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RESEARCH ARTICLE

Analysis on the efficiency of China's top ten joint-stock banks based on the super-efficiency DEA method

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Abstract

Banks are special types of economic and financial institutions that specialize in various currency and credit loan businesses. They have always been regarded as the most important part of a country's real economy. It has a major issue related to the national economy and people's livelihood. Production, operation and management activities and the healthy development of the financial industry are very inseparable from the coexistence of financial banks. Joint-stock banks are also a very important part of the bank. With the current rapid development of China's modern financial industry, the market for joint-stock banks The competition is becoming more and more fierce. Bank efficiency is an important indicator to evaluate the profitability and competitiveness of each bank. Efficiency evaluation is of great significance to the sustainable development of banks. Super-efficiency DEA is an important method to study the efficiency of companies. This paper uses the super-efficiency DEA method to study the efficiency of the top ten domestic joint-stock banks with scale efficiency indicators and technical efficiency indicators. This research shows that during the epidemic period, reducing operating costs is of great significance to improving bank efficiency, getting rid of the shackles of business outlets, financial innovation through the Internet and big data, and allowing customers to enjoy banking services anytime and anywhere has gradually become the goal of major listed banks.

Key words: super-efficiency DEA, bank efficiency, scale efficiency, technical efficiency

1 | INTRODUCTION

As the current Chinese market economy and social development model has entered a new economic normal, the entire banking industry has also begun to face the new technical challenges of traditional financial technology disintermediation and the rapid rise of finance in the mobile Internet era. Therefore, how to challenge in the new economic environment and new technology Continuously improving the operating efficiency and market competitiveness of banks is one of the biggest challenges facing China's joint-stock banks. Proposed by Feng Yaqi. (2020) (1) . With the steady growth of our country's economy and the continuous deepening of reform and opening up, market competition among banks has intensified. As a concentrated expression of the competitiveness of the banking industry, the calculation of efficiency is particularly important. Proposed by Qiao Sen et al. (2021) (2) . Wang Jing (2021) This article proposes that my country's commercial investment banks are mainly large-scale commercial institutions with profitable operations as the main purpose and a variety of financial investment project businesses as the main operating body. And it plays a very important and key guiding role in the adjustment of my country's economic structure and social and economic supervision and management (3) . Commercial banks are facing unprecedented challenges under the new economic normal and the new financial normal. The substantial increase in non-performing assets has led to a further serious decline in the quality of non-performing asset management of Chinese

commercial banks. As my country's financial market management system has gradually formed and improved, more and more financial companies have begun to choose direct external financing, and the trend of financial institutions' disintermediation has intensified. On the other hand, the rapid development of mobile Internet and financial big data will also lay a solid technical foundation for the continuous development and upgrading of Internet commercial finance. Third-party platform payment, online financing platforms, online crowdfunding platforms, Internet wealth management and other innovations are better. It has met customer needs and played a positive role in improving resource allocation and financial innovation. At the same time, it has also had an impact on the traditional business model of commercial banks, and the living space of commercial banks has been squeezed. The supervision of commercial banks is becoming more and more stringent, so the efficiency of commercial banks is very important.

This paper uses the super-efficiency DEA method to establish a model, uses four input indicators and three output indicators to analyze the efficiency of commercial banks, and uses the data of 2019 and 2020 to analyze and compare the efficiency of the top ten commercial banks. The reasons for the high and low efficiency of each bank put forward suggestions to solve the problem, and provide reference opinions for the sustainable development of my country's commercial banks. This article analyzes the impact of the epidemic on the efficiency of banks based on the data of one year before and after the epidemic. The results show that reducing operating costs and reducing the number of employees under the epidemic have a great effect on improving efficiency and responding to the impact of the epidemic. In addition, he suggested that all large listed commercial banks start to transform their physical and digital business as soon as possible.Banks can be used as a physical service operator, gradually transforming and sinking to become a national infrastructure public facility physical service network operator, and break away from the traditional physical service network system. The shackles will get a broad financial scene (4)

