

Determinants of Commercial Bank Efficiency in China: Two-Stage Data Envelopment Analysis (DEA) Approach 2016-2021 Period

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Abstract:- Policies before economic reform and liberalization decades ago made China a stagnant and impoverished. The opening of China's economic gates to international trade in the free market reforms of 1979, made China a developing country with the fastest-growing economy in the world. The current growth in total assets and contributions of Chinese financial institutions cannot be separated from the role of large banks belonging to the central government and society as a whole. The estimation technique in this study uses the Two-Stage Data Envelopment Analysis model. This model uses 6 cross section data units and 6 time series data sets. Throughout the study period, all state-owned commercial banks in China performed efficiently (stage 1). The results of the study (stage 2) show that state-owned commercial banking companies in China tend to perform efficiently throughout the study period. Based on the constructed hypothesis construct, of the four hypotheses, only one hypothesis is statistically accepted. Chinese government-owned commercial banks can continue to perform efficiently even during an uncertain situation, as evidenced in the 2020-2021 research sample showing that efficiency levels are consistently in the high category amid the conditions of the Covid-19 pandemic

Keywords:- Bank Efficiency, Capital Adequacy Ratio, Loan to Deposit Rati, Interest Income, Gross Domestic Product, and Data Envelopment Analysis.

I. INTRODUCTION

Banks are salient institutions in China's progress and have rapidly helped China's economic development over the past thirty years, followed by the rapid growth of Chinese banking companies (Chen et al., 2021; Hu et al., 2020). Furthermore, based on data from The People's Bank of China, the total assets of financial institutions in China reached 381.95 trillion Yuan at the end of 2021, an increase of 7.8% compared to the previous year. The current growth in total assets and contributions of Chinese financial institutions cannot be separated from the role of the four major banks owned by the central government and society as a whole. On the other hand, commercial banking has also dominated the national market in China and contributed to China's success (Chang et al., 2017; Dong et al., 2020).

Sourced from financial reports through their respective official websites, each bank recorded fluctuations in net profit from 2016-2021 (Table 1). Specifically, the Agricultural Bank of China experienced a decrease in net profit growth in 2018 with a percentage of 4.92%, a difference of 0.01% from the previous year (4.93%). In addition, in 2020, all commercial banks in China posted a decline in net profit with a decreasing range between 3.3-11% from the previous year. Thus, as a whole, the profit achievements of all commercial banks in China reflect fluctuations in net profit.

Table 1 Net Profit of Every Bank in China 2016 – 2021 (Billion of Renminbi)

Banks	2016	2017	2018	2019	2020	2021
Agricultural Bank of China	184	193	203	213	216	242
Bank of China	184	185	192	202	205	227
Bank of Communication	68	71	74	78	80	89
China Construction Bank	232	244	256	269	274	304
Industrial & Commercial Bank of China	279	287	299	313	318	350
Postal Savings Bank of China	40	48	52	61	64	77

In terms of lending, every commercial bank in China over the past six years has experienced significant fluctuations in credit distribution shown in Table 2. Furthermore, specifically in 2018, five commercial banks (Bank of China, Bank of Communication, China Construction Bank), Industrial & Commercial Bank of China, and Postal Savings Bank of China) experienced a

decrease in the spread of loan funds from the previous year, scilicet 0.79%, 2.49%, 3.16%, 0.68%, and 2.76%. In addition, in 2021, loan disbursement growth appears to fluctuate between commercial banks and annually. In short, of the six banks, only the Agricultural Bank of China recorded an increase in credit distribution growth from 2016-2021 compared to the other five commercial banks.

Table 2 Total Customer Loans of Every Bank in China in 2016-2021 (Billion of Renminbi)

Banks	2016	2017	2018	2019	2020	2021
Agricultural Bank of China	9.719	10.720	11.940	13.360	15.170	17.175
Bank of China	9.973	10.897	11.819	13.069	14.216	15.713
Bank of Communication	4.221	4.580	4.854	5.304	5.848	6.560
China Construction Bank	11.488	12.574	13.365	14.541	16.231	18.170
Industrial & Commercial Bank of China	13.057	14.233	15.420	16.761	18.624	20.667
Postal Savings Bank of China	3.011	3.630	4.277	4.974	5.716	6.454

However, efficiency evaluations must continue to be carried out regularly to maintain performance, developing the growth, and compete globally (An et al., 2021; Y. Li, 2020). At the same time, increasing efficiency and productivity must be able to run simultaneously to achieve the bank's main goals, improve the competency, and the quality of service to customers (Mehdiabadi et al., 2020). Furthermore, in the literature, there are many previous studies related to the efficiency of banking performance because the efficiency of bank performance is more resilient to shocks, thereby influencing growth positively and significantly.

