

# Efficiency Measurement and Influencing Factors of Listed Banks-Based on Super Efficiency DEA

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**Abstract:** *Using the financial data of 2006-2015 year. Selecting sixteen listed banks in China and use the CCR and BCC model to measure the technical efficiency and pure technical efficiency and scale efficiency of banks. On that basis using super efficiency DEA method to analyze further between efficient decision making units of listed banks. The results showed firstly, the average technical efficiency of four major state-owned banks showed U-Curve variation tendency in the past 10 years and lower than the average level of other joint-stock banks; Secondly, according to analyze further, we can find scale inefficiency mainly caused the technical inefficiency. It is a remarkable fact that more than four major state-owned banks even some other joint-stock banks have also appeared the trend of scale inefficiency in recent years; According to analyze further between efficient decision making units, we found that the Bank of Beijing Co., Ltd, Industrial Bank Co., Ltd and China Merchants Bank were ranked the top three and their efficiency value all greater than 1, comparing with the other joint-stock banks efficiency, four major state-owned banks still have not a small gap, the state-owned commercial banks need great improvement in efficiency.*

**Keywords:** DEA, listed bank, bank efficiency

## 1. Introduction

Efficiency is the core of the bank management and an important standard to measure the financial institutions operating performance, efficiency value can reflect the overall situation of the bank's resource allocation and business performance, which reflects the bank's competitive advantage. At present China is in economic transition period, the banking industry is undergoing major changes, such as interest rate liberalization, private banks access relaxed or bank listing, these change the banking industry. By the end of 2015, sixteen banks successfully listed on the A shares market, the overall competitiveness has been improved to a certain extent. Although the sixteen listed banks realized main cities coverage, these banks still have many problems, such as the management level is poor, the high rate of non-performing loans and lack of innovation ability, after all these are caused by the low efficiency, so the listed banks push country's economic development is not fully reflected. Estimates of bank efficiency is an important means for performance evaluation and its affecting factors are conducive to the bank to optimize the allocation of resources, so it has a certain practical significance. This paper structure as follows: the second section introduces the literature of bank efficiency evaluation and research findings so far at home and abroad on; the third section introduces the evaluation model and the use of the selected variables and data sources; the fourth section basing on the financial data of 2006-2015 years of China's 16 listed banks, first of all use the CCR model to measure and Analysis on technical efficiency of listed commercial banks, then use BCC model to measure the pure technical efficiency and scale efficiency and then analyze the reason of inefficient, finally using the method of super efficiency DEA to analyze further between efficient decision making units and give efficiency of each bank's rank; the fifth section summarizes the status of listed banks and puts forward some countermeasures and suggestions to improve the efficiency.

## 2. Literature Survey

The DEA method is a linear programming technique, it is an analytic method of non parametric frontier efficiency. It was proposed by Farrell (1957). Sherman and Gold (1985) applied the DEA technology in the bank industry in the first time, the method firstly selects the appropriate input and output index and then compared to the best bank samples, in this way we can determine samples are valid or invalid. Oral and Yolalan (1990) used DEA method to analysis the operating efficiency between 20 branches of Turkey commercial bank, the result indicates that service efficiency has a significant impact on the operating efficiency of branches. Jose pastor (1999) used DEA method to estimate 1993-1995 years of Spain bank's efficiency value, the empirical result shows that the inefficiency of Spanish banking industry mainly comes from the scale inefficiency. David (2002) uses To bit regression analysis and DEA method to measure the economic transition of the bank efficiency in the first time, the study found that the higher the capitalization of banks, the higher the efficiency. Emili Tortosa-Ansina (2008) uses DEA method to calculate the efficiency of Spanish banks, the result shows that the bank efficiency has improved. A Deville (2009) use DEA method to measure the efficiency of each branch of a bank group in France in 2004 and evaluate the efficiency of the bank, he found that only 1/3 was valid in all branches. MM. Mostafa (2010) analyzes the efficiency of Arabia bank by using neural network method and ten summarize the related matters of input and output index design in DEA method

