Research on Commercial Bank's Operating Efficiency

Lanxin Zhang(✉)

Ohio State University, Columbus, USA
heather_zlx@163.com

Abstract. In this paper, we identify the specific factors influencing how well commercial banks operate by measuring their operating performance indicators, combining them with their operating input indicators, using data envelopment analysis technology, and investigating the effectiveness of their input. Solow residual value method and regression analysis to examine the causal relationship between various factors and their operating performance. Using data from 15 Chinese commercial banks from 2008 to 2021 and analyzing the factors affecting the operational efficiency of banking adequacy commercial, such banks loan ratio, total deposit, earnings per share, capital adequacy ratio, debt-to-assets ratio, return on assets, per capital income, and M2, we find that decreasing the bad loan ratio and improving return on assets and M2 can promote the operational efficiency of commercial banks. This conclusion provides a theoretical scientific foundation for enhancing the effectiveness of Chinese commercial bank.

Keywords: commercial banks · operating efficiency · banks loan ratio · total deposit · earnings per share · capital adequacy ratio · debt-to-assets ratio · return on assets · per capital income

1 Introduction

The property rights that Coase (1960) proposed to have a significant effect on improving the efficiency of the economic system [2]. Under economic conditions, granting property rights can solve negative externalities, thereby improving economic operating efficiency. Leibenstein (1966) first proposed the "x efficiency theory", which states that various unknowns in addition to the traditional enterprise inputs of the labor force, money, land, and entrepreneurial aptitude also have a role in determining the output of businesses [4]. The X factor is the unknowable and the efficiency brought on by these unidentified factors is the x-efficiency. Commercial banks have also been examined from the standpoint of efficiency in numerous theoretical studies.

Operational efficiency mainly uses to assess how effectively profits are generated with operational expenses. The operating efficiency of a bank represents its ability to create income relative to its non-interest operational expenses [7]. An important topic in efficiency research is how to quantitatively evaluate efficiency, which involves the measurement of efficiency.

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Farrell's efficiency is a research model of enterprise efficiency proposed by British economist M.J. Farrell in 1957 based on the multi-input characteristics of enterprise production [3]. He divides enterprise efficiency into three aspects: technical efficiency, allocation efficiency, and comprehensive efficiency. Technical efficiency refers to the ratio of the input factors under the optimal production conditions to the input factors required under the current production technology conditions under the condition of a given output [6]. Allocation efficiency refers to the gap between the current input ratio of various factors and the optimal factor input ratio under the current factor relative price ratio. Comprehensive efficiency refers to a comprehensive index that can reflect both technical efficiency and allocation efficiency.

The data envelopment method (DEA) was proposed by Charnes, Cooper, and Rbodes (1978) based on Farrell (1957) [1]. The DEA method uses the idea of linear programming to project all the statistical data of the input and output of the decision-making unit into the geometric space without considering the influence of specific production functions and other random factors and without estimating the relevant coefficients and parameters [10]. Find out the envelope surface of the "input-output" combination relationship of the efficiency frontier determined by the highest output and the lowest input and evaluate the relative efficiency of the decision-making unit by comparing the degree of deviation between the decision-making unit and the DEA frontier [8]. Sherman and Gold (1985) first used the DEA method to measure the efficiency of commercial banks, and then many scholars widely used the DEA method to evaluate the efficiency of financial institutions [9].

The advantages of applying the DEA method to bank efficiency evaluation are that it can deal with the actual situation of multiple inputs and multiple outputs in real-life management activities like banks: there is no need to construct the frontier of a specific production function: the input and multiple outputs of various resources of the bank The output of the product does not need to be standardized, which avoids the inconsistency of data processing [5]. According to whether the returns to scale are variable, the DEA method can be divided into two models: the constant returns to scale model and the variable returns to scale model; according to the different processing methods for the complete efficiency in the efficiency measurement, the DEA method is further developed into a super-efficiency model.

2 Data Sources and Study Design

2.1 Data

To define the variable, we combine the data availability, select the data of 15 Chinese commercial banks, and the period chosen from 2008 to 2021. Specifically, these data comprise variables from 15 Chinese commercial banks such as bank operating efficiency, bad loan ratio, total deposit, earnings per share, capital adequacy ratio, debt-to-assets ratio, return on assets, per capita income, and M2. These data are obtained from the Wind database, which is most frequently used to collect research data and recognized by academics. The academic community has approved of this database, and the information included therein possesses some authority. Consequently, it is a suitable data source for this paper's analysis and research.