In the literature regarding bank performance efficiency, Xu (2018) states that the performance efficiency of commercial banks in China is significantly influenced by the macroeconomic situation and monetary policy. These findings provide evidence that banking is inseparable from the surrounding economic environment. Furthermore, Chen et al., (2020) stated that bank performance efficiency was able to loosen credit constraints and increase the growth rate of financially dependent industries during the crisis. Using time-series data from 1972-2013, Abedin (2017) also revealed that the efficiency and profitability of the banking sector affected the Bangladeshi economy. Showing similar results, Chen et al. (2018) stated that the degree of performance efficiency of Chinese banks as a whole remains low.

More specifically, most studies show that state-owned banks are less efficient than other forms of ownership. Zhou et al. (2019), Fukuyama & Tan (2022), and Antunes et al. (2021) examined the evaluation of the efficiency of listed Chinese commercial banks from 2014-2016, and found differences in the efficiency levels of all banks discovered in general and within stages, types of banks, and in different countries' economic conditions. Furthermore, Rezik & Kalai (2018) stated that the country's economy is closely related to the efficiency of banking performance because the actualization of banking operations can be different and more risky. Revealing similar research results, Zhou et al. (2019) show that the efficiency of Chinese banks decreased during the 2006-2008 financial crisis, and state-owned commercial banks in China experienced the lowest cost efficiency during 2008-2014.

This study argues that performance analysis based on financial ratios is limited to representing the prediction of the success or failure of a bank and cannot be used to substantially investigate to the level of efficiency achieved by a bank. Therefore, further analysis is needed to identify performance factors and their influence on the level of

efficiency of commercial banks in China. Therefore, this study uses DEA (Data Envelopment Analysis) as an analytical tool with linear programming techniques to measure relative efficiency levels and identify input and output values related to banking operations which then serve to explore the causes and sources of bank inefficiencies (Adeabah et al., 2019).

II. LITERATUR REVIEW

There are various kinds of research that identify both factors, internal and external to companies that can affect the level and approach of commercial bank efficiency with different scopes so that the variables used in the previous literature are very diverse. Research Zhou et al. (2019) analyzed the efficiency of Chinese banking by identifying the capital organization, capital allocation, and profitability levels in 16 companies registered as Chinese commercial banks. This study aims to evaluate the efficiency of each bank in order to determine the development and increase competitiveness of each company. The results showed that all Chinese commercial banks analyzed in the 2014-2016 period were declared inefficient, and inefficiencies occurred at different stages of the system for different types of banks. Fukuyama & Tan (2022) found the same results in their research, namely that the Chinese banking industry had the highest level of stability inefficiency and the most powerful volatility occurred during 2007-2017. Fukuyama & Tan's research (2022) aims to analyze the efficiency level of banking in the geographical region of China using three stages of analysis, namely input efficiency, evaluation of stability efficiency, and output efficiency.

Antunes et al. (2021) conducted research on 39 Chinese commercial banks during the period 2010 – 2018, the aimed to investigate the interrelationships between efficiency and several bank-specific variables, such as profitability, bank size, cost management, traditional business, and non-traditional business. The results of Antunes et al. (2021) show that Chinese state-owned banks had the highest efficiency during the study period. Regression analysis was also carried out in this study with the results of bank size, proactive expense management, and non-traditional business having a positive effect on the level of bank efficiency, at the same time bank's profitability, traditional bank business, and expense management have a negative impacted on bank efficiency.

