

Study on the Management Efficiency of Chinese Banking Industry —Based on DEA-Malmquist Model

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Abstract: Bank efficiency has always been a hot issue in the field of financial research at home and abroad. As one of the most important parts of national economy, commercial Banks play an important role in the healthy development of national economy and the international competitiveness of a country. The improvement of bank efficiency is the key to preventing bank risks and promoting the sustainable development of the banking industry, and the core of China's deepening financial system reform. Therefore, for China, it is very important to study the efficiency of commercial Banks in both theoretical and practical sense.

1 INTRODUCTION

Commercial Banks play an extremely important role in the development of China's financial industry and are the main body of China's financial system. With the rapid development of foreign Banks in China and the constant changes in the international financial environment, especially the gradual opening of the financial industry after China's entry into the WTO and the shareholding reform of state-owned commercial Banks, Chinese commercial Banks have entered a stage of rapid development. The increasingly complex financial environment and the continuous progress of the economy and society force commercial Banks to continuously improve their ability in management and operation, especially the impact of the financial crisis, making commercial Banks have to strengthen the awareness of risk prevention, improve the business structure, develop new businesses and innovative products. Therefore, it is urgent to compare the operating efficiency of China's state-owned commercial Banks with that of joint-stock commercial Banks, calculate the efficiency level of China's commercial Banks by empirical research, and explore ways and measures to improve the operating efficiency of China's commercial Banks.

2 LITERATURE REVIEW

The research on the operation efficiency of Banks in foreign countries began in the 1950s and developed rapidly. The measurement methods and models used in the research are also constantly updated. At present, the quantitative analysis method is basically adopted to study the efficiency of the banking industry in various countries. Osman Zaim (1995) studied the operating efficiency of state-owned Banks, private Banks and foreign Banks in Turkey, analyzed the impact of financial

liberalization on the efficiency of Banks, and pointed out from the comparison of efficiency indicators that state-owned Banks are more efficient than private Banks. Bhattacharyya Arunava, Lovell c. a. k. and Sahay Pankaj (1997) used the DEA method to analyze the changes in the efficiency of state-owned, private and foreign-owned Banks in India, and the results showed that the average efficiency of state-owned Banks was the highest, while that of private and foreign-owned Banks was lower.

Allen n. Berger, Iftekhhar Hasan, Mingming Zhou (2007) used DEA method to analyze the data of China's banking industry from 1994 to 2003. He found that the efficiency of the four major banks is the lowest in China's banking industry, and the efficiency of foreign banks is the highest. The efficiency of banks with foreign shares has been greatly improved. He believed that foreign shareholders can improve the operating efficiency of participating banks, so foreign shareholders may improve the efficiency of the four major banks.

Compared with foreign studies, the research on the efficiency of commercial Banks in China started a little late. Most of the research on the efficiency of Chinese commercial Banks by domestic scholars focuses on qualitative research or financial index method. In recent years, some people also use DEA method to calculate and analyze the efficiency of Banks. Zhang Jianhua (2003) made a comprehensive analysis of the efficiency of China's state-owned, joint-stock and urban commercial banks in 1997-2001, using DEA method to measure the efficiency of all kinds of commercial Banks in China, it is concluded that the study found that the highest efficiency in China's banking sector is ten joint-stock commercial Banks, business scope of the lowest efficiency is limited in a certain area of city commercial Banks. Cai Yuezhou and Guo Meijun (2009) used the Malmquist of DEA index method to calculate and decompose the input and output data of 11 listed commercial Banks in China from 2004 to 2008. It is found that since 2004, the total factor productivity of listed commercial Banks has declined slightly and the technological change has declined, while the pure technical efficiency and scale efficiency have improved slightly. The shareholding system reform is conducive to the improvement of the operating efficiency of commercial Banks. Zhou Ruzhuo (2013) found that the operating efficiency of China's banking industry was greatly affected by the financial crisis, and the employee compensation and operating cost had a great impact on the operating efficiency. In order to improve the operation efficiency of China's banking industry and even the whole financial institutions, we must reform the financial system, strengthen supervision, improve the internal corporate governance of financial institutions, and improve the overall competitiveness. Zhang Xi and Zhao Xin (2019) found that there is a significant positive correlation between the level of financial innovation and the total factor productivity of the banking industry. Financial innovation, especially the innovation of financial science and technology, has significantly improved the efficiency of technological progress of the banking industry, thus driving the growth of the total factor productivity of the banking industry.