Table 1. Variable description [Self-graphed]

Variable type	Variable symbol	Variable name	Variable meaning
Explained variable	EF	Bank Operating Efficiency	Derived from Eq. (3)
Core explanatory variable	Risk	Bad Loan Ratio	The ratio of bad debt to total credit sales
Control variables	TD	Total Deposit	Logarithm of deposit amount
	EPS	Earnings Per Share	Earnings for each outstanding share of common stock
	CAR	Capital Adequacy Ratio	The ratio of total capital to risk-weighted assets.
	DAR	Debt-to-Assets Ratio	The ratio of total debt to total asset
	ROA	Return On Assets	The ratio of net profit to total asset
	PCI	Per Capita Income	The average income per capital
	M2	M2	Logarithm of money supply

2.2 Study Design

According to the above research basis, we regard bank operating efficiency as the explained variable, bad loan ratio as the core explanatory variable, and take the total deposit, earnings per share, capital adequacy ratio, debt-to-assets ratio, return on assets, per capita income, and M2 as control variables. We use those definitions to construct a panel regression model and carry out clear symbol definitions and variable interpretations. The specific definitions and explanations are shown in Table 1.

Referring to Solow residual, this paper uses data to calculate bank operating efficiency. To be specific, this paper uses classic Cobb-Douglas production function as follows:

$$Y_{it} = A_{it} L_{it}^{\alpha} K_{it}^{\beta} \tag{1}$$

In which Y denotes revenue or deposit of banks, A denotes technology level of banks, L denotes employees of banks, and K denotes capital level of banks. Conduct logarithm for both sides of the equation, and consider the random disturbance, this paper can get the following regression equation to derive α and β,

$$\ln Y_{it} = \ln A_{it} + \alpha \ln L_{it} + \beta \ln K_{it} + u_{it} \tag{2}$$

Table 2. Descriptive statistics [Self-graphed]

	Efficiency 1	Efficiency 2
Risk	−0.252*** (−7.99)	−0.194*** (−5.11)
TD		0.0214 (0.29)
EPS		−0.0307 (−0.91)
CAR		0.00424 (0.40)
DAR		0.0185 (1.05)
ROA		0.522*** (6.02)
M2		0 (.)
_cons	0.304*** (7.05)	−2.589 (−1.11)
N	512	476
Bank dummy	Yes	Yes
Year dummy	Yes	Yes

Note: t statistics in parentheses, *, **, *** indicate significant at $p < 0.05$, $p < 0.01$, $p < 0.001$

Then this paper can use Solow residual method to derive bank operating efficiency by using the following expression:

$$EF_{it} = \frac{\Delta Y_{it}}{Y_{it}} - \alpha \frac{\Delta L_{it}}{L_{it}} - \beta \frac{\Delta K_{it}}{K_{it}} \tag{3}$$

Based on Solow residual derived from the above expression, we construct the following panel regression model:

$$EF_{it} = \beta_0 + \beta_1 Risk_{it} + \sum v_j X_{jit} + m_i + \lambda_t + u_{it} \tag{4}$$

EF represents bank operating efficiency, Risk represents the bad loan ratio, X represents control variables, including the total deposit, earnings per share, capital adequacy ratio, debt-to-assets ratio, return on assets, per capita income and M2. β_1 represents coefficient of core explanatory variables and v represents the coefficient of the control variable. m represents the bank individual effect, λ represents the time effect, and uit represents the random disturbance. The results are shown in Table 2.

According to Table 3, bad loan ratio, return on assets, and M2 all have a significant impact on affecting operational efficiency of commercial banks, and bad loan ratio has a negative impact. The bad loan ratio increases by 1 unit, and the efficiency will decrease by 0.1936 units. Return on assets and M2 have a positive impact on efficiency which means have significant roles in increasing bank operating efficiency. The higher the ROA and M2, the higher the efficiency, but a total deposit, earnings per share, capital adequacy ratio, and debt-to-assets ratio don't have much impact on the operational efficiency of commercial banks.

3 Model Selection

3.1 Heterogeneity

Heterogeneity refers to the investigation of whether the explanatory effect of the explanatory variable on the variable being explained exhibits a distinct pattern in the subsample than in the complete sample and whether it significantly varies across the subsamples. This paper focuses on a thorough examination of the impact of banks with low or high bad loan ratios because we find that bad loan ratio plays a significant role in affecting the operational efficiency of commercial banks.