In addition to analyzing efficiency, this research also performs regression analysis of the factors that affect the level of banking efficiency. Nguyen et al. (2021) identify the optimal CAR level and the minimum CAR reasonable

level applied to each bank. Dao & Nguyen (2020) identify a relationship between CAR and bank performance, and GDP has a significant effect on bank performance. Majdina et al. (2019) analyzed the efficiency of Islamic and conventional banks in Indonesia and analyzed the factors that affect the level of efficiency. Majdina et al. (2019) found differences in efficiency between Islamic and conventional banks and presented several factors that have a positive effect on the level of bank efficiency, namely assets, ROA, and CAR. Sadi'yah et al. (2021) identified several factors affecting the ROA of private banks listed on the Indonesia Stock Exchange for the 2014-2018 period. The results of research by Sadi'yah et al. (2021) show that simultaneously the variables LDR (Loan to Deposit Ratio), OER (Operational Efficiency Ratio), and NPL (Non-Performing Loans) have a significant effect on ROA. LDR has a significant and positive effect on ROA, OER, and NPL have a significant and negative effect on ROA.

Irawan & Syarif, (2019) also conducted research that aimed to investigate empirical evidence on the factors that affect banking performance with research results showing that Capital Adequacy Ratio (CAR), Loan to Deposit Ratio (LDR), Loan to Asset Ratio (LAR), Bank Size, Operational Efficiency Ratio (OPE), and Net Interest Margin (NIM) simultaneously have a significant effect on non-performing loans (NPL). One of the external factors that can affect bank efficiency is GDP. Shawtari (2018) tested bank efficiency using different performance measures, namely return on assets, return on equity, bank margin (MAR), and GDP. The results of his research show that GDP is a factor that greatly determines banking performance and efficiency.

III. RESEARCH VARIABLES AND OPERATIONAL DEFINITION VARIABLES

➤ *Input Variable:*

- *Employment Expenses*

Labor cost is used as an input variable because it is one of the indicators for obtaining output results. Labor costs are always considered in determining policies related to the outcome those banks want to achieve (Milenković et al., 2022). Thus, the labor costs incurred can serve to test the efficiency level of bank performance. Labor costs are all costs incurred by the company for the payment of direct and indirect labor can be seen from DMU's income statement published by accounting period (Huang, 2017; Kocisova et al., 2019; Meiryani et al., 2022).

- *Total Assets*

Assets are an essential financial indicator, because they determine the sustainability of the activities carried out by the company (Curtis et al., 2020; Wang et al., 2020). Previous research has mostly used total assets as an input variable to measure the efficiency level of banking performance (Curtis et al., 2020; Kočíšová, 2015; Ouenniche & Carrales, 2018; Wang et al., 2020). Total assets are calculated by adding up fixed assets and current assets. Data on total assets can be obtained from information on each bank's financial position report for a certain period.

The following is how to calculate total assets according to Wang et al., (2020): Total Assets: Fixed Assets + Current Assets

- *Operating Expenses*

Operating expenses are issued load incurred to carry out operational activities and to generate profits or achieve company goals (Akbari et al., 2020; Huang, 2017; Khan & Wang, 2021). Therefore, operating expenses selected, as one of the input variables in this study. Operating expenses data needed to perform calculations can be seen from the report of profits and losses in every bank. Operating expense is calculated by adding production costs and operating expenses for the company's main activities (Akbari et al., 2020).

➤ *Output Variable:*

- *Total Loans*

Loans are one of the output variables chosen by researchers because loans are the primary banking activity (Fukuyama & Tan, 2022; Milenković et al., 2022; Ouenniche & Carrales, 2018). Total loans are measured from the outstanding loans that banks provide to customers and are the total of short-term loans and long-term loans (Fukuyama & Tan, 2022). Information on total loans can be obtained from the financial statements issued by the bank each period. Total loans: short-term loans + long-term loans.

- *Net Profit*

Net profit is a financial component which is the top goal of all companies (Borodin & Mityushina, 2020; Putra & Muzakir, 2020; Telli, 2018). Therefore, net profit as an output variable in this study to show the efficiency of banking performance. The net profit value is the value from the reduction between gross profit and operating expenses, which can be seen from the financial reports those have been issued by every bank for a certain period (Putra & Muzakir, 2020).

➤ *Independent Variable:*

- *Capital Adequacy Ratio (CAR)*

Capital Adequacy Ratio (CAR) is an essential component in banking to measure a bank's ability to bear risks on bank assets (Abidin et al., 2021; Haryanto, 2018; Nguyen et al., 2021; Sitompul & Nasution, 2019). CAR is often used in similar research to examine its relationship with the level of banking efficiency. CAR is calculated by dividing total capital and risk-weighted assets, then multiplying by 100%.