Compared with foreign scholars, China scholars started late to study the efficiency of commercial banks. Wei Yu, Wang Li (2000) uses DEA method to calculate the technical efficiency, scale efficiency and scale return of Chinese banks in 1997, according to the research results, the paper puts forward the means to improve the efficiency of banks. Qin Wanshun, Ouyang Jun (2001) uses DEA method to measure

the overall efficiency of China's commercial banks, the result shows that China's commercial banks have generally low efficiency, The four major state-owned banks compared with other commercial banks have lower efficiency. Zhang Jianhua (2003) uses DEA's basic model and improved model to calculate the efficiency of China's three commercial banks between 1997-2001 years and firstly uses Malmquist index to analyze the efficiency change of banking industry in China. Wang Cong, Tan Zhengxun (2007) on the basis of demonstrating banking industry efficiency and competitiveness uses two step DEA and multivariate principal component rotation method to analysis the efficiency structure and competitiveness. Zhao Xiang (2010) uses BCC model and super efficiency DEA method to measure the efficiency of a commercial bank's 40 branches in Beijing, the result shows that the average efficiency was higher. Wei Xu, Hu Xuwei (2013) uses factor analysis method to make a comprehensive analysis of the operating performance in China's listed banks during 2009-2011 years. Han Song, Su Xiong (2016) started with bank operation structure, establishing a complex network DEA model with bank characteristics and then using it to evaluation the overall structure of bank efficiency. This model which reflects liability business and off balance sheet business, depicts the commercial bank operating expenses and fixed assets investment.

### 3. Methodology

#### a) Research Method

Data envelopment analysis (DEA) is a linear programming method, it measures the relative efficiency between decision making units which have the same input and output. This method is based on the research of Farrell (1957), then Sherman and Gold (1985) apply this technology to the banking industry in the first time. On the premise of constant returns to scale, the general idea is to divide the overall efficiency of decision-making units into two parts, technical efficiency and allocative efficiency which consist of the overall efficiency. Technical efficiency reflects the ability of decision making units to obtain maximum output under given inputs. Allocative efficiency reflects the ability of a decision making unit to use inputs at an appropriate rate when a given price is applied. If relax the assumption of constant returns to scale, Technical efficiency can be further divided into pure technical efficiency and scale efficiency. Pure technical efficiency measures the gap between the production frontier and the current production point of decision making unit; scale efficiency measures the distance between the production frontier and the change of returns to scale.

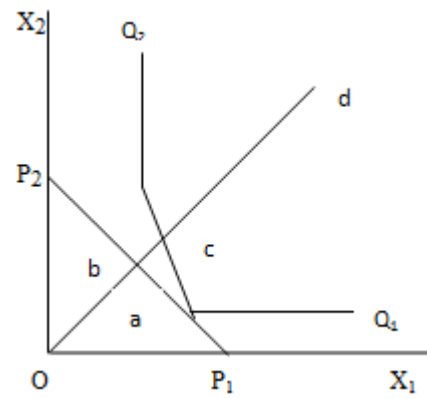


Figure 1

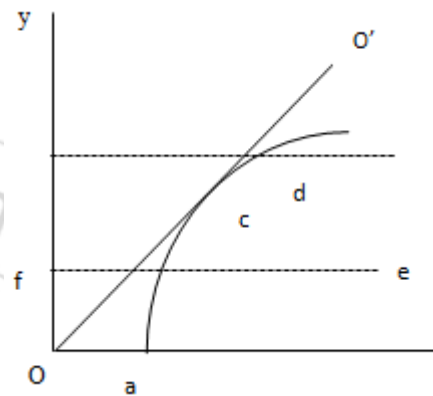


Figure 2

Assuming that  $X_1, X_2$  is the two input of the decision making unit,  $Y$  is the output and then constant returns to scale. In Figure 1  $P_1P_2$  is the cost budget line for the decision making unit which represents the ideal minimum cost of the current output level,  $Q_1Q_2$  is an equal output line which indicates the highest level of output that an investment portfolio can produce at the current level of technology, the  $P_1P_2$  and  $Q_1Q_2$  tangent to the "a" point, if the decision making unit is produced at "a" point, it can be produced with the least cost and the best input configuration. If the decision-making unit at "d" point production need to use greater input and cost to production. Define the overall efficiency  $OE$  the ratio of the minimum cost to the actual cost of the decision making unit at the current output level:

