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Research on the Competitiveness Analysis of Commercial Banks Based on the Malmquist Index - A Case Study of 26 Listed Commercial Banks in China

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Abstract: Bank Competitiveness is a concentrated reflection of China's financial strength. Using the Malmquist Index calculation method based on the DEA (Data Envelopment Analysis) approach, this study analyzes the performance of 26 commercial banks in terms of operating expenses, net fixed assets, net interest income, and non-interest income indicators. Through empirical analysis, the competitiveness of commercial banks is evaluated from aspects such as efficiency change, technological change, scale efficiency, and total factor productivity. The research findings indicate that although commercial banks have shown some improvement overall in different years, their progress in terms of production efficiency remains limited. Based on the analysis results, suggestions for countermeasures are proposed, including optimizing resource allocation, promoting continuous technological innovation, optimizing scale management, and establishing effective monitoring and evaluation mechanisms.

Keywords: Commercial Bank Competitiveness, Malmquist Index, Total Factor Productivity.

1. Introduction and Literature Review

1.1. Introduction

Commercial banks play a crucial role in China's financial system, and enhancing their competitiveness is vital for the stability of the financial market and economic development in China. In the fiercely competitive financial environment, commercial banks need to continuously optimize their operational efficiency and service quality to meet market demands and competitive pressures. The DEA-Malmquist index model is used to evaluate the competitiveness of commercial banks, focusing on indicators such as operating expenses, net fixed assets, net interest income, and non-interest income.

This study selects data from 26 commercial banks for the years 2016 to 2022, analyzing their efficiency, technological changes, scale efficiency, and total factor productivity in different years. Through data analysis and interpretation, the study reveals the evolving trends in the competitiveness of commercial banks, identifies the main influencing factors, and highlights potential areas for improvement. The research findings can serve as a reference and decision-making basis for Chinese commercial banks and practitioners, helping them adopt corresponding strategies to enhance competitiveness and operational performance in various aspects. Additionally, this study provides rich theoretical and practical insights for the academic community regarding the application and extension of models for assessing the competitiveness of commercial banks.

1.2. Literature Review

This article aims to evaluate and analyze the competitiveness of 27 commercial banks in China using the Malmquist Index model. The assessment of commercial bank competitiveness holds significant importance in improving the operational efficiency of banking businesses and developing the financial market. Data Envelopment Analysis (DEA) has evident advantages in dealing with input-output problems in small sample sizes without assuming a specific form of production function. Hence, it has garnered extensive attention in academia, particularly in the evaluation and analysis of bank efficiency.

Ding Zhongming [1] et al. conducted an empirical study on the efficiency of commercial banks using DEA, analyzing the efficiency of 15 domestic and foreign commercial banks. The CCR and BCC models were employed to measure bank efficiency, and reform measures were proposed to enhance operational efficiency, strengthen corporate governance structures, improve innovation capabilities, and optimize bank scale to increase the efficiency of commercial banks.

Shi Lele [2] et al. calculated the efficiency of China's listed commercial banks using the DEA method and explored the impact of factors such as capital adequacy ratio, liquidity ratio, asset quality, profitability, and management capabilities on bank efficiency. The results indicated that state-owned commercial banks had higher overall efficiency compared to non-state-owned commercial banks, but concerning individual banks, the influence of bank type on efficiency was not significant.

Wu Guiping [3] et al. used DEA and Malmquist productivity index to quantify changes in the operational efficiency of the banking industry. The results showed a significant improvement in operational efficiency after banks went public, with state-owned banks making the most progress. However, there was a general trend of decreasing scale efficiency across commercial banks.

Huang Jiankang [4] et al. evaluated the competitiveness of commercial banks using the DEA method and analyzed the pressures faced by the Chinese banking industry and the methods for seeking new growth drivers. The study revealed significant differences in competitiveness and operational efficiency among commercial banks of different natures.

Building upon previous research, this paper will comprehensively assess the competitiveness level of 27 commercial banks in China using the DEA-Malmquist Index model. Additionally, corresponding improvement measures

will be proposed to promote the sustainable development of commercial banks and enhance the efficiency of the financial market.

2. Model Construction

2.1. Malmquist Index Model Principle

The foundation for constructing the Malmquist Index is the distance function, which is precisely the reciprocal of the efficiency values in the DEA theory's CCR (Charnes, Cooper, and Rhodes) model and BCC (Banker, Charnes, and Cooper) model. Under the assumption of constant returns to scale, let (x^t, y^t) represent the distance function of period t ($Dt\ c(x,yt)$) and period t+1 ($D^t_c+1(x^t,y^t)$); and let (x^{t+1},y^{t+1}) represent the distance function of period t ($D^t_c(x^{t+1},y^{t+1})$) and period $t+1$ ($D^t_{c+1}(x^{t+1},y^{t+1})$).