- *Loan to Deposit Ratio (LDR)*

The Loan Deposit Ratio (LDR) is a ratio that is of great concern for assessing bank liquidity (Abidin et al., 2021; Adeabah et al., 2019; Darwanto, 2019). Researchers make LDR one of the independent variables because LDR has an important role in banking. LDR is the ratio obtained from dividing the number of funds distributed by the bank

to customers by the total funds received by the bank multiplied by 100%.

• *Interest Income*

Interest income is related to the income that the bank earns from interest charged to customers or borrowers (Fukuyama & Tan, 2022; Haralayya & Aithal, 2019; Nguyen et al., 2021). High interest income increases profits and affects profitability, also increases bank efficiency. Meanwhile, the low interest income has an impact on the small profit earned and the decline in the level of bank profitability and efficiency. Interest income is obtained from the accumulation of product cost and profit margins that have been set by banks (Alhassan & Tetteh, 2017; Haralayya & Aithal, 2019; Nguyen et al., 2021).

• *Gross Domestic Product (GDP)*

Gross Domestic Product (GDP) measures the level of national economic development and comprehensively represents all external factors as macroeconomic conditions (Cook & Davíðsdóttir, 2021; Shawtari, 2018; Wei et al., 2020). The development of each industry is closely related to the level of a country's GDP/Gross Domestic Product, including the banking industry. Therefore, researchers use GDP as an independent variable originating from external factors that affect the efficiency of Chinese banking performance. GDP is measured by the total monetary value of all finished goods and services produced within country boundaries at a certain time (Shawtari, 2018).

This study uses secondary data, analyzed based on a panel dataset that includes six commercial banks owned by the Chinese state government. Furthermore, the variables used for model analysis are original data collected from financial reports for the 2016-2021 period accessed from the website of each bank. In addition, GDP data is obtained from the official website of the National Bureau of Statistics of China.

IV. ANALYSIS METHOD

This study uses the Data Envelopment Analysis (DEA) approach, which is a non-parametric technique developed to evaluate the relative efficiency of a Decision Making Unit (DMU) with input and output level analysis (Adeabah et al., 2019; Nguyen et al., 2021). DMU is a business unit whose level of efficiency is analyzed. DMU is said to be efficient if the value is equal to 1 and relatively inefficient if the value is less than 1 (Nguyen et al., 2021). The measurement model using DEA has several advantages, namely, it can be used for the analysis of each DMU with many inputs or outputs, the relationship between input and output variables does not have to be known, and can be used to identify inputs and outputs with different units. The following is a general equation for calculating Data Envelopment Analysis (DEA) according to (Nguyen et al., 2021):

$$h_s = \frac{\sum_{i=1}^m u_{is} y_{is}}{\sum_{j=1}^n v_{js} x_{js}} \quad (1)$$

➤ *Information:*

- h_s = DMU efficiency
- u_{is} = weight of output i produced
- y_{is} = weight of input i produced
- v_{js} = weight of input j
- x_{js} = number of input j given by DMU

The above formula gives an infinite situation which can cause problems with the calculation results. Therefore, constraint equations are formed to facilitate the analysis process using computational techniques that are constantly evolving. The following is the equation of the constraint function:

$$\frac{\sum_{i=1}^m u_{is} y_{is}}{\sum_{j=1}^n v_{js} x_{js}} \leq 1 ; r = 1,2,\dots, N \text{ and } u_i, X_j \geq 0 \quad (2)$$

➤ *Information:*

N denotes the number of DMU samples.