$$OE = Ob / Od \quad (3.1)$$

Obviously, when the overall efficiency value is 1, the decision making unit is effective, the value is less than 1, the decision making unit is invalid. Overall efficiency can be decomposed into technical efficiency (TE) and allocative efficiency (AE):

$$OE = TE * AE \quad (3.2)$$

In Figure 1 technical efficiency and allocative efficiency can be expressed as:

$$TE = Oc / Od \quad (3.3)$$

$$AE = Ob / Oc \quad (3.4)$$

It can be seen that when the technical efficiency value is 1, the decision making unit can be produced on the equal production curve under the current technology, at this time is

the effective technology; When the technical efficiency value is less than 1, the decision making unit will be produced on the right side of the equal output curve, at this time is the ineffective technology. When the allocative efficiency value is 1, it shows that the decision making unit can select the lowest consumption input portfolio on the cost budget line, When the allocative efficiency value is less than 1, at this time is the ineffective allocative.

If cancel the constant returns to scale, technical efficiency (TE) can also be decomposed into pure technical efficiency (PTE) and scale efficiency (SE). Pure technical efficiency measures the distance between the decision making unit and the production frontier when the constant returns to scale change. Scale efficiency measure the distance between the production frontier and the change of production returns with constant returns to scale. Suppose the decision making unit is single input single output, In Figure 2 'OO' indicates that production returns are constant, and "abcd" represents a variable production frontier. Assuming that the decision making unit is produced at "e" point then pure technical efficiency and scale efficiency can be expressed as:

$$PTE = fb / fe \quad (3.5)$$

$$SE = fg / fb \quad (3.6)$$

The value of pure technical efficiency is 1, indicating that the input resources are efficient at the current level of technology, if the failure to achieve effective technology at this time it is due to ineffective scale, therefore, the focus is how to improve its scale efficiency; When the scale efficiency value is 1, the decision making unit is produced on the production frontier with constant returns to scale, at this time is the effective scale. The relationship between technical efficiency and pure technical efficiency and scale efficiency is:

$$TE = SE * PTE \quad (3.7)$$

### B. Positivism model

#### Constant returns to scale model C<sup>2</sup>R

CRS model is proposed by Charnes, Cooper and Rhodes in 1978, belongs to the most basic DEA model, also known as CCR model. CRS model is a DEA model based on scale returns, Suppose there are n decision units, the input of the first j decision unit, the output index is  $x_j = (x_{1j}, x_{2j}, \dots, x_{mj})^T > 0$ ,  $y_j = (y_{1j}, y_{2j}, \dots, y_{sj})^T > 0$ . The input and output metrics correspond to a weight vector is  $W = (W_1, W_2, \dots, W_m)^T$ ,  $u = (U_1, U_2, \dots, U_s)^T$ . For the  $j_0$  ( $1 \leq j_0 \leq n$ ) a decision making unit, CRS model and its dual programming is:

$$\begin{aligned} (P_{C^2R}^I) \quad & \left\{ \begin{array}{l} \max \mathbf{u}^T \mathbf{y}_{j_0}, \\ \text{s.t. } \mathbf{w}^T \mathbf{x}_j - \mathbf{u}^T \mathbf{y}_j \geq 0, \quad j = 1, \dots, n, \\ \mathbf{w}^T \mathbf{x}_{j_0} = 1, \\ \mathbf{w} \geq \mathbf{0}, \mathbf{u} \geq \mathbf{0}, \\ \min \theta, \end{array} \right. \\ (D_{C^2R}^I) \quad & \left\{ \begin{array}{l} \text{s.t. } \sum_{j=1}^n \mathbf{X}_j \lambda_j \leq \theta \mathbf{X}_{j_0}, \\ \sum_{j=1}^n \mathbf{Y}_j \lambda_j \geq \mathbf{y}_{j_0}, \\ \lambda_j \geq 0, \quad j = 1, \dots, n \end{array} \right. \end{aligned}$$