Through the above scholars' application of DEA method in the study of bank efficiency, it can be known that DEA method can not only measure the efficiency value of Banks, but also provide strategies to improve bank efficiency according to the measured results. Generally speaking, there are a lot of empirical researches on bank efficiency by domestic scholars, but the range of empirical researches on bank efficiency is not very long, and it is not able to explain exactly what factors affect the efficiency changes. But compared with foreign scholars, Chinese domestic scholars adopt new input and output index data based on the actual situation of China, and the research results are in line with the development status of Chinese commercial Banks.

3 EMPIRICAL ANALYSIS

3.1 DEA-Malmquist index

Data Envelopment Analysis (DEA) is a kind of system Analysis method developed based on relative efficiency evaluation by the famous operational research experts A. charnes and w. w. cooper.

A nonparametric statistical method for evaluating the effectiveness of decision-making units with the same type of multi-input and multi-output by using mathematical programming model. The basic idea is to put each evaluation unit as a decision making unit (DMU), the group made up of numerous DMU is evaluation, based on the comprehensive analysis of input and output ratio, with the weight of each DMU input and output indicators as a variable to evaluate operation, determine the efficient frontier, and according to the distance of the front face of each DMU and effective production, determine whether each DMU DEA effective.

The early application of the Malmquist index focused on the research field of consumer behavior, while later the Malmquist index was widely used in the analysis of input and output, especially in the research field of evaluating the dynamic changes in the production efficiency of a certain industry and the trend of productivity changes in a certain region (metallography, 2007). The Malmquist index was proposed by Malmquist. S. (1953), which used the ratio of distance function to calculate the input index. (x^t, y^t) and (x^{t+1}, y^{t+1}) are input-output relations in period t and period t+1, respectively. The change of input-output relationship from (x^t, y^t) to (x^{t+1}, y^{t+1}) is the change in productivity. The change of productivity comes not only from the change of technical level, but also from the change of technical efficiency. The change in technology level is the movement of the production frontier. Technical efficiency is the utilization efficiency of production technology, that is, the distance between the production front and the actual output. The distance function can be used to calculate the technical efficiency and technical progress. If the index is greater than 1, the production efficiency increases from period t to period t+1, indicating that the productivity has improved. If the index is less than 1, the production efficiency decreases from period t to period t+1, indicating a decline in productivity. If its exponent is equal to 1, there is no change in productivity.

3.2 Selection of input variables and output variables

According to the existing research literature, so far, there is no unified method and standard for the selection of input and output variables for the measurement of the operation efficiency of the banking industry. They are all based on the different research focuses to select the variables suitable for their own research. In general, the methods commonly used in most domestic literatures to measure the input and output of banking operation efficiency mainly include production method, intermediary method and capital method. In this paper, in order to improve the ability to distinguish between DEA efficiency, draw lessons from past research, in consideration of the main, on the basis of input and output variable selection method, according to two aspects of the management efficiency of the banking sector, profit ability and management ability, and our comprehensive mediation method, selected the national net asset value, number of employees, total deposits three input variables and the total amount of the loan and the total net profit of the two output variables.

3.3 Sample selection and data source

China's banking sector, including policy Banks, state-owned commercial Banks, joint-stock

commercial Banks, city commercial Banks and other rural financial institutions, based on the research purpose and the availability of data, elimination of public data, no policy Banks and city commercial Banks and rural financial institutions, has chosen the industrial and commercial bank of China, agricultural bank of China, bank of China, China construction bank, bank of communications five state-owned commercial bank and China Citic Bank, Everbright bank, Huaxia Bank, Minsheng Bank, Shenzhen development Bank, China merchants Bank, industrial Bank and Shanghai Pudong development Bank, eight national joint-stock commercial Banks as the research sample, the assets of these 13 commercial Banks account for about 60% of the total assets of China's banking industry, and their management ability and management level can also well represent the overall development of China's banking industry, which is a good representative.

Therefore, the panel data of 14 years from 2005 to 2018 were selected as the research object. The data required for this study were all from China financial yearbook, annual report of China banking regulatory commission and annual reports of sample Banks from 2005 to 2018. The data source is highly accurate and authoritative. The total net profit of Guangdong development bank in 2005 and 2006 is negative, which is restricted by data and not easy to be compared. The data of HengFeng Bank and Zheshang Bank from 2007 to 2010 are missing, so they are deleted here. Since PingAn bank merged with Shenzhen development bank in 2012, this paper will be listed as PingAn Bank. Shanghai Pudong development bank will be listed as Shanghai Pudong development bank.