The change in technological efficiency from period t to period $t+1$ under the technological conditions of period t:

$$M^t = \frac{D_c^t(x^{t+1}, y^{t+1})}{D_c^t(x^t, y^t)}$$

The change in technological efficiency from period t to period $t+1$ under the technological conditions of period $t+1$:

$$M\ (x^t, y^t, x^{t+1}, y^{t+1}) = (M^t \times M^{t+1})^{\frac{1}{2}}$$

$$= \left[\frac{D_c^t(x^{t+1}, y^{t+1})}{D_c^t(x^t, y^t)} \times \frac{D_c^{t+1}(x^{t+1}, y^{t+1})}{D_c^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}}$$

Färe et al. proposed the FGNZ model, which decomposes the Malmquist Index (Total Factor Productivity) into the Technical Change Index (TC) and the Composite Technical Efficiency Change Index (TEC), where the Composite Technical Efficiency Change Index is further decomposed into the Pure Technical Efficiency Change Index (PTE) and the Scale Efficiency Change Index (SE). The decomposition form of FGNZ is as follows:

$$M_{FGNZ} = (x^t, y^t, x^{t+1}, y^{t+1})$$

$$= \left[\frac{D_c^t(x^{t+1}, y^{t+1})}{D_c^{t+1}(x^t, y^t)} \times \frac{D_c^t(x^{t+1}, y^{t+1})}{D_c^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}}$$

$$\times \frac{D_V^{t+1}(x^{t+1}, y^{t+1})}{D_V^t(x^t, y^t)}$$

$$\times \frac{D_c^{t+1}(x^{t+1}, y^{t+1}) \Big/ D_V^{t+1}(x^{t+1}, y^{t+1})}{D_c^t(x^t, y^t) \Big/ D_V^t(x^t, y^t)}$$

$$= TC_{(FGNZ)} \times PTE_{(FGNZ)} \times SE_{(FGNZ)}$$

In this context, $D^t_{\ v}$ and $D^t_{\ v+1}$ represent the distance functions for period t and period t+1, respectively, under the assumption of variable returns to scale.

2.2. Relevant Concepts and Meanings

The Malmquist Index (TFP) is a dynamic indicator that measures the changes in Total Factor Productivity from period t to period $t+1$. When this index is greater than 1, it indicates an upward trend in Total Factor Productivity from period t to period $t+1$, implying an improvement in efficiency. If it equals 1, it means that Total Factor Productivity remains unchanged from period t to period $t+1$, indicating no change in efficiency. When the index is less than 1, it signifies a downward trend in Total Factor Productivity from period t to period $t+1$, suggesting a decrease in efficiency.

The Composite Technical Efficiency Change Index (TEC) represents the degree to which each observed unit approaches the production frontier from period t to period $t+1$. It reflects the extent of changes in technical efficiency for enterprises and serves as an indicator of the quality of management methods and decisions made by management teams. TEC > 1 indicates an improvement in technical efficiency, demonstrating proper management methods and correct decision-making. TEC < 1 indicates a deterioration in technical efficiency, reflecting improper management methods and decisions.

The Technical Change Index (TC) represents the movement of enterprises from the production frontier in period t to the production frontier in period $t+1$, indicating the degree of changes in production technology. It serves as an indicator of the level of technological progress or innovation. TC > 1 signifies movement outside the production frontier, indicating overall technological progress in the industry. TC < 1 indicates a movement of the production frontier towards the origin, suggesting an overall trend of technological decline in the industry.

3. Empirical Analysis

3.1. Selection of Sample

This paper selects 36 listed banks on the China A-share market as the research subjects. Due to missing data, 26 commercial banks with available and accurate data are chosen as the research sample. These banks include Bank of Communications, Industrial and Commercial Bank of China, China Construction Bank, Agricultural Bank of China, Bank of China, China Postal Savings Bank, China Everbright Bank, China Guangfa Bank, Huaxia Bank, Ping An Bank, Shanghai Pudong Development Bank, Industrial Bank, China Merchants Bank, Zhejiang Commercial Bank, China Minsheng Bank, China CITIC Bank, Beijing Rural Commercial Bank, Bank of Beijing, Bank of Hangzhou, Anhui Guoyuan Bank, Jiangsu Bank, Bank of Nanjing, Bank of Ningbo, Shanghai Rural Commercial Bank, Bank of Shanghai, and Chongqing Rural Commercial Bank.

3.2. Selection of Data

Considering the accessibility of data, the data time interval selected is from 2016 to 2022. The corresponding data is sourced from the CSMAR database and the annual reports of various banks for the years 2016 to 2022.

