabilities of maintaining the original efficiency level are 0.261, 0.474, and 0.354 for low, medium, and high levels, respectively. Medium-level provinces are the most stable. The probability of low-level provinces directly jumping to high level is 0.470, higher than

remaining at low level (0.261), echoing the high values observed in Guizhou and Qinghai in some years. Spatial Markov results show a significant high-neighbor enhancement effect: When the neighborhood is at a high level, the probability of low-level provinces jumping to high level reaches 0.560, compared with 0.427 under a low-level neighborhood. The probability of remaining low also falls from 0.293 to 0.200. However, the effect weakens as the province's own level rises. For medium-level provinces, the upgrading probability rises only from 0.225 to 0.297; high-level provinces are almost unaffected by neighborhood conditions. The key to neighborhood effect is escaping a low-level environment, and absorption depends on local conversion capacity.

### 4.4. Convergence analysis

Moran's I is 7.886 and 7.763, significant at 1%, indicating spatial correlation in residuals. LM-lag and LM-error tests are also significant, so a spatial Durbin model (SDM) with two-way fixed effects is used as the benchmark. The absolute beta convergence coefficient is −0.534, and the conditional coefficient is −0.601, both significant at 1%. Across SDM, SAR, SEM, and non-spatial two-way fixed models, absolute convergence ranges from −0.528 to −0.564, and conditional convergence ranges from −0.585 to −0.629, all significant. This indicates robust beta convergence: Lagging provinces grow faster than leading provinces. The annual convergence speed is about 0.763 for absolute convergence and 0.919 for conditional convergence, with half-lives of about 0.91 and 0.75 years. However, such high speed largely reflects rapid mean reversion of super-efficiency values rather than steady-state catch-up. In the SDM two-way fixed specification, the spatial autoregressive coefficient is insignificant, and LR and Wald tests cannot reject zero spatial terms; when only individual fixed effects are controlled, spatial terms are highly significant. This suggests that spatial linkage mainly comes from common annual shocks absorbed by time fixed effects, and the neighborhood effect mainly operates through state transition probabilities rather than the growth equation. Among control variables, only human capital is significant.

## 5. Conclusions and policy recommendations

### 5.1. Conclusions

(1) Interprovincial conversion efficiency is generally at an upper-middle level. Eastern provinces are stable near the efficient frontier, while central and western provinces fluctuate sharply and lack sustained improvement.

(2) Regional differences have shifted from cross-overlapping to gradient differentiation, with between-subgroup differences becoming the main source.

(3) The spatial Markov chain confirms a high-neighbor enhancement effect, but hierarchical rigidity remains.

(4) Beta convergence is significant, but the high convergence speed partly reflects mean reversion rather than structural catch-up.

### 5.2. Policy recommendations

First, implement differentiated financial development strategies. Eastern provinces should optimize financial structure and allocation efficiency, guiding resources toward technological innovation and emerging industries. Central and western provinces should stabilize financial supply expectations, develop inclusive finance and industrial chain finance, improve credit enhancement and risk sharing, and reduce procyclical credit fluctuations.

Second, promote regional financial coordination. Build cross-regional financial service platforms, guide eastern capital and technology toward central and western industrial projects, explore joint credit and enclave-park financial cooperation, and improve local industrial supporting facilities, talent, and institutions. This will strengthen the ability of less developed regions to absorb spillovers from high-level areas.

Third, establish a dynamic efficiency monitoring mechanism. Regularly evaluate the conversion efficiency of financial empowerment of new quality productive forces, include financial input structure, human capital accumulation, and innovation finance in the monitoring system, and distinguish efficiency levels from convergence speed. For provinces with large fluctuations, adopt classified policies, strengthen coordination between financial and industrial policies, and shift convergence from mean-reversion type to

structural catch-up type.

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