2 | LITERATURE DISCUSSION

The data envelopment evaluation and analysis (dea) model is a nonlinear parameter data evaluation and analysis method proposed in the period equal to charnes and equal to 1978. By using the linear data programming envelope model, a data acquisition envelope interface can be constructed to obtain the best Best decision-making unit. Zhou Xinfeng and Wang Xuguang (2021) mentioned (5) In the measurement results of traditional DEA models, multiple decision-making units are usually effective. In response to this situation, Andersen and Petersen proposed an improved DEA model: super The efficiency DEA model, which can calculate the efficiency of DEA effective decision-making units on the original basis. The efficiency value of the effective DMU is usually greater than 1, and then the effective DMU is distinguished. This model is called the super efficiency model. Mentioned by Jiang Shuofan et al. (2021) (6) and the efficiency of commercial banks is also an issue that everyone pays special attention to. Digital transformation has become an opportunity to forward thinking about the innovative development direction of commercial bank finance. First proposed by Liu Zhiguo (2021) (7) In late January 2020, new cases of new coronary pneumonia (covid-19) continued to emerge, and governments across the country began to actively implement emergency measures for disease prevention and control such as channel closures, isolation, and quarantine , The emergency risk response of first-level cities has been launched in many places, and the external flow of population has been restricted to a large extent. Most large bank outlets have shortened their daily business hours or have been forced to close down. Traditionally, large commercial bank outlets have suffered a certain economic impact. Shock. Under the severe impact of the epidemic, the People's Bank of China has rapidly accelerated the pace of online digital financial transformation, using online digital financial technology to rapidly develop contactless financial services, enabling contactless online digital micropayments, online microfinance and Various types of online investment and wealth management and other financial businesses have developed rapidly and healthily. Proposed by Bu Ya and Zhang Qian (2021) (8) He Xinju and Wu Huaqing (2021) respectively proposed that it is

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important for investment banks to increase revenue and reduce expenditure. (9) Zhou Tao (2021) respectively proposed the net profit and technology of commercial investment banks of listed companies this year Innovation efficiency still has a slight decline, scale operation efficiency is still in a state of long-term stagnant growth, and efficiency after technological innovation progress is still showing an upward and downward trend, and this is also the main factor that has caused a significant increase in the productivity of various factor enterprises across the country in recent years. (10) Cost control during the epidemic stage is the key reason for listed banks to improve efficiency

3 | RESEARCH METHODS

Data envelopment cost analysis can generally be divided into two basic analysis models: the basic model of ccr and its basic model of bcc. It was proposed in 2009 that using its basic model of ccr not only can effectively determine the overall return to scale effect and the value of return to scale, but also can accurately evaluate the overall and technical budget efficiency of each decision-making budget unit. bc^2 is also widely known as the conventional model of remuneration variability and the remuneration volatility model. This model was proposed by A. Charnes and W. W. cooper before 1985, which can accurately measure the purity of the decision-making processing unit and the efficiency of technical processing. CCR model model. Here, the return of scale increase does not change, which means that the proportion of the return of different production scale increases is far equal to the proportion of the return of various factors of production. The variable production scale increase rate of return means that the proportion of the return of the increase in the total production scale is not large or equal to the proportion of the increase in the scale of various factors of production. Efficiency comparison refers to the relationship of efficiency comparison changes between technology input and enterprise output or input cost and enterprise income in various business operations. The main types include enterprise technology activity efficiency, scale activity efficiency and total input efficiency. Among them, technical production efficiency mainly reflects the degree of effective

control of the comprehensive utilization of existing advanced technologies by the production center, that is, the technical ability of the estimated observation object to obtain the maximum batch output without a given amount of technical input; The production efficiency of a given scale mainly reflects its effective control over the scale of production investment, that is, it can reflect whether the respective decision-making technology units can conduct joint operations under the most appropriate production investment scale: the total production efficiency is determined by the production efficiency of the decision-making technology and the production investment. Given the combined composition of scale production efficiency, it is also called scale decision technology production efficiency. When the decision-making technology unit that is evaluated and observed can achieve both the production technology efficiency and the production scale efficiency, it can be called the scale production technology efficiency.

