A Comprehensive Analysis of the Effects of Capital Regulation and Heterogeneity on Bank Efficiency

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Abstract: This article analyzes the impact of capital regulation on bank efficiency using panel data from 165 commercial banks in China from 2013 to 2019. The results indicate that cost efficiency changes slightly and profit efficiency fluctuates greatly. Under the pressure of capital regulation, the profit efficiency of commercial banks with sufficient capital improves, while profit efficiency of banks with insufficient capital decreases slightly, and the cost efficiency of all commercial banks increases. Based on the heterogeneity analysis of banks, it is found that the cost efficiency and profit efficiency of different types of commercial banks differ significantly in response to capital regulation.

Keywords: Capital regulation; Bank efficiency; Heterogeneity

1. Introduction

The improvement of banking efficiency is of great significance to promote high-quality development of banks. Capital regulation enables commercial banks to control the level of risk-taking, which helps them to operate soundly and thus creates conditions for the improvement of bank efficiency. However, capital regulation, to some extent, influences the business structure of banks, which would not only restrict bank operations but may adversely affect bank efficiency [1]. Therefore, the trade-off between the strength of capital regulation and bank efficiency is of great practical importance. At the same time, the issue of imbalance development of banks remains prominent. Therefore, against the background, does capital regulation have a promoting or inhibiting effect on the efficiency of commercial banks? Does this impact differ for different banks? These are the main questions explored in this article.

Research is controversial as to whether capital regulation improves bank efficiency. Some scholars believe that capital regulation can improve bank efficiency. Capital regulation promotes commercial banks to hold sufficient capital, which helps them operate soundly as well as improves bank efficiency and competitiveness [2,3]. However, some scholars argue that capital regulation is detrimental to bank efficiency [4,5]. Other scholars argue that the relationship between capital and bank efficiency is non-linear [6].

The marginal contributions of this article may be reflected in two aspects. First, this article takes into account the changes in regulatory and adjusts the capital regulatory pressure variable, so that the results are more in line with the regulatory reality. Second, considering the differences in response of different types of banks to capital regulation, profit efficiency and cost efficiency are calculated, and different types of banks are further distinguished from the perspective of bank heterogeneity.

2. Data and methodology

2.1. Data

This study compiled the dataset mainly from Wind Database. The sample contains data from six state-owned commercial bank (SOCBs), twelve joint-stock commercial banks (JSCBs), seventy-seven city commercial banks (CCBs), and seventy rural commercial banks (RCBs) from 2013 to 2019.

2.2. Stochastic frontier specification

Bank efficiency is calculated using the stochastic frontier model and a flexible translog form is specified. The model can be presented as follows:

$$
\begin{aligned}
\ln\left(\frac{E_{it}}{w_{2it}}\right) = {} & \alpha_0 + \alpha_1 \ln Y_{1it} + \alpha_2 \ln Y_{2it} + \beta_1 \ln\left(\frac{w_{1it}}{w_{2it}}\right) + \beta_2 \ln\left(\frac{w_{3it}}{w_{2it}}\right) + \frac{1}{2}\alpha_{11}(\ln Y_{1it})^2 + \frac{1}{2}\alpha_{22}(\ln Y_{2it})^2 \\
& + \frac{1}{2}\alpha_{12}\ln Y_{1it}\ln Y_{2it} + \frac{1}{2}\beta_{11}\ln\left(\frac{w_{1it}}{w_{2it}}\right)^2 + \frac{1}{2}\beta_{22}\ln\left(\frac{w_{3it}}{w_{2it}}\right)^2 + \frac{1}{2}\beta_{12}\ln\left(\frac{w_{1it}}{w_{2it}}\right)\ln\left(\frac{w_{3it}}{w_{2it}}\right) \\
& + \gamma_{11}\ln Y_{1it}\ln\left(\frac{w_{1it}}{w_{2it}}\right) + \gamma_{12}\ln Y_{1it}\ln\left(\frac{w_{3it}}{w_{2it}}\right) + \gamma_{21}\ln Y_{2it}\ln\left(\frac{w_{1it}}{w_{2it}}\right) + \gamma_{22}\ln Y_{2it}\ln\left(\frac{w_{3it}}{w_{2it}}\right) \\
& + v_{it} \\
& \pm u_{it}
\end{aligned}
\tag{1}
$$

Where E_{it} refers to total cost (TC) and total profit (TP), respectively, v_{it} is the random component that incorporates error and luck, and u_{it} refers to inefficiency component. The output variables in this study contain total loans (Y1) and revenue (Y2). The prices of fixed assets (W1), capital (W2) and labor (W3) are common in existing studies. W1 is the ratio of revenue expenditure to fixed assets; W2 is defined by the ratio of interest expenses to total deposits; W3 is the ratio of cash paid to and for employees to total assets.