The bank efficiency value obtained from the DEA analysis results is used as the dependent variable, and then identified with the independent variables through the Tobit regression test. Tobit analysis was selected because the dependent variable in this study is censored, while the independent variables are uncensored or free. The dependent variable referred to earlier is that the dependent variable has an upper and lower limit, and in this study, the efficiency value limits are 0 to 1 (Milenković et al., 2022). The Tobit regression model tested using the STATA v15 application. The following is the equation to analyze the factors that affect banking efficiency:

$$Y_{it} = \alpha + \beta_1 CAR_{1it} + \beta_2 LDR_{2it} + \beta_3 IINC_{3it} + \beta_4 GDP_{4it} + \varepsilon_{it} \quad (3)$$

➤ *Information:*

- i : Individual Unit (Banking)
- t : Time
- Y : Bank performance efficiency
- α : Constant
- β_{1-4} : Coefficient
- CAR : Capital Adequacy Ratio
- LDR : Loan to Deposit Ratio
- $IINC$: Interest Income
- GDP : Gross Domestic Bruto
- ε : Error

V. RESULTS AND DISCUSSION

Testing the banking efficiency level is calculated using the non-parametric Data Envelopment Analysis (DEA) method through the DEAP v21 application. The data used are grouped into input variables and output variables. Input variables consist of employment expenses, total assets, and operating expenses. Furthermore, the output variables consist of total loans and net profit. The test results using the DEA method produce an efficiency level indicated by a score of 0-1. The highest efficiency score resulting from the analysis is 1, which describes the best or the optimal ability of a bank to manage its resources. Meanwhile, when the score is away from the value of 1, it can be interpreted that the bank is inefficient in managing its resources (Boďa & Zimková, 2021; Van den End, 2016).

The results showed that the efficiency level of state-owned commercial banks in China continued to experience consistently high operational efficiency for six consecutive years, marked by an average value of the resulting efficiency level in the range of 0.8-1 or in the high category. Furthermore, this high category infers that all Chinese government commercial banks are able to strategically reduce input variables in their operational or banking activities and maximize their performance in terms of cash flow related to profits and distribution of loans or credit. Furthermore, this study also presents the level of homogeneity of data characteristics related to the performance of commercial banks in China, as presented in Table 3.

Table 3 DEA Calculation Results

	ABOC	BOCH	BCOM	CHCB	ICOB	PSBC
2016	0,864	0,958	1	1	1	1
2017	0,855	0,948	1	1	1	0,772
2018	0,870	0,925	0,977	1	0,955	0,831
2019	0,794	0,944	1	1	0,991	0,870
2020	0,895	0,984	1	1	0,986	0,870
2021	0,944	0,988	1	1	1	0,874

The table above is the result of DEA calculations at six Chinese commercial banks for six periods, namely from 2016 to 2021. Chinese commercial banks consisting of six banks demonstrated different efficiency levels from 2016 to 2021. The Agricultural Bank of China achieved fluctuating efficiency levels, namely (0.864 -- 2016), (0.855 -- 2017), (0.875 -- 2018, and (0.794 -- 2019) is the lowest score for six years of experience. In addition, the last two years (0.895 -- year 2020) and (0.944 -- 2021) are the highest achievements of the Agricultural Bank of China during the six observation periods. Similar to the Agricultural Bank of China, the Bank of China also never achieved an efficiency score of 1 (100%) during the six years of observation. Bank of China got a score of 0.958 in 2016, 0.948 in 2017, and a score of 0.925 in 2018 was the lowest score during the six observation periods. Furthermore, the efficiency score for 2019 was 0.944, and in 2020 and 2021 of 0.984 and 0.988.

observation periods, 0.831 in 2018, 0.870 achieved in 2019, and the efficiency values for 2020 and 2021 are 0.870 and 0.874 respectively. Furthermore, the efficiency score of the DEA calculation results is illustrated in the graph below.

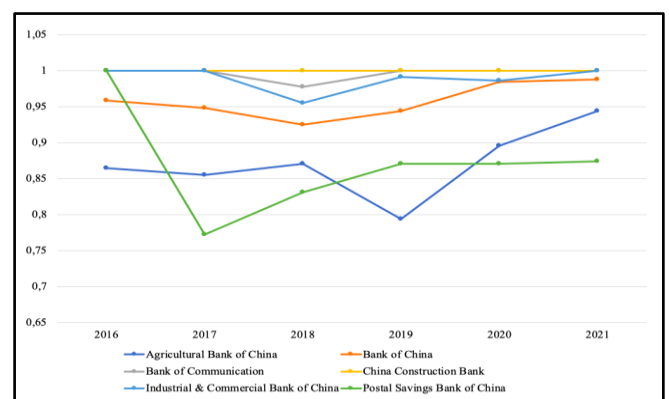


Fig 1 Graph of Efficiency Score

Unlike the two previous banks, the Bank of Communication achieved a score of 1 (100%) for five years of observation, namely 2016, 2017, 2019, 2020 and 2021. Meanwhile, in 2018 the Bank of Communication experienced a decrease in its efficiency score to 0.977. Furthermore, the Industrial & Commercial Bank of China is the only bank that has a perfect efficiency score of 1 (100%) for six consecutive years. Finally, Postal Savings Bank of China achieved a score of 1 (100%) only in 2016, and the subsequent efficiency score was always below 100%, namely 0.772 in 2017 was the lowest score during the six