(1) Total efficiency (STE) effectiveness. Ccr application model evaluation is a comprehensive evaluation of the effective application scale and the effective use of the application technology at the same time, that is, the overall efficiency of the evaluation. The total efficiency index value θ must meet: $0 \leq \theta \leq 1$. When the evaluation efficiency index value $\theta = 1$, the evaluation scale decision technology unit is deemed to be effective for the evaluation scale decision technology, otherwise the evaluation scale decision technology behavior is invalid.
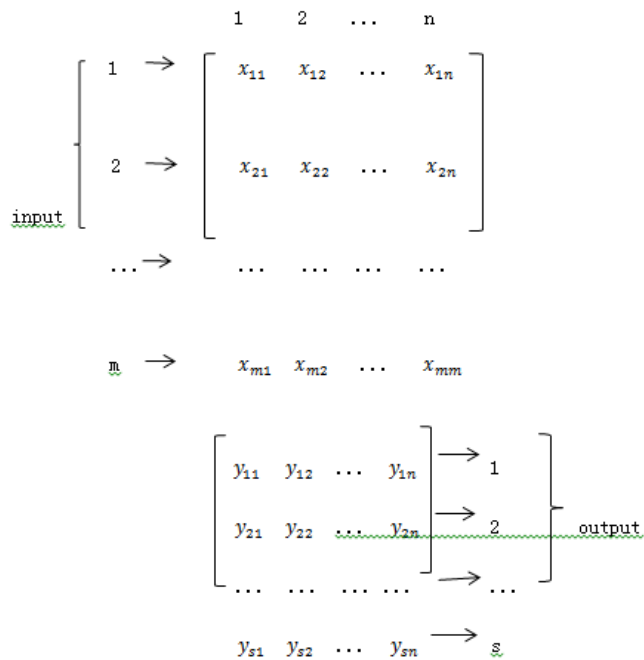
(2) Technical efficiency (TE) effectiveness. The bcc theory model is mainly used to analyze and evaluate whether the enterprise decision-making management unit is technically effective. The technically efficient value θ must satisfy: $0 \leq \theta \leq 1$. When $\theta = 1$, the object evaluated by us must be in a technically efficient state, otherwise the object is in an invalid technical efficiency.

(3) Analyze the effectiveness of scale in efficiency (se). It is determined separately by the total efficiency of the product and the efficiency of the main technology application, and its calculation formula is e/se=ste/te. (4) The effectiveness of super-efficiency DEA. The efficiency value of 0 is no longer limited to the range of 0 to 1, but allows the efficiency value to exceed 1. If the method value is greater than $\theta \geq 1$, it is valid for other application-scale technology appli-

cation methods; meanwhile, if the method value is greater than $\theta<1$, it is invalid for other technology-scale application methods or other application-scale application methods are invalid. This method can compare and sort the decision-making units well.

(5) Make full use of the c input in the cccr decision-making model analysis, which can carry out more large-scale revenue calculation and analysis for the dmu in each decision-making calculation unit. When input ex;=1, dmu is a scale expected return unchanged; when 21"<1, dmu is a scale expected return continuously increasing; when it enters>1, dmu is a scale expected return continuously decreasing .