If the optimal value of  $(P_{C^2R}^I)$  is equal to 1, the decision unit  $j_0$  is called weak DEA efficiency ( $C^2R$ ); If the planning  $(P_{C^2R}^I)$  exists the optimal solution  $\mathbf{w}^* > \mathbf{0}, \mathbf{u}^* > \mathbf{0}$ , and the optimal value of  $\mathbf{u}^{*T} \mathbf{y}_{j_0} = 1$ , the decision making unit  $j_0$  is DEA efficiency ( $C^2R$ ).

#### Variable scale reward model BC<sup>2</sup>

The assumption that returns to scale is constant implies that decision making units can scale up output by increasing inputs, indicating that it does not affect the efficiency. This strict assumption has a clearly gap with the actual, and when the decision making unit is not all in the best scale, technical efficiency and scale efficiency will be mixed together. In 1984, Banker, Charnes and Cooper to solve this problem, put forward the DEA model of variable returns to scale, generally called BC2 model. For the  $j_0$  ( $1 \leq j_0 \leq n$ ) decision making unit, the BC2 model and its dual programming is:

$$\begin{aligned} (P_{BC^2}^I) \quad & \left\{ \begin{array}{l} \max \mathbf{u}^T \mathbf{y}_{j_0} + u_0, \\ \text{s.t. } \mathbf{w}^T \mathbf{x}_j - \mathbf{u}^T \mathbf{y}_j - u_0 \geq 0, \quad j = 1, \dots, n \\ \mathbf{w}^T \mathbf{x}_{j_0} = 1, \\ \mathbf{w} \geq \mathbf{0}, \mathbf{u} \geq \mathbf{0}, \end{array} \right. \\ (D_{BC^2}^I) \quad & \left\{ \begin{array}{l} \min \theta \\ \text{s.t. } \sum_{j=1}^n \mathbf{x}_j \lambda_j \leq \theta \mathbf{x}_{j_0}, \\ \sum_{j=1}^n \mathbf{y}_j \lambda_j \geq \mathbf{y}_{j_0}, \\ \sum_{j=1}^n \lambda_j = 1, \\ \lambda_j \geq 0, \quad j = 1, \dots, n \end{array} \right. \end{aligned}$$

If the optimal value of  $(P_{BC^2}^I)$  is equal to 1, the decision making unit  $j_0$  is called weak efficiency DEA ( $BC^2$ ); If the planning  $(P_{BC^2}^I)$  exists the optimal solution  $\mathbf{w}, \mathbf{u}, u_0$  meet  $\mathbf{w}^* > \mathbf{0}, \mathbf{u}^* > \mathbf{0}$ , and the optimal value  $\mathbf{u}^{*T} \mathbf{y}_{j_0} + u_0 = 1$ , then called the decision unit for

efficiency DEA (BC<sup>2</sup>).

### C. Variable Selection

The selection of bank input index and output index is the key to measure the efficiency of banks, it reflects the extent to which banks effectively deploy their resources and their ability to compete in markets and sustainable development. There are three kinds of input index and output index methods: Production Law, intermediate law and asset law, these methods are basically consistent in the selection of input index, net asset value, number of employees and operating expenses are selected as inputs; but in the output index above three methods exist obvious differences. The production law considers the bank as the organization to provide services, so the number of accounts, the number of loans applied and the customer service survey rate are regarded as output index. Intermediate law considers the bank as the intermediary of capital circulation so the amount of bank deposit and loan as its output. In the asset law, the bank is also regarded as the intermediary of the capital circulation, but the items that produce the income are listed as output, mainly summarized as interest income and non interest income. The three methods have certain rationality and limitation. The study focuses on the bank as a financial institution profitability, so choose the net value of fixed assets, the number of employees and operating expenses as the input index; loans, other earning assets and total pre tax profit for the output index.