First, Based on the Bad Loan Ratio
According to the bad loan ratio, this paper classifies commercial banks into two categories: banks with low bad loan ratios and banks with high bad loan ratios. Banks with low bad loan ratios include these banks that have a bad loan ratio of less than 1.46. Banks with high bad loan ratios include these banks that have a bad loan ratio of 1.46 or higher. The results are shown in Table 3.

According to Table 4, as far as banks with a low bad loan ratio are concerned, due to the low level of bad loan ratio, the operational efficiency of these banks is higher than other banks even though their return on assets and M2 is less than others. In terms of banks with high bad loan ratios, due to the high level of bad loan ratio, the operational efficiency of these banks is less than other banks even though their return on assets and M2 are higher than another.

Second, Based on the Return on Assets
According to the return on assets, this paper classifies commercial banks into two categories: banks with low returns on assets and banks with a high return on assets. Banks with low returns on assets include these banks that have a return on assets of less than 1.017. Banks with a high return on assets include these banks that have a return on assets of 1.017 or higher. The results are shown in the Table 4.

According to Table 5, as far as banks with low return on assets are concerned, due to the high level of bad loan ratio, the operational efficiency of these banks is less than other banks. In terms of banks with a high return on assets, due to the low level of bad loan ratio, the operational efficiency of these banks is higher than other banks.

3.2 Robustness Analysis

When a model's significant explanatory variables have a generally constant trend and do not dramatically alter because of perturbations, the model is considered robust. There

Table 3. Heterogeneity controls table of bad loan ratio [Self-graphed]

	Banks with low bad loan ratio	Banks with high bad loan ratio
Risk	−0.0423 (−1.10)	−0.456*** (−4.45)
TD	0.0262 (0.54)	−0.800* (−1.99)
EPS	−0.00699 (−0.37)	−0.0622 (−0.33)
CAR	0.00180 (0.24)	−0.0267 (−0.89)
DAR	0.00445 (0.39)	0.0455 (0.86)
ROA	0.223*** (3.42)	1.006*** (4.16)
M2	0.127 (1.70)	0.930* (2.34)
_cons	−3.109* (−2.26)	4.680 (0.52)
N	295	174

Note: t statistics in parentheses, *, **, *** indicate significant at $p < 0.05$, $p < 0.01$, $p < 0.001$

are several techniques to evaluate the robustness of the model, one of which is to alter the sample size to see whether the main explanatory variables have any discernible influence on the explanatory variables. The model can be regarded as a robust model if the core explanatory variables' coefficient or effect on the explanatory variables is negligible. A different approach is to choose similar variables from the core explanatory variables for regression and then determine whether the core explanatory variables have a significant impact on the explanatory variables. The model can be regarded as robust if the coefficients or effects of the primary explanatory variables on the secondary explanatory variables do not change considerably. In this study, we opt for the first scheme technique, which involves limiting the sample size. First, the range of 15 Chinese commercial banks is chosen to remain constant, and 10 years' worth of data from 2011 to 2021 are taken for regression analysis to check the stability of the underlying model. According to this method, after the empirical regression, the robustness regression results are shown in the Table 5.

According to the regression results in Table 6, before the robustness analysis, the coefficient of the bad loan ratio imports on the operational efficiency of commercial banks is- 0.194, which is significant at a 2% level of significance. When the robustness analysis is conducted, the coefficient of the effect of bad loan ratio import on the operational efficiency of commercial banks is -0.246, which is significant at a 2% level of significance. Comparing these two coefficients, we can see that the impact of bad loan ratio import on the operational efficiency of commercial banks changes significantly.

Table 4. Heterogeneity controls table of returns on assets [Self-graphed]

	Banks with low return on assets	Banks with high return on assets
Risk	−0.183** (−3.27)	0.00209 (0.06)
TD	−0.0775 (−0.57)	0.0562 (0.94)
EPS	−0.0897 (−1.11)	−0.0149 (−0.57)
CAR	0.00820 (0.52)	−0.0136 (−1.67)
DAR	0.0360 (1.38)	−0.0150 (−1.00)
ROA	0.910*** (5.74)	0.210* (2.57)
M2	0.286 (1.60)	0.112 (1.24)
_cons	−5.827 (−1.68)	−1.796 (−0.90)
N	314	162

Note: t statistics in parentheses, *, **, *** indicate significant at $p < 0.05$, $p < 0.01$, $p < 0.001$

3.3 Endogeneity Analysis

Endogeneity refers to situations in which a predictor in a linear regression model is correlated to the error term. We can know that the core explanatory variables bad loan ratio and the rest of the control variables have some explanatory effect on the operational efficiency of commercial banks, on the contrary, the operational efficiency of commercial banks will also have an impact on bad loan ratio and the rest of the control variables, thus there may be an endogeneity problem. According to this idea, the regression results of this paper after dealing with the endogeneity problem are shown in the Table 6.