Suppose that m is the number of output input and income indicator units, n is the number of input decision-making income unit indicators, and s is the number of input-output income indicator units. The input and output conditions are as follows:

$$
h_i = \frac{u^r y_i}{v^r x_j} = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \;,\quad j=1,2,\ldots,n
$$

By appropriately selecting the weights v_i (i =1, 2,..., m) and u^r (r =1, 2,..., s), so that j =1, 2,..., n has h_j<=1, the performance evaluation of the first decision-making unit can be summarized as the following optimization model:

$$
\max h_{jo} = \frac{\sum_{r=1}^{s} u_r y_{rjo}}{\sum_{i=1}^{m} v_i x_{ijo}}
$$

$$
s.t. \begin{cases} \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leqslant 1,\ j=1,2,\ldots,n \\ v_i \geqslant 0\,(i=1,\ldots,m),\ u_r \geqslant 0\,(r=1,\ldots,s) \end{cases}
$$

This is a fractional programming problem, which can be transformed into an equivalent linear programming problem through the following transformations. make:

$$
t = \frac{1}{\sum_{i=1}^{m} v_i x_{ijo}},\ w=tv_i,\ m=tu_r
$$

then the optimization model becomes

$$
\max h_{jo} = t\sum_{i=1}^{s} u_r y_{rjo} = \sum_{i=1}^{s} \mu_r y_{rjo}
$$

$$
s.t. \begin{cases} \sum_{i=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} w_r x_{ij} \leqslant 0,\ j=1,2,\ldots,n \\ \mu_r \geqslant 0,\ (r=1,2,\ldots,s),\ w_r \geqslant 0\,(i=1,2,\ldots,m) \end{cases}
$$

input

$$
\begin{array}{cccc} & 1 & 2 & \ldots & n \\ 1 \rightarrow & x_{11} & x_{12} & \ldots & x_{1n} \\ 2 \rightarrow & x_{21} & x_{22} & \ldots & x_{2n} \\ \ldots \rightarrow & \ldots & \ldots & \ldots & \ldots \\ m \rightarrow & x_{m1} & x_{m2} & \ldots & x_{mm} \end{array}
$$

$$
\begin{array}{cccc} y_{11} & y_{12} & \ldots & y_{1n} \rightarrow 1 \\ y_{21} & y_{22} & \ldots & y_{2n} \rightarrow 2 \\ \ldots & \ldots & \ldots & \ldots \rightarrow \ldots \\ y_{s1} & y_{s2} & \ldots & y_{sn} \rightarrow s \end{array} \Big\} \text{output}
$$

If v_i is used to represent the weight of the i-th input and u^r represents the weight of the r-th output, then the expression of the input h_j of the j-th decision-making unit is

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(1) If $\theta*$ =1, but at least a certain value of input or an output function is greater than 0, then this decision management unit is weak dea effective, and other economic and technical activities of the decision management unit are not at the same time weak technical activities. Jiahe has the best economic scale.

(2) If the function $\theta*$=1, and the functions(*-)=0,s(*+)=0, then the economic decision-making management unit is effective for adea, and other economic decision-making activities of the decision-making management unit are both economical and technologically effective and economical scale effective.

(3) $\theta*$ <1, the decision-making unit is not DEA effective, and economic activities are neither technically effective nor scale effective.

(4) If let $let x\delta_0 = \theta * \ x_0 - s*^-, y\delta_0 = y_0 + s*^+$ then (xδ_0,yδ_0) can be regarded as the effective projection of (x$_0$,y$_0$)on the effective frontier, which is effective compared to the original at least n effective decision-making management units.

(5) If there isλ_j* (j=1,2,...,m), $\sum^N_j =1\lambda_j*$ so that if it is true, then if the decision calculation unit is the largest and beneficial, it will not change, if it does not change, it will existλ_j* (j=1, 2,...m), if the scale is established, and 1, then the unit with the decision-making power is its increase in scale; if it does not existλ_j* (j=1,2,...m), $\sum^n_j=1\lambda_j*$ ==1 is established, and $\sum^n_j=1\lambda_j*$ >1, then a decision calculation unit is a decreasing scale value and benefit value.