This paper selects the Industrial and Commercial Bank; China Construction Bank; China of Bank; Agricultural Bank of China; Bank of Communications Co., Ltd; China Merchants Bank; China Minsheng Banking Corp., Ltd; Shanghai Pudong Development Bank; Industrial Bank Co., Ltd; Hua Xia Bank Co., Ltd; Ping An Bank Co., Ltd; China Citic Bank; China Everbright Bank Co., Ltd; Bank of Nanjing; Bank of Beijing Co., Ltd; Bank of Ningbo 16 joint-stock commercial banks as the research sample, time selection panel data during 2011-2015 to evaluation. Data from the China Financial Yearbook and the annual report of the banks open.

### 4. Discussion

Firstly, CCR model and BCC model are used to measure the technical efficiency, pure technical efficiency and scale efficiency of listed banks in China from 2006 to 2015 year by using DEAP2.1 software, then the overall situation of the efficiency is given and the reasons for inefficiency of some

banks are analyzed. On these basis, based on the super efficiency DEA method, using EMS1.3 software to analyze the efficiency of 16 listed banks and then getting the change of its efficiency ranking the efficiency of each bank.

### A. Efficiency analysis of Listed Banks Based on CCR model

CCR model is established on the assumption that returns to scale are unchanged. When the bank is in the maximum output and the minimum cost, the model can be used to calculate the technical efficiency of the bank. Table 1 summarizes the technical efficiency of listed commercial banks in 2006-2015 years. The following conclusions can be obtained from the data in Table 1:

First from the trend point of view, the average technical efficiency of four major state-owned banks showed U-Curve variation tendency in the past 10 years, during the period of 2006-2009 year, the average technical efficiency showed a decreasing trend in four years, while the average technical efficiency of banks showed an increasing trend in 2010-2015 year, it is consistent with the trend of social economy and banking development. In addition to China Merchants Bank, Shanghai Pudong Development Bank and Ping An Bank Co., Ltd, the other 13 banks before 2010 year all complete the listing, Coupled with 08 years of financial crisis on the banking industry, it caused a certain impact, so in this period the overall average technical efficiency of banks in a decreasing trend. In 2010 the banks completed the listing, therefore their own technical efficiency are varying degrees of improvement. Coupled with China's economy entered a period of rapid development, so in this period the overall average efficiency of the bank presents an increasing trend.

Secondly from the structural point of view, Four state-owned banks in the past ten years the average technical efficiency value is 0.72, among them the technical efficiency value, the highest bank is industrial and commercial bank. But it lower than the agricultural bank. Joint-stock banks ten years average technical efficiency value is 0.91 significantly higher than the top four state-owned banks, China Merchants Bank and Beijing bank's efficiency value is the highest and effective technology. Finally, from the perspective of effective technology, in the four major state-owned banks in addition to industrial and Commercial Bank of China in 2013 and 2014 was effective that the rest is invalid; compared to the joint-stock banks, the effective period is much less.

**Table 1:** Technical efficiency value during 2006-2015 year

Bank	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	mean
ICBC	0.724	0.569	0.789	0.791	0.961	0.940	0.988	1.000	1.000	0.943	0.871
CCB	0.710	0.552	0.646	0.700	0.838	0.821	0.779	0.800	0.813	0.900	0.756
BOC	0.605	0.547	0.659	0.718	0.762	0.778	0.805	0.816	0.843	0.849	0.738
ABC	0.516	0.542	0.425	0.454	0.524	0.516	0.521	0.546	0.545	0.648	0.524
BOCOM	1.000	1.000	0.620	0.823	0.805	0.882	0.944	0.965	0.977	0.902	0.892
CMB	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CMBC	0.982	0.856	0.896	0.752	0.768	0.832	0.891	0.803	1.000	1.000	0.878