The test results show that each bank has a different trend during the six periods studied, some banks have fluctuating efficiency scores, and some are stable enough. In the graph, China Construction Bank is the most efficient bank because always 100% during six years of observation. Furthermore, the second most efficient bank is the Bank of Communication, followed by the Industrial & Commercial Bank of China, the Bank of China, the Agricultural bank of China, and the Postal Savings Bank of China. Yusuf &

Muhajir (2020) explained that the level of banking efficiency is divided into four categories, namely high, medium, low, and inefficient efficiency.

Six commercial banks in China have high-efficiency scores, as evidenced by 34 observations of banks with efficiency scores in the range of 0.81–1.00. Furthermore, 4.5% has a middle efficiency score seen from 2 bank observations with scores in the range of 0.60–0.80. This value interprets that the six Chinese commercial banks analyzed are banks that are efficient and optimal in managing their resources. The decrease in the efficiency level in specific periods in several banks is affected by different variables in each bank caused by banking input or output variables. Differences in efficiency values also

caused by the ability of banks to differ from one another when managing the resources they have. In addition, differences in strategic management and target markets between each bank specifically have different portions and doses. However, overall, all samples have a performance efficiency level that is not much different from the average to high rating. In addition, this stability also indirectly is the role of the government which in the majority acts as a stakeholder and simultaneously as a supremacy controller, maintaining and overseeing the operations and performance of every government-owned business entity or which in this study is a commercial bank.

A. Tobit Test Results

Table 4 Tobit Test Results

Variable	Coef.	Z	Sig.	Information
CAR	-0,0015	-0,09	0,927	Not significant
LDR	0,0037	2,54	0,011	Significant
LN_IINC	0,0035	0,09	0,926	Not significant
LN_GDP	-0,064	-0,64	0,522	Not significant
(Constant)	3,6082			
Prob > chi2	0,0300			
Panel Variable: code (strongly balanced) Time Variable: period, 2016 to 2021 Delta: 1 year				

➤ Based on the results of Tobit regression analysis (stage 2), the resulting equation is as follows.

$$DEA_Z = 3,6082 - 0,0015(CAR) + 0,0037(LDR) + 0,0035(IINC) - 0,064(GDP) + \epsilon \quad (4)$$

Furthermore, the following is an inference from the results of the Tobit regression analysis in this study.

- Constant value (a): 3.6082 can be interpreted that if the variables CAR, LDR, IINC, and GDP are constant or not included in the study, the DEA_Z variable can still increase by 3.6082.
- The CAR regression coefficient of -0.0015 indicates that if the CAR ratio continues to increase above the optimum (non-optimal) limit, banking performance efficiency (DEA_Z) can continue to decrease (tend to worsen) by 0.0015 points assuming the other independent variables are constant.
- The LDR regression coefficient of 0.0037 reflects that if the LDR ratio continues to increase (taking into

account the equilibrium level between deposits and distribution of loans or outstanding credit), the resulting bank's performance efficiency output can continue to increase by 0.0037 points, assuming other independent variables are constant.

- The IINC regression coefficient of 0.0052 represents that if interest income continues to increase as a substantial profit segmentation, the resulting bank performance efficiency can continue to escalate by 0.0035 points assuming other independent variables are constant.
- The GDP regression coefficient of -0.064 implies that if GDP continues to increase (taking into account commercial banks as measurable contributors), the efficiency of the resulting bank's performance may not necessarily continue to escalate by 0.064 points because GDP has a significant increment, which can gradually help improve performance efficiency banking. Especially from the output side (total distributed loans and net profit) generated by the bank, of course, assuming the other independent variables are constant. In short, GDP contributes indirectly to the formation of

performance related to bank efficiency because this measure is a measure of the country's macro economy and has a different impact on each industry including commercial banks themselves as a banking sub-industry.