3.3. Selection of Indicators

In order to measure the competitiveness of banks, the selection of input-output indicators can be based on the relevance, comparability, and accessibility of the indicators, as well as from the perspective of bank profitability. Specifically, operating expenses and net fixed assets can be chosen as input indicators. Operating expenses represent the total cost incurred by the bank in conducting its business, reflecting the level of operating costs and resource utilization.

Net fixed assets, on the other hand, indicate the investment level and efficiency of the bank in asset allocation.

As for output indicators, net interest income and non-interest income can be selected. Net interest income reflects the profitability and interest income level of the bank's core business, obtained by subtracting interest expenses paid to depositors from interest income derived from lending and deposit activities. Non-interest income includes other sources of income, such as fee income, credit card income, securities trading income, etc. It is an important source for banks' diversified operations and reducing reliance on interest rate spreads.

By selecting these indicators, the bank's operating costs, financial strength, operational scale, core business profitability, and diversified business income can be comprehensively considered, enabling a more comprehensive evaluation of the bank's competitiveness.

Table 1. Selection of Input-Output Indicators for Banks

Input Indicators	Operating Expenses	Output Indicators	Net Interest Income
	Net Fixed Assets		Non-Interest Income

3.4. Analysis of Empirical Results

This study conducts an empirical analysis of the efficiency of commercial banks using total factor productivity and related indicators. By comparing and analyzing the average total factor productivity of 26 commercial banks, the efficiency level is assessed. Total factor productivity is a productivity indicator that measures the relationship between total inputs and total outputs. From an efficiency perspective, it reflects the ratio of economic output to various resource inputs over a certain period of time.

3.4.1. Analysis of Average Total Factor Productivity for 26 Commercial Banks Across Years

The average values of the Composite Technical Efficiency Change Index (TEC), Technical Change Index (TC), Pure Technical Efficiency Change Index (PTE), Scale Efficiency Change Index (SE), and Total Factor Productivity (TFP) growth rate for the 26 listed commercial banks from 2016 to 2022 are presented in Table 2.

Table 2. Annual Average Values of Malmquist Index and Decomposed Indicators for 26 Commercial Banks from 2016 to 2022

year	effch	techch	pech	sech	tfpch
2	1.046	0.934	1.059	0.988	0.977
3	0.877	1.354	0.866	1.012	1.187
4	1.135	1.216	1.135	1	1.38
5	1.032	0.914	0.99	1.042	0.944
6	1.034	0.94	0.999	1.035	0.971
7	1.02	0.938	1	1.02	0.957
mean	1.021	1.036	1.005	1.016	1.058

Based on the data presented in Table 2, we can analyze the trends in efficiency and total factor productivity for commercial banks over the years and the entire time span.

Firstly, the year-by-year analysis shows the following trends. The Efficiency Change Index experienced significant improvements in 2016 and 2018, while remaining relatively stable in other years. The Technical Change Index exhibited more fluctuations, with notable growth in 2017. The changes in Production Efficiency and Scale Efficiency Index were mostly close to 1, indicating relatively minor improvements. The Total Factor Productivity Change Index also showed fluctuations but demonstrated an overall increasing trend.

Secondly, the analysis covering the entire time span reveals that the overall Efficiency Change Index for commercial banks slightly exceeds 1, indicating a slight improvement in overall efficiency. The cumulative value of the Technical Change Index surpasses 1, indicating growth in technological levels. The cumulative values of Production Efficiency and Scale Efficiency Change Index are close to 1, indicating limited improvements in resource allocation and economies of scale. The cumulative value of the Total Factor Productivity Change Index exceeds 1, suggesting an overall improvement in total factor productivity.

In summary, as shown in Table 2, overall efficiency and total factor productivity have shown some improvement. Technological progress has played a positive role in enhancing competitiveness, but there are limitations in improving production efficiency and economies of scale. Commercial banks should focus on resource allocation, economies of scale, and technological innovation to achieve continuous improvements in efficiency and productivity, thereby enhancing competitiveness and sustainable development capabilities.

3.4.2. Analysis of Average Total Factor Productivity for 26 Commercial Banks

As shown in Table 3, the annual average values of the Composite Technical Efficiency Change Index (TEC), Technical Change Index (TC), Pure Technical Efficiency Change Index (PTE), Scale Efficiency Change Index (SE), and Total Factor Productivity (TFP) Growth Rate for the 26 listed commercial banks from 2016 to 2022 are presented.