Due to the time limitation of bank data analysis, the banks in each sample in this article are only: Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, China Construction Bank, Bank of Communications, Shanghai Pudong Development Bank, China Everbright Bank, Huaxia Bank, Minsheng Bank, The inspection period of Ping An Bank is 2019-2020. The two-year statistical data results for 2019 and 2020 are selected as quantitative comparisons. It is due to the occurrence of a new type of acute coronavirus-type acute pneumonia in my country at the end of 2019. The severity of the economic blow. The data of the two years are selected to mainly study the impact of the epidemic on the efficiency of various banks.

From the basic theoretical ideas of the above-mentioned data analysis envelope efficiency analysis method, we can already clearly see that a reasonable and sufficient determination of the company's input, output indicators and its operating price level indicators is an important key to the company's efficiency indicator scoring. In this article, it is recommended to select company employees. The four main indicators of labor force, operating cost of sales, total fixed assets and the company's total liabilities are integrated as the company's input-output indicators, and the company's operating sales revenue, total profits and operating net profit are selected as the four indicators of input-output.

4 | EMPIRICAL ANALYSIS

Using the above method and the 2019-2020 two-year data operation of the top ten commercial banks, the following results are obtained:

Comprehensive efficiency value (STE)/CCR

technical efficiency value (TE)/BCC

scale efficiency Rate value (SE)

Value of return to scale (R)/CCR

DMU	(STE)/CCR	(TE)/BCC	(SE)	(R)/CCR	Return To scale	Super Efficiency DEA value	Efficiency ranking
Jian She Bank	1.0000	1.0000	1.0000	1.0000	constant	1.08500547	second
Gong Shang Bank	1.0000	1.0000	1.0000	1.0000	constant	0.00001749	seventh
Zhong Guo Bank	0.9832	0.9933	0.9898	0.7689	increase	0.00000578	eighth
Jiao Tong Bank	0.9039	0.9404	0.9612	0.7749	increase	0.00000117	ninth
Zhao Shang Bank	1.0000	1.0000	1.0000	1.0000	constant	0.00035024	sixth
Nong Ye Bank	0.9288	0.9351	0.9933	0.8270	increase	0.00000405	tenth
Min Sheng Bank	0.9518	0.9932	0.9584	0.8304	increase	0.00071001	fifth
Hua Xia Bank	0.7768	1.0000	0.7768	0.3124	increase	0.67260732	third
Pu Fa Bank	1.0000	1.0000	0.9999	1.0000	constant	0.12305368	fourth
Ping An Bank	1.0000	1.0000	1.0000	0.9999	increase	1.17874793	first

struction Bank, Industrial and Commercial Bank of China, China Merchants Bank and Shanghai Pudong Development Bank remain unchanged, while the returns to scale of the other six banks are all increasing.

DMU	(STE)/CCR	(TE)/BCC	(SE)	(R)/CCR	Return To scale	Super Efficiency DEA value	Efficiency ranking
Jian She Bank	1.0000	1.0000	1.0000	1.0000	constant	1.07187466	second
Gong Shang Bank	1.0000	1.0000	0.9999	1.0000	constant	0.00001523	seventh
Zhong Guo Bank	0.9564	0.9769	0.9790	0.7320	increase	0.04411296	third
Jiao Tong Bank	0.8841	0.8905	0.9928	0.8051	increase	0.00000045	eighth
Zhao Shang Bank	1.0000	1.0000	1.0000	1.0000	constant	0.00010404	sixth
Nong Ye Bank	0.9056	0.9081	0.9972	0.8480	increase	0.00000007	tenth
Min Sheng Bank	0.8779	0.8866	0.9902	1.0234	increase	0.00000019	ninth
Hua Xia Bank	0.9304	1.0000	0.9304	0.2266	increase	0.00065774	fourth
Pu Fa Bank	0.9441	1.0000	0.9441	0.8265	increase	0.00046350	fifth
Ping An Bank	1.0000	1.0000	1.0000	0.9999	increase	1.23879002	first