3.4 Measurement results of operating efficiency

In this paper, the commercial Banks operating efficiency measure is mainly using DEA method, using the BCC model under the hypothesis of variable scale reward for 13 commercial Banks from 2005 to 2018 the Malmquist index measurement, related calculation and the result of decomposition (see table 1).

Firstly, according to the Malmquist index changes of all commercial Banks, the average value of the Malmquist index of all commercial Banks in the sample from 2005 to 2018 is 1.052, which means that the overall operating efficiency of 13 commercial Banks has slightly improved in 13 years, with an improvement of 5.2% (see table 1) in the lower right corner. Moreover, the improvement of their operating efficiency mainly comes from technological changes, rather than efficiency changes. During the analysis period, the efficiency change decreased by 0.2% (with the net efficiency change decreasing by 0.1% and the scale efficiency change decreasing by 0.1%), while the technical change increased by 5.5%. Thus, the analysis of this paper draws a preliminary conclusion that the operating efficiency of these 13 commercial Banks is slightly improved from 2005 to 2018.

Secondly, the Malmquist index of agricultural bank of China and Hua Xia Bank was 0.983 (slightly down 1.7%) and 0.981 (slightly down 1.9%), and the operating efficiency of the other 11 commercial Banks was improved to some extent. The more significant changes were in bank of China, China construction bank, China Citic Bank, ever bright bank, China Minsheng Bank, Pingan Bank and industrial bank. The Malmquist indexes over the decade were 1.065, 1.057, 1.055, 1.051, 1.054, 1.220 and 1.083, respectively (see table 1). The changes were relatively stable for industrial and commercial bank of China (ICBC) and bank of communications (BOCOM), with Malmquist indices of 1.035 and 1.017, respectively, over the 10-year period.

Table 1. Malmquist index changes of all commercial banks

Bank name	effch	techch	pech	sech	tfpch
Industrial and Commercial Bank of China	0.991	1.044	1.000	0.991	1.035
Agriculture Bank of China	0.975	1.009	0.982	0.993	0.983
Bank of China	0.997	1.067	1.000	0.997	1.065
China Construction Bank	1.001	1.056	1.000	1.001	1.057
China Bank of Communications	0.995	1.022	0.997	0.998	1.017
CITIC Bank	1.009	1.045	0.999	1.010	1.055
Everbright Bank	1.001	1.050	1.000	1.001	1.051
Huaxia Bank	0.993	0.987	1.000	0.993	0.981
Minsheng Bank	0.998	1.055	1.000	0.998	1.054
Pingan Bank	1.000	1.220	1.000	1.000	1.220
China Merchants Bank	1.007	1.039	1.004	1.003	1.046
Industrial Bank	1.004	1.079	1.000	1.004	1.083
Pudong Development Bank	1.000	1.051	1.000	1.000	1.051
Average Value	0.998	1.055	0.999	0.999	1.052

Note: effch represents efficiency change; techch represents technology change; Pech represents pure efficiency change; sech represents scale efficiency change; tfpch represents Malmquist index.

However, we should pay attention to the main sources of improving the operating efficiency of commercial banks. Pingan Bank has the highest operating efficiency, with Malmquist index of 1.220, but its main source is not the change of efficiency, but the change of technology. The improvement of the operating efficiency of industrial and Commercial Bank of China, Bank of China, Bank of communications of China and Minsheng Bank mainly depends on the change of technology, but the change of efficiency has declined. In addition, Everbright Bank mainly relies on technological change, with efficiency change increasing by 0.1% and technology change increasing by 5.0%; Industrial Bank mainly relies on technological change, with efficiency change increasing by 0.4% and technology change increasing by 7.9%; Shanghai Pudong Development Bank's operation efficiency improvement mainly depends on technological change, but efficiency change does not increase.

3.4.1 Annual changes in operating efficiency

First of all, from the change of each year, the Malmquist index of 13 commercial banks in 2005-2018 was 0.943 (the operating efficiency decreased by 5.7%) in 2006-2007, and the main reason for the decrease of operating efficiency was the decrease of technological change and the decrease of pure efficiency; the Malmquist index was 1.195 in 2011-2012, and the improvement of operating efficiency was more significant, the main reason was technology Change and increase of pure efficiency change; during 2016-2017, Malmquist index was 1.195, and the improvement of operating efficiency was also significant, mainly due to the increase of technology change and scale

efficiency change; the relatively stable change of operating efficiency was that during 2009-2010 and 2017-2018, Malmquist index was 1.007 and 1.009 respectively (see Table 2).