SPD	1.000	1.000	1.000	0.884	0.960	0.910	1.000	1.000	1.000	1.000	0.975
CIB	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.919	1.000	0.992
HXBC	0.943	0.851	0.836	0.725	0.711	0.582	0.656	0.650	0.625	0.684	0.726
PABC	0.824	1.000	1.000	1.000	0.862	1.000	1.000	1.000	1.000	1.000	0.969
ZHB	1.000	1.000	0.837	0.886	0.875	0.895	0.890	0.845	1.000	1.000	0.923
CEB	1.000	0.915	1.000	1.000	1.000	1.000	1.000	1.000	0.753	0.840	0.951
BON	1.000	0.909	0.882	0.722	0.927	0.780	0.817	0.771	0.715	0.831	0.835
BOB	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
NBB	1.000	0.981	1.000	0.732	0.707	0.682	0.711	0.677	0.712	0.595	0.780

ICBC = Industrial and Commercial Bank of China; CCB = China Construction Bank; BOC = Bank of China; ABC = Agricultural Bank of China; BOCOM = Bank of Communications Co.,Ltd; CMB = China Merchants Bank; CMBC = China Minsheng Banking Corp.,Ltd; SPD = Shanghai Pudong Development Bank;CIB = Industrial Bank Co.,Ltd; HXBC = Hua Xia Bank Co.,Ltd; PABC = Ping An Bank Co.,Ltd ZHB = China Citic Bank; CEB = China Everbright Bank Co.,Ltd BON = Bank of Nanjing;BOB = Bank of Beijing Co.,Ltd; NBB = Bank of Ningbo

### B. Efficiency analysis of Listed Banks Based on BCC model

If we relax the hypothesis that the returns to scale in CCR model are invariable, we can derive the BCC input oriented model with variable returns to scale. It represents the minimum input cost of the maximum output at the same scale.It can decompose technical efficiency into pure technical efficiency and scale efficiency, which is the reason for further verification of the technical inefficiency of banks. Explaining how much technical inefficiency is due to inefficiency pure technical, and how much is caused by ineffective scale.

Pure technical efficiency measures the distance between the decision making unit and the production frontier when the returns to scale change. That reflects the bank's daily operating level and management policy. The scale efficiency indicates under the bank's maximum output, the technical efficiency of the production boundary of the input and the optimal size of the input ratio. From table 2 we can see that listed bank's average pure technical efficiency value was 0.96 nearly 10 years , indicating that the bank's operating level is in a good level in this period, the average technical efficiency value of the four state-owned banks is 0.93,slightly lower than other joint-stock banks; in the past ten years listed bank's average scale efficiency value is 0.93,the scale efficiency value of the four state-owned banks is 0.78, and the scale efficiency value of other joint-stock banks is 0.94.Thus the inefficiency technical of banks is mainly caused by ineffective scale, indicating in recent years more than four state-owned banks and some other joint-stock banks also appeared ineffective scale trend. The main reason for these phenomena is that these banks in the use of the current level of technology production scale is too large, resulting in diseconomies of scale

**Table 2: Pure technical efficiency value during 2006-2015 year**

Bank	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	mean
ICBC	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CCB	1.000	1.000	0.971	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.997
BOC	1.000	0.940	0.615	1.000	1.000	1.000	1.000	0.988	1.000	1.000	0.954
ABC	0.895	0.950	0.967	0.648	0.680	0.674	0.664	0.666	0.667	0.720	0.753
BOCOM	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CMB	1.000	1.000	0.914	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.991
CMBC	1.000	0.936	1.000	0.885	0.877	0.935	0.944	0.909	1.000	1.000	0.949
SPD	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CIB	1.000	1.000	0.843	1.000	1.000	1.000	1.000	1.000	0.921	1.000	0.976
HXBC	0.946	0.867	1.000	0.774	0.808	0.661	0.657	0.678	0.659	0.734	0.778
PABC	0.854	1.000	1.000	1.000	0.877	1.000	1.000	1.000	1.000	1.000	0.973
ZHB	1.000	1.000	1.000	1.000	0.980	1.000	0.911	0.916	1.000	1.000	0.981
CEB	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.756	0.851	0.961
BON	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BOB	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
NBB	1.000	1.000	1.000	1.000	0.850	1.000	1.000	1.000	1.000	1.000	0.985