B. CAR Ratio to Efficiency Level

Based on the results of the Tobit regression test, the CAR ratio has a regression coefficient of -0.0015 with a significance level (p-value) of 0.927. Therefore, the first hypothesis (CAR) was confirmed to have no significant effect on the resulting level of banking efficiency (rejected). This relationship can be caused by the size of the CAR ratio, which has its equilibrium point. Furthermore, a CAR debilitated reflects the level of risk of managing funds in both the Tier-1 and Tier-2 categories, tend to be assigned a high-risk predicate because of the amount of capital required to protect depositors. In addition, a CAR that is too high reflects a suboptimal fund management strategy, especially concerning loan distribution activities.

The relationship between the CAR ratio and the efficiency of bank performance has no effect because the CAR ratio has its minimum point. After all, CAR focuses on the size of capital adequacy with controllable risk and not the size of a bank's capital. Meanwhile, bank performance efficiency relies on input and output related to bank operations as a whole both in terms of cost management, Cost of Fund (CoF) management strategies, and in terms of margin safety which can be controlled by the CFO or CEO of a bank, which consequently maximizes output or the resulting performance. Also, based on previous literature studies, the results of this study support research from (Havidz & Setiawan, 2015; Latifah et al., 2012; Sudyatno, 2013; Supriyono & Herdhayinta, 2019) explains that the CAR variable does not affect bank efficiency.

C. LDR Ratio to Efficiency Level

Based on the results of the Tobit regression test, the LDR ratio has a regression coefficient of 0.0037 with a significance level (p-value) of 0.011. Therefore, the second hypothesis states that the LDR ratio affects the efficiency level of bank performance is accepted. The results show that a high LDR ratio results in a more optimum level of banking efficiency because this measure reflects depositor funds that are optimally managed by the bank and distributed through loan activities to prospective borrowers. Furthermore, LDR is the ratio of loans extended to third parties, so the higher the LDR ratio, the profit or income received by the bank continues to grow, which in turn increases the bank's performance to be more efficient by maximizing output in comparison with the input that must be issued.

The effect of the LDR ratio on the efficiency of a bank's performance is because basically, LDR is one of the keys to the success of a bank. The success referred to is because the LDR represents the maximization of funds owned by depositors to be further managed by the banking sector and through various management strategies and segmentation of credit distribution deployed. Furthermore,

behind the high distributions of credit by the bank, there is the management of CoF and safety margins which are strategically able to be managed optimally by the top management such as at the CFO and CEO level. In addition, this study supports the results of research conducted by (Anwar, 2019; Buchory, 2015; Karamoy & Tulung, 2019; Kristianti & Yovin, 2016; Rupeika-Apoga et al., 2018), whose research results show that the LDR ratio affects the efficiency of the performance of the bank formed. Thus, an LDR with a high size is capable of gradually producing a bank's performance efficiency at the optimum point.

D. Interest Income on the Level of Efficiency

Based on the results of the Tobit regression test, the interest income ratio has a regression coefficient of 0.003 with a significance level (p-value) of 0.926. Therefore, the third hypothesis states that there is no significant effect between interest income and the resulting level of banking efficiency. Therefore, the third hypothesis states that interest income affects the efficiency level of bank performance is rejected. Therefore, the results of this study state that the measure of interest income is not the main measure of the level of efficiency produced by a bank, but rather from the strategic input or costs incurred to generate profit from both interest income and non-interest income segmentation.

Furthermore, interest income does not affect banking efficiency because there are two different contexts that top-middle managers must continue to manage strategically and dynamically, namely the costs incurred and the income generated to produce a level of performance efficiency at an optimum point. On a more detailed side, interest income is an income item whose nature still has to be deducted by the cost components incurred by the CFO and other interrelated costs such as CoF and administration expenses so that the measure of the level of efficiency produced is not directly based on the amount of interest income generated. Then, according to previous literature, Abidin et al. (2021); Boussemart et al. (2019); Doan et al. (2018); Syadullah (2018) make similar results and supports the results of this study. In short, the interest income variable has an indirect causal relationship to the resulting level of performance efficiency.