From the above table using the calculation according to the formula in the above table, it can be seen that in 2019, China Merchants China Construction Bank, Industrial and Commercial Bank of China, Shanghai Pudong Development Bank, and Ping An Bank's average efficiency score for the year is greater than the total annual efficiency effective, and the total annual efficiency value is greater than the average of the score deae. Only China Merchants China Construction Bank and China Merchants China Ping An Bank are valid. The returns to scale of China Con-

It can be seen from the above table that in 2020, the total efficiency of China Construction Bank, Industrial and Commercial Bank of China, China Merchants Bank and Ping An Bank is effective, and only China Construction Bank and Ping An Bank are effective with super-efficiency DEA values. Decreasingly, the scale efficiency of the other six banks increased.

The following uses Ping An Bank, China Construction Bank and Hua Xia Bank as a typical analysis:

Ping An Bank ranked first in super-efficiency DEA for two consecutive years, and Ping An Bank ranked

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second in the past two years, and its technical efficiency value in the past two years was one. The technical efficiency is effective, which shows that the existing technology has been fully utilized in the bank's operation, and Ping An Bank has obtained the maximum productivity with a given investment. The scale operation efficiency is divided into one, the project scale operation efficiency is effective, and each project decision-making management unit can carry out joint operation under the most clear and suitable project investment scale. The overall efficiency value is also one and the super efficiency dea value is greater than one, so the overall efficiency value is also valid. The return to scale value is slightly less than one, so the return to scale is increasing. The super-efficiency DEA value in 2020 is slightly larger than the super-efficiency DEA value in 2019, indicating that Ping An Bank has become more efficient after the outbreak of the epidemic. The main reason is that Ping An Bank has actively taken countermeasures to reduce investment and reduce operating costs by 14.9 billion. , But the net profit was only reduced by 730 million, so the efficiency was improved in the end.

China Construction Bank ranks second in the past two years, and its technical efficiency value is one in the past two years. The technical efficiency is effective, which shows that the existing technology has been fully utilized in the bank's operation, and Ping An Bank has obtained the maximum productivity with a given investment. The scale operation efficiency is divided into one, the project scale operation efficiency is effective, and each project decision-making management unit can carry out joint operation under the most clear and suitable project investment scale. The overall efficiency value is also one and the super efficiency dea value is greater than one, so the overall efficiency value is also valid. The return to scale value is all one, so the return to scale is unchanged. After the epidemic, China Construction Bank also reduced its investment and greatly reduced operating costs. However, operating income and net profit did not drop significantly, and operating efficiency was improved. Therefore, under the impact of the epidemic, the profit of China Construction Bank has not been significantly affected for the time being. .

Hua Xia Bank ranked third in 2019. Decline to fourth

place in 2020. The bank's technical efficiency value has been one in the past two years, and the technical efficiency is effective; the scale efficiency is less than one, and the scale and efficiency are invalid, so the comprehensive efficiency value is also invalid. The return to scale value is less than one in the past two years, then the return to scale is increasing. Hua Xia Bank also adopted a reduction in operating costs to deal with the epidemic. Although operating income has decreased, its total profit has increased. Net profit also increased by 770 million. The comprehensive efficiency value of Hua Xia Bank in 2020 is greater than the comprehensive efficiency value in 2019, indicating that under the influence of the epidemic, it has not had a negative impact on Hua Xia Bank's performance for the time being.

The Bank of China ranked eighth in 2019 and third in 2020. The super-efficient DEA value has increased. The returns to scale are all increasing, and the total efficiency is invalid. Although the cost of the Bank of China has decreased, so the efficiency has been improved.

5 | CONCLUSIONS AND RECOMMENDATIONS

Under the severe impact of the new coronavirus epidemic, reducing the company's operating and management costs, using non-contact online digital bank payments, online microfinance, and online fund management, etc., providing contactless services can not only satisfy customers in the event of an epidemic Demand can also improve bank efficiency. It is recommended that banks speed up financial innovation and use Internet technology to provide customers with more convenient financial services.

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