**Table 3: Scale efficiency value during 2006-2015 year**

Bank	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	mean
ICBC	0.724	0.569	0.789	0.791	0.961	0.940	0.988	1.000	1.000	0.943	0.871
CCB	0.710	0.552	0.646	0.700	0.838	0.821	0.779	0.800	0.813	0.900	0.756
BOC	0.605	0.581	0.678	0.718	0.762	0.778	0.805	0.827	0.843	0.849	0.745
ABC	0.576	0.571	0.690	0.701	0.771	0.766	0.785	0.820	0.817	0.899	0.740
BOCOM	1.000	1.000	0.641	0.823	0.805	0.882	0.944	0.965	0.977	0.902	0.894
CMB	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CMBC	0.982	0.915	0.981	0.850	0.876	0.891	0.944	0.883	1.000	1.000	0.932
SPD	1.000	1.000	1.000	0.884	0.960	0.910	1.000	1.000	1.000	1.000	0.975
CIB	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998	1.000	1.000
HXBC	0.997	0.981	0.992	0.937	0.880	0.880	1.000	0.959	0.949	0.933	0.951
PABC	0.965	1.000	1.000	1.000	0.972	1.000	1.000	1.000	1.000	1.000	0.994
ZHB	1.000	1.000	0.837	0.866	0.893	0.895	0.977	0.923	1.000	1.000	0.939
CEB	1.000	0.915	1.000	1.000	1.000	1.000	1.000	1.000	0.997	0.988	0.990
BON	1.000	0.909	0.882	0.722	0.927	0.780	0.817	0.771	0.715	0.831	0.835
BOB	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
NBB	1.000	0.981	1.000	0.732	0.832	0.682	0.711	0.677	0.712	0.595	0.792

**C. Efficiency analysis of Listed Banks Based on super DEA**

In the BCC model can be calculated which decision-making unit is effective that efficiency value is 1. But the BCC model can't evaluate the effective decision making units. The super efficiency DEA model is based on the BCC model, aiming at the comparison of the efficiency value between the effective decision making units, It can distinguish the difference between DEA effective decision making units and can be effectively sort the evaluated decision units. The essence of the super efficiency model is to recalculate the production frontier of an effective decision making unit, then calculated efficiency value is greater than the efficiency value in BCC model; For invalid decision making units, the production frontier will not change, the calculated results are in agreement with the efficiency values in the BCC model. The evaluation results calculated by the super efficiency DEA model are shown in Table 4, It can be seen that the model makes the original efficiency value of 1 banks have a new efficiency score, and makes the efficiency of each bank more obvious. Taking the efficiency DEA score of ICBC in

2013 and 2014 as an example, the bank is on the efficiency frontier and the efficiency value is 1 in the two years, now the efficiency value in 2103 is 1.026, in 2104 is 1.343, this shows that even in 2013 and in 2014 the proportion of output decreased by 2.6% and 34.3%, ICBC in the past two years is still efficient.

In 2006-2015 year super efficiency evaluation, the Bank of Beijing, industrial bank and China Merchants Bank ranked the top three, the second is the efficiency of China Everbright Bank, Shanghai Pudong Development Bank and Ping An Bank whose value is greater than 1. The highest efficiency of the four state-owned banks is industrial and Commercial Bank of China, followed by Construction Bank, Bank of China and Agricultural Bank but the efficiency of the four lines is less than 1 and is inefficient. It can be see that compared with other joint-stock banks, the four state-owned banks have not a small gap. The State - owned commercial banks also need great improvement in efficiency.