E. GDP to the Level of Efficiency

Based on the results of the Tobit regression test, the GDP ratio has a regression coefficient of -0.064 with a significance level (p-value) of 0.522. Therefore, the fourth hypothesis states that there is no influence between the GDP ratio and the resulting level of banking efficiency. Furthermore, GDP is a measure of the highs and lows of a country's economic activity, so GDP has a causal relationship that incrementally/indirectly/gradually affects the efficiency level of the resulting bank's performance.

Furthermore, GDP represents consumption behavior in the social sphere, so that banks are part of the needs of society as financial intermediaries to depositor-debtor relations, are affected by GDP movements periodically even with the assumption of complex value-chain cycles so GDP can contribute to developing bank's performance. In

addition, there are many variations of omitted elements that are ignored in the relationship between GDP and banking efficiency, such as the level of public trust in banks, government policies on GDP, and the behavior of various companies or banks. Also, in previous literature, Al-Harbi (2019); Hosen & Muhari (2019); Katircioglu et al. (2020); Lv & Li (2021) showed similar results, supporting the results of this study. Thus, this study concludes that GDP has an indirect relationship to the level of banking efficiency. In addition, even though of the four hypotheses developed only one is statistically accepted, these four variables (CAR, LDR, IINC, and GDP) have a significant simultaneous effect on the efficiency of the resulting bank performance, it is evident that the probability values generated are greater in comparison with a chi-squared value (Prob > chi2: 0.03) or equivalent to a p-value (0.03) at the *p<0.05 level.

VI. CONCLUSION

➤ *Based on the results of the research and discussion previously described regarding the analysis of the level of efficiency of commercial banks in China for the 2016-2021 period, the conclusions drawn from this research are as follows:*

- Throughout the study period, all government-owned commercial banks in China performed efficiently (stage-1) with a moderate (0.60-0.80) to high (0.81-1.00) efficiency category with a relatively high sample percentage. achieving the "high" efficiency category was 94.45% of the entire sample. Meanwhile, 5.55% of the other samples are in the "moderate" efficiency category.
- The results of the study (stage 2) show that state-owned commercial banking companies in China tend to perform efficiently throughout the study period. The sample companies maintain a range of their CAR and LDR ratios, reflecting the financial health of the banking system. In addition, government support and China's economic stability indirectly encourage people's behavior in the context of the use of banking services and their relation to economic activity which in turn has an impact on the efficiency of the performance of commercial banks in China as a whole.
- Based on the constructed hypothesis construct, of the four hypotheses, only one hypothesis is statistically accepted. However, simultaneously, CAR, LDR, main bank revenue (IINC), and GDP contribute to the formation of the efficiency level of commercial banking in China. Thus, in terms of bank performance efficiency cycles, a measure of bank performance efficiency is the main input-output for the formation of sustainable bank performance optimization.
- The results of this study also corroborate previous research, Zhou et al. (2019), Fukuyama & Tan (2022), and Antunes et al. (2021), which state that commercial banks, especially those owned by the Chinese government, continue to achieve a level of efficiency because they can manage their operations strategically and dynamically. Furthermore, this study also

strengthens the results of Zhou et al. (2019), through the support of the statement that Chinese government-owned commercial banks can continue to perform efficiently even amid an uncertain situation, it is proven that in 2020-2021 the research sample showed that the level of efficiency was consistently in the "high" category amid the conditions of the Covid-19 pandemic.

➤ *There are several limitations that arise from the findings that have been produced in this study as follows.*

- The assumption of a positive flow in the DEA analysis methodology concept is unable to comprehensively answer the level of bank efficiency (causing an outcome bias) if the research data has a volatile data flow and the input-output embedded in the DEA analysis must have a direct effect and go back and forth between one other input and output variables.
- This research is also limited to the analysis of the performance of commercial banks, especially limited to the scope of Chinese state-owned or state-owned commercial banks, so the resulting external validity tends to be lower because the area of the research study is specific to certain subsamples.
- The scope of analysis in this study is also limited to the banking industry, notably commercial business lines, so The discussion and inference of research results are limited. In addition, the consequences of the first limitation can lead to misleading research inferences or what is commonly known as reporting bias.
- The methodological design built in this study is limited to empirical methodology, notably through the use of archival data, so the information obtained has limited inference because it depends on the flow conditions of the data obtained.

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