2.3. Bank efficiency model

Two types of bank efficiency are adopted in this study, where CE and PE refer to cost efficiency and profit efficiency, respectively. The model includes two types of control variables (CVS).

$$
PECAR_{it} = \alpha_0 + \alpha_1 CAR_{it} + \alpha_2 Controls_{it} + \mu_i + \varepsilon_{it}
\tag{2}
$$

$$
PE_{it} = \beta_0 + \beta_1 CAPHIGH_{it} + \beta_2 CAPLOW_{it} + \beta_3 Controls_{it} + \mu_i + \varepsilon_{it}
\tag{3}
$$

$$
CECAR_{it} = \alpha_0 + \alpha_1 CAR_{it} + \alpha_2 Controls_{it} + \mu_i + \varepsilon_{it}
\tag{4}
$$

$$
CE_{it} = \beta_0 + \beta_1 CAPHIGH_{it} + \beta_2 CAPLOW_{it} + \beta_3 Controls_{it} + \mu_i + \varepsilon_{it}
\tag{5}
$$

Capital adequacy ratio (CAR) is an important element of capital regulation. Therefore, in the basic regression, this study first measures the relationship between CAR and bank efficiency. More importantly, in order to examine whether banks below and above the capital adequacy regulatory requirements respond differently to capital regulation, this study introduces two dummy variables of capital regulatory pressure: CAPL and CAPH, referring to Jacques and Nigro [7]. Among them, CAPL = 1/CAP – 1/MINCAP when the CAR of commercial banks is lower than the minimum regulatory requirement, otherwise CAPL = 0. If the

CAR of banks is higher than the requirement, then CAPH = 1/MINCAP – 1/CAP, otherwise CAPH = 0. According to related administrative measures, for systemically important banks and others, this study takes MINCAP as 11.5 and 10.5, respectively. In order to control risk and other factors, two types of control variables are specified. The first comprises of bank specific variables, including the size of bank (SIZE), measured by the natural logarithm of total assets and return on assets (ROA), which refers to the proportion of net income in total assets and the ratio of loan-to-deposit (LTD). The second type is macroeconomic variables, in which GDP represents GDP growth rate, and Inf denotes inflation rate.

3. Empirical results

3.1. Bank efficiency

Figure 1 traces the evolution of cost efficiency by types and year. From 2013 to 2019, the changes in cost efficiency of commercial banks were relatively smooth and at high levels, fluctuating around 90%. Among them, the cost efficiency of JSCBs has been ahead of other banks, while SOCBs have been the least efficient. This may be due to the fact that the large scale of SOCBs increases the difficulty of management and causes a waste of resources in the process of information transfer, leading to high costs.
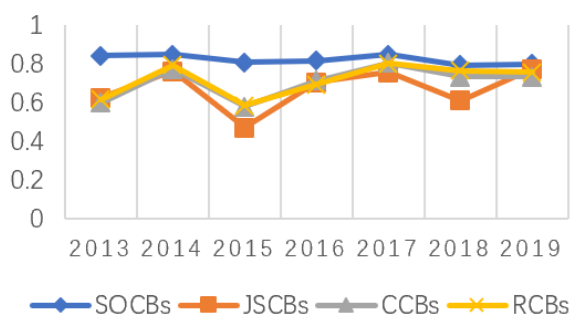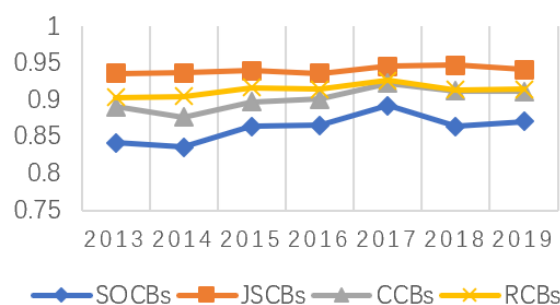

Figure 1. Cost efficiency

Figure 2. Profit efficiency

Figure 2 shows the profit efficiency. SOCBs have higher profit efficiency than others. This is due to the fact that the deep capital advantage and technological base allow SOCBs to constantly look for new profit growth points. The profit efficiency of JSCBs is the most volatile among the four types of banks. The profit efficiency of CCBs and RCBs changes in a similar trend.