**Table 4: Super Efficiency DEA value during 2006-2015 year**

Bank	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	mean	rank
ICBC	0.724	0.569	0.789	0.791	0.961	0.94	0.988	1.026	1.343	0.943	0.907	11
CCB	0.71	0.552	0.646	0.7	0.838	0.821	0.779	0.8	0.813	0.9	0.756	13
BOC	0.605	0.547	0.659	0.718	0.762	0.778	0.805	0.816	0.843	0.849	0.738	14
ABC	0.516	0.542	0.425	0.454	0.524	0.516	0.521	0.546	0.545	0.648	0.524	16
BOCOM	1.207	1.504	0.62	0.823	0.805	0.882	0.944	0.965	0.977	0.902	0.963	8
CMB	1.422	1.076	1.16	1.09	1.264	1.091	1.18	1.143	1.141	1.255	1.182	3
CMBC	0.982	0.856	0.896	0.752	0.768	0.832	0.891	0.803	1.004	1.485	0.927	10
SPD	1.44	1.132	1.118	0.884	0.96	0.91	1.089	1.296	1.356	1.17	1.136	5
CIB	1.78	1.173	1.095	1.217	1.14	1.171	1.298	1.187	0.919	1.088	1.207	2
HXBC	0.943	0.851	0.836	0.725	0.711	0.582	0.656	0.65	0.625	0.684	0.726	15
PABC	0.824	1.108	1.18	1.087	0.862	1.008	1.107	1.169	1.332	1.542	1.122	6
ZHB	1.037	1.04	0.837	0.866	0.875	0.895	0.89	0.845	1.222	1.107	0.961	9
CEB	1.153	0.915	1.087	1.67	1.339	1.579	1.18	1.119	0.753	0.84	1.164	4
BON	1.046	0.909	0.882	0.722	0.927	0.78	0.817	0.771	0.715	0.832	0.84	12

BOB	1.403	1.437	1.6	1.602	1.442	1.362	1.436	1.411	1.345	1.182	1.422	1
NBB	1.588	0.981	2.352	0.732	0.707	0.682	0.711	0.677	0.712	0.595	0.974	7

## 5. Conclusion

This paper selects the cross-sectional data of 16 listed commercial banks in China during 2006-2015, selecting fixed asset net value, employee number and operating expenses as input index, loans, other profit assets and pre tax profit as output index. And then use CCR model, BCC model and super efficiency DEA method to measure the efficiency of listed banks. Focusing on the analysis of the various banks efficiency trends and ineffective bank reasons. The result shows that the average technical efficiency trend of China's listed commercial banks is roughly "U" in the past ten years. The average technical efficiency showed a decreasing trend in 2006-2009 four year and in 2010-2015 year, the average technical efficiency of banks showed an increasing trend. Further analysis of the reasons for ineffective technology shows that the technical inefficiency of China's banks is mainly caused by ineffective scale. It is worth noting that in recent years more than four state-owned banks and some other joint-stock banks also appeared ineffective scale trend, it is different from previous year's conclusions. The main reason for these phenomena is that these banks in the use of the current level of technology production scale is too large, resulting in diseconomies of scale. Finally, a more in-depth evaluation of the efficiency of the decision making unit found that the Bank of Beijing, industrial bank and China Merchants Bank ranked the top three and its efficiency value is 1. Compared with other joint-stock banks, the four state-owned banks have still a gap, the state-owned commercial banks need much improvement in efficiency. The reason, in recent years, China's economy has entered a transition period, China's export-oriented economic slowdown, financial market further opening, the bank deposit interest rate floating no longer set limit, speed the development of private banks, the listed banks more competitive, and increased business risk has a negative impact on bank's profitability and efficiency. According to these, listed banks should increase the level of non-performing assets in the later development. Downsizing and proper cutting branches, increasing technological innovation, optimizing the financial services and information construction. By this way it can improve the core competitiveness, management level and management efficiency.

## 6. Future Scope

The research on the operating efficiency of listed commercial banks is a very complex and comprehensive subject which involves management, investment, technological innovation and many other fields. Due to the limited level of the author adding listed commercial banks operating efficiency itself is also dynamic and diversity, therefore, this paper still has many problems to be further. The paper's limited is that data only select the listed commercial banks 2006 - 2015 panel data for ten years, therefore in the analysis of the problem will inevitably have

some one-sided, especially in the prediction of some trends will have some bias in the future more samples can be selected in order to meet the reality of the development of listed commercial banks and combine with the economic development situation at home and abroad. Finally, It is more accurate to measure the operational efficiency of listed commercial banks, which will lay a solid theoretical foundation for promoting the comprehensive development.

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