Secondly, from the composition of Malmquist index, technological change is the most obvious among these items. In the ten years, the average annual technological change of all commercial banks is 1.055, with a slight increase in technological change; while the pure efficiency change and scale efficiency change have a slight decrease, with a value of 0.999; from the year of technological change, the most obvious technological change is in 2006-2007, with an average technological change of 0.8322005-2006 for each commercial bank. The value is 1.260, and other years are relatively stable; Although the impact of scale efficiency change and technology change on business efficiency change of commercial banks is generally different, the impact of technology change of most commercial banks on business efficiency change is relatively greater. This paper initially finds a trend that the operating efficiency of commercial banks is relatively high from 2005 to 2006, which has declined from 2006 to 2007, and has been improved year by year from 2007 to 2008, and has declined significantly from 2008 to 2009. This is mainly due to the impact of the financial crisis in 2008, the overall banking industry in China has been impacted to varying degrees, and then gradually recovered from 2009 to 2013. Long trend. However, from 2013 to 2015, there was a slight decline. Influenced by the adjustment of China's economic development mode and the transformation of economic structure, the operating efficiency of China's banking industry will also change to some extent.

This paper preliminarily finds a trend: the operating efficiency of commercial Banks was relatively high from 2005 to 2006, decreased from 2006 to 2007, and improved year by year from 2007 to 2008, and decreased significantly from 2008 to 2009. This is mainly due to the impact of the financial crisis in 2008, the Chinese banking industry was entirely impacted to different degrees, and then gradually resumed the growth trend from 2009 to 2013. However, from 2013 to 2015, there was a small decline. Influenced by the adjustment of China's economic development model and the transformation of economic structure, the operating efficiency of China's banking industry will also change to a certain extent.

Table 2. Changes of Malmquist index of all commercial Banks in each year from 2000 to 2013

year	effch	techch	pech	sech	tfpch
2005-2006	0.848	1.260	1.001	0.848	1.069
2006-2007	1.133	0.832	0.988	1.147	0.943
2007-2008	1.023	1.073	0.995	1.028	1.098
2008-2009	1.015	0.966	1.002	1.013	0.980
2009-2010	0.990	1.017	1.018	0.972	1.007
2010-2011	0.983	1.068	1.000	0.984	1.050
2011-2012	0.989	1.209	1.001	0.987	1.195
2012-2013	0.977	1.091	0.984	0.992	1.066
2013-2014	1.037	0.961	0.999	1.038	0.996
2014-2015	1.013	0.979	0.999	1.014	0.992
2015-2016	0.983	1.132	0.996	0.987	1.113
2016-2017	1.009	1.184	1.000	1.010	1.195
2017-2018	0.993	1.016	0.999	0.994	1.009
average	0.998	1.055	0.999	0.999	1.052

3.4.2 comparative analysis of operating efficiency between state-owned commercial Banks and joint-stock commercial Banks

From the above analysis, it can be known that the improvement of operating efficiency of 13 commercial Banks from 2005 to 2018 mainly comes from technological change, rather than efficiency change, which is to say, the operating efficiency change of 13 commercial Banks mainly comes from technological change. Therefore, this paper mainly chooses technological changes to comprehensively study and compare the changes of operating efficiency between state-owned commercial banks and joint-stock commercial banks.

From table 3, it can be known that the technological changes of state-owned commercial Banks and joint-stock commercial banks in China from 2005 to 2018. From the overall situation, the 13 commercial banks have great changes in the sample time, with the average technological change of all banks being 1.055. Among the state-owned commercial banks, the technological changes are the bank of China and China construction bank (1.067 and 1.056, respectively). Among the joint-stock commercial Banks, ping an bank (see 1.220 in table 1) is the one with the greatest technological change, mainly due to the merger of ping an bank and Shenzhen development bank in 2012, which resulted in a substantial increase in paid-in capital, total deposits and operating income. Among them, the state-owned commercial Banks increased rapidly from 0.982 in 2005 to 1.267 in 2007. Since then, the technical change has remained at a high level and the overall increase has been observed for two consecutive years, which is related to the reform of China's banking sector.