Table 3. Average Malmquist Index and Decomposed Indicator Values for 26 Commercial Banks from 2016 to 2022.

firm	effch	techch	pech	sech	tfpch
1	1.054	1.034	1.014	1.039	1.09
2	1.078	1.071	1	1.078	1.154
3	1.017	1.042	1	1.017	1.06
4	1.088	0.982	0.998	1.09	1.069
5	0.971	1.044	0.934	1.039	1.014
6	0.913	0.907	1	0.913	0.828
7	1.019	1.093	0.995	1.025	1.114
8	0.995	1.06	0.975	1.02	1.054
9	1.05	1.044	1.006	1.044	1.096
10	1	1.059	1	1	1.059
11	0.984	1.087	0.967	1.018	1.07
12	1.011	1.063	1	1.011	1.075
13	1.021	1.059	1	1.021	1.081
14	0.942	1.059	0.951	0.991	0.997
15	0.953	1.077	0.906	1.051	1.026
16	0.980	1.091	0.970	1.01	1.069
17	1.04	0.977	1.076	0.967	1.016
18	1.055	1.022	1.026	1.028	1.078
19	1.041	1.025	1	1.041	1.066
20	0.997	0.998	1	0.997	0.995
21	1.114	1.01	1.102	1.011	1.126
22	1.130	0.984	1.124	1.006	1.112
23	1.037	1.046	1.02	1.016	1.084
24	1.027	1.069	1.033	0.994	1.097
25	1.065	1.06	1.064	1.001	1.129
26	0.998	1.001	0.996	1.002	0.998
mean	1.021	1.036	1.005	1.016	1.058

The Efficiency Change Index (effch) has an average value of 1.021, indicating a slight overall improvement in the average efficiency of commercial banks. This suggests that, considering the operating expenses and fixed asset net amount, banks have made some progress in resource utilization and operational processes. Some banks have an efficiency change index above 1.0, indicating good performance in resource allocation and production efficiency, while others have an index below 1.0, indicating a need for further optimization and improvement.

The Technical Change Index (techch) has an average value of 1.036, indicating an overall improvement in the technological level of commercial banks. This may reflect the technological advancements made by banks in terms of net interest income and non-interest income, including efforts to improve business processes, introduce new technologies, and enhance customer experience.

The Production Efficiency Change Index (pech) has an average value of 1.005, indicating a small overall change in average production efficiency for commercial banks. This suggests that improvements in resource allocation and operational processes have contributed only to a limited extent in enhancing production efficiency. Some banks may need to optimize resource allocation better to improve production efficiency and reduce costs.

The Scale Efficiency Change Index (sech) has an average value of 1.016, indicating a slight overall improvement in average scale efficiency for commercial banks. This suggests that some banks have gained certain advantages in expanding their operations and successfully utilized the input of fixed asset net amount to achieve higher net interest income and non-interest income.

The Total Factor Productivity Change Index (tfpch) has an average value of 1.058, indicating a certain degree of overall improvement in average total factor productivity for commercial banks. This could be attributed to a combined effect of technological progress, production efficiency improvements, and advantages gained from scale operations.

In conclusion, based on the empirical results in Table 3, it can be inferred that overall, commercial banks have made some improvements in operating expenses, fixed asset net amount, net interest income, and non-interest income. However, there is limited progress in production efficiency, which may require more efforts to enhance resource utilization efficiency.

4. Conclusion and Recommendations

4.1. Conclusion

The following conclusions can be drawn from the analysis of the above banks:

1. Overall, the efficiency of commercial banks has shown slight improvement in different years, but the magnitude of improvement is limited, especially in terms of production efficiency.

2. The overall technological level of commercial banks has improved, reflecting the technological progress in interest net income and non-interest net income.

3. The overall scale efficiency of commercial banks has slightly improved, indicating that some banks have gained

advantages in expanding their scale of operation.

4. The overall total factor productivity of commercial banks has shown a certain degree of improvement, which may be attributed to the combined effect of technological progress, improvement in production efficiency, and advantages gained from scale of operation.

4.2. Recommendations

In terms of improving production efficiency, commercial banks should focus on identifying bottlenecks in resource allocation and operational processes, optimize business workflows, enhance work efficiency, and reduce operating expenses. Additionally, emphasis should be placed on employee training and skill development to improve the utilization efficiency of fixed assets.

In the aspect of promoting technological innovation, commercial banks should continuously invest in technology innovation, introduce new technologies, digital solutions, and intelligent systems to enhance operational efficiency and customer experience. Furthermore, strengthening collaboration with technology companies can drive the application of financial technology and elevate overall technological capabilities.

Regarding optimizing operational scale, banks can expand their scale through mergers, acquisitions, or exploring new markets to achieve economies of scale. Simultaneously, it is important to focus on improving internal management efficiency to ensure that scale expansion leads to increased revenue growth and profit enhancement.

For implementation and evaluation, commercial banks should establish an effective performance evaluation system, regularly monitor and assess changes in various indicators, promptly identify issues, and seize improvement opportunities. Moreover, conducting comparative analysis with other banks in the same industry can facilitate learning and drawing insights from industry best practices to continuously enhance competitiveness.

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