Two-Stage Instrumental Variable Method

In this paper, we have chosen t−1 of the bad loan ratio as the instrumental variable, because t−1 of the bad loan ratio is substantially connected with bad loan ratio t, which can affect bad loan ratio t, but is not correlated with the disturbance term. Therefore, if the instrumental variable t−1 of the bad loan ratio can affect the bad loan ratio, it can only affect the operational efficiency of commercial banks t by first affecting the operational efficiency of commercial banks t−1, and the operational efficiency of commercial banks t will then affect the bad loan ratio.

Specifically, the two-stage instrumental variables were constructed as follows.

Phase 1

$$Risk_{it} = \beta_0 + \beta_1 Risk_{it-1} + \sum v_j X_{jit} + m_i + \lambda_t + u_{it}$$

Table 5. Robustness test table [Self-graphed]

	Individual time double fixed effects model	2011 and up
Risk	−0.194*** (−5.11)	−0.246*** (−5.92)
TD	0.0214 (0.29)	0.00193 (0.02)
EPS	−0.0307 (−0.91)	−0.0508 (−1.40)
CAR	0.00424 (0.40)	0.00288 (0.26)
DAR	0.0185 (1.05)	−0.00373 (−0.20)
ROA	0.522*** (6.02)	0.523*** (5.89)
M2	0 (.)	0.256* (2.08)
_cons	−2.589 (−1.11)	−3.510 (−1.48)
N	476	446
Bank dummy	Yes	Yes
Year dummy	Yes	Yes

Note: t statistics in parentheses, *, **, *** indicate significant at $p < 0.05$, $p < 0.01$, $p < 0.001$

Phase 2
$EF_{it} = \beta_0 + \beta_1 Risk_{it} + \sum v_j X_{jit} + m_i + \lambda_t + u_{it}$

The basis on this, the paper goes on to conduct empirical regressions to determine the regression outcomes of the endogeneity analysis, which are displayed in Table 6 of the two-stage instrumental variational approach to endogeneity testing.

According to the results in Table 7, before the two-stage instrumental variable method is applied, bad loan ratio import on the operational efficiency of commercial banks is significant, and the specific influence coefficient is −1.002. After the two-stage instrumental variable method is applied, bad loan ratio import on the operational efficiency of commercial banks is still significant, and the specific regression coefficient is −0.253, which also confirms that bad loan ratio has a serious impact on the operational efficiency of commercial.

Table 6. Two-stage instrumental variable method endogeneity test table [Self-graphed]

	Phase 1 Risk	Phase 2 EF
Risk (−1)	−1.002*** (−3.89)	
Risk		−0.253*** (−5.78)
TD	−0.0784 (−0.69)	0.0306 (0.38)
EPS	−0.0472 (−0.95)	−0.0636 (−1.85)
CAR	−0.0349 (−1.78)	−0.00348 (−0.30)
DAR	−0.108* (−2.23)	−0.00929 (−0.47)
ROA	−0.268 (−0.94)	0.616*** (6.14)
M2	0.101 (0.62)	0.140 (1.21)
_cons	12.76 (1.94)	−2.082 (−0.87)
N	475	432

Note: t statistics in parentheses, *, **, *** indicate significant at $p < 0.05$, $p < 0.01$, $p < 0.001$

4 Research Conclusions

This paper selects relevant data from 15 Chinese commercial banks from 2008 to 2021 to analyze the specific factors influencing how well commercial banks operate, since the operational efficiency of commercial banks is one of the key factors to improve China's economic development. The conclusions of the analysis are as follows: First, bad loan ratio, return on assets, and M2 are important in determining bank operational efficiency. Second, a bad loan ratio has a detrimental effect on efficiency which means the operational efficiency of banks will decrease when the bad loan ratio increases. Third, return on assets and M2 have a positive effect on efficiency which means the operational efficiency of banks will increase when the return on assets and M2 increase. Based on the above findings, we can make the following policy recommendations. From the management level, first, commercial banks should decrease the bad loan ratio which means do not borrow from people with low credit. Second, commercial banks should increase the return on assets and M2. From the staff level, they should work hard and handle as much business as possible during working time.

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