Table 3. Comparison of technological changes between state-owned commercial Banks and joint-stock commercial Banks

year	Average of state-owned commercial Banks	Average of joint-stock commercial Banks	Average of all Banks
2005-2006	0.982	1.157	1.260
2006-2007	0.997	0.883	0.832
2007-2008	1.267	1.011	1.073
2008-2009	1.023	0.974	0.966
2009-2010	0.982	1.037	1.017
2010-2011	1.075	1.068	1.068
2011-2012	1.176	1.215	1.209
2012-2013	1.151	1.098	1.091
2013-2014	1.030	1.011	0.961
2014-2015	1.103	0.943	0.979
2015-2016	1.111	1.146	1.132
2016-2017	1.023	1.343	1.184
2017-2018	1.014	1.008	1.016
average	1.069	1.062	1.055

From the comparison of technological change between state-owned commercial Banks and joint-stock commercial Banks, the technological change of joint-stock commercial Banks was lower than that of state-owned commercial Banks from 2006 to 2007, and slightly higher than that of state-owned commercial Banks after 2009. In 2008, influenced by the financial crisis in the United States, the technological changes of state-owned commercial Banks and joint-stock commercial Banks declined from 2008 to 2009. The reason is that the external environment for the development of China's banking industry was seriously deteriorated after the financial crisis. At the same time, the financial crisis has also brought a serious impact on the development of China's real economy, making the loan demand of enterprises increase and the repayment ability decline, which directly affects the profitability of China's banking sector.

Subsequently, in November 2008, the Chinese government announced an economic stimulus package of 4 trillion yuan by the end of 2010, implemented a proactive fiscal policy and a loose monetary policy, and substantially increased the amount of loans in 2008 and 2009. Since the total amount of loans is selected as one of the output indicators in this paper, the loose monetary policy implemented by the state makes the loan scale of Chinese Banks increase unprecedentedly, which makes up for the shortage of external demand caused by the banking financial crisis and promotes the economic recovery and steady growth. Therefore, the technical changes of the 13 commercial Banks in China have all increased. Moreover, the direct impact of the crisis on the overall operation

of the Chinese banking industry is relatively limited, which has not affected the fundamental and foundation of the overall operation of the Chinese banking industry. However, state-owned commercial Banks, with the support of national policies, have made rapid adjustment and suffered a significant impact. From 2012 to 2013, the state-owned commercial Banks and joint-stock commercial Banks of technological change are decline, mainly due to the 2012 China banking regulatory policy and the influence of China's domestic economic downturn, Banks funding is limited, the cost of capital rise, between banking competition for deposits is more intense, has led to the decline of technological change. Technological changes mainly reflect the changes in the technological level and ability of Banks to innovate, and are also influenced by the direct technical factors such as the use of advanced information technology, equipment and staff quality by commercial Banks, as well as non-technical factors such as economic and social conditions. Comparing the technological changes between state-owned commercial Banks and joint-stock commercial Banks (2005-2018), it can be found that both state-owned commercial Banks and joint-stock commercial Banks were in a state of technological progress entirely during this period, and their technological innovation capacity was constantly improved. The overall technological innovation capacity of state-owned commercial Banks was slightly higher than that of joint-stock commercial Banks.

4. CONCLUSIONS AND SUGGESTIONS

Based on the empirical analysis of the relevant data collected from 13 Chinese commercial Banks from 2005 to 2018, the efficiency change index, technical change index, pure efficiency change index, scale efficiency change index and Malmquist index of 13 Chinese commercial Banks during this period were calculated. In the decomposition of total factor productivity index, the change of technology change index is the most obvious, with the average value of 1.055 over 13 years, indicating that the overall technology has made progress. Based on the actual situation of China and the development status of China's commercial Banks, this paper proposes that both state-owned commercial Banks and joint-stock commercial Banks speed up technological innovation based on the previous research and summary. Some Chinese commercial Banks have taken measures such as reducing staff, increasing efficiency and streamlining their operating offices and branches, but the results are not obvious. Technological innovation is the key to reduce the cost of operating factors, through the application of new knowledge, science and technology or management mode, the development of new financial products, providing customers with new services, or through integration and optimization methods such as improving the quality of existing products and services, so as to improve product market competitiveness and realize the market value, improve the operational efficiency of commercial Banks.

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