In general, the profit efficiency of commercial banks has been fluctuating widely, reaching a low point in 2015 and a peak in 2017. The significant decline in profit efficiency between 2014 and 2015 was predictable since the dramatic shock in 2015 brought a huge impact to banks. In order to curb the spread of risks, The People's Bank of China continued to liberalize the floating cap on deposit rates. The initiative impacted the profitability model of banks dominated by spreads. The highest profit efficiency in 2017 may be related to internet finance. With the integration of technology into banking business, technology spillover, financial innovation, and other positive effects promote the improvement of profit efficiency.

3.2. Basic regression analysis

As the basis of the study, a regression has been performed on the sample. According to Hausman test, the fixed-effect model has been chosen. **Table 1** shows the estimates of bank efficiency and capital regulation.

Table 1. Fixed-effect estimation results

Variables	PECAR	CECAR	PE	CE
CAR	0.007**	0.001*		
	(0.003)	(0.001)		
CAPH			1.247*	0.408*
			(0.663)	(0.216)
CAPL			-0.021***	0.007***
			(0.001)	(0.000)
SIZE	0.258***	0.035***	0.258***	0.034***
	(0.020)	(0.009)	(0.021)	(0.009)
ROA	0.283***	0.057***	0.284***	0.058***
	(0.023)	(0.009)	(0.023)	(0.009)
GDP	0.025***	0.003***	0.025***	0.003***
	(0.002)	(0.001)	(0.002)	(0.001)
INF	0.004	-0.013***	0.003	-0.013***
	(0.007)	(0.002)	(0.007)	(0.002)
LTD	-0.002**	0.002***	-0.002**	0.002***
	(0.001)	(0.000)	(0.001)	(0.000)

Note: * means significant at the 10% level, ** means significant at the 5% level, and *** means significant at the 1% level

The coefficient reveals that the capital adequacy ratio positively impacts bank efficiency. This means that both, cost control and profit generating capacity, improve when bank capital increases and vice versa. Namely, well-capitalized commercial banks may have higher efficiency.

In column 4, the estimated coefficient of regulatory pressure, CAPH is 1.247, and for CAPL, the coefficient is significantly negative. It indicates that the profit efficiency of well-capitalized commercial banks increases under regulatory pressure, while the profit efficiency of undercapitalized banks decreases slightly. This may be due to the fact that well-capitalized commercial banks face less capital pressure; meanwhile, capital regulation strengthens banks' risk control capacity and enhances their profitability. However, undercapitalized banks have common characteristics, such as a weaker internal operating base. Due to the limited market-based replenishment capacity, these banks usually face greater pressure to recapitalize, and regulation increases the operating burden, thus lowering its profit efficiency.

In regard to bank specific variables, it appears that SIZE has a positive impact on bank efficiency, and ROA has a positive relationship with efficiency. For macroeconomic variables, GDP growth provides commercial banks greater opportunities for efficiency improvement, and INF is negatively related to cost efficiency. The faster the rate of inflation grows, the faster the payment of banks would increase, and cost efficiency would decrease as a result.

3.3. Heterogeneity analysis

The results of the heterogeneity test are shown in **Table 2**. There is a positive link between regulation pressure and profit efficiency of SOCBs, showing that capital regulation can effectively improve the profit efficiency of SOCBs. For JSCBs, regulatory pressure can significantly affect the efficiency of undercapitalized commercial banks, making profit efficiency higher and cost efficiency lower.

Table 2. Heterogeneity analysis

Type	SOCBS		JSCBS		CCBS		RCBS	
	PE1	CE1	PE2	CE2	PE3	CE3	PE4	CE4
CAPHIGH	4.869**	1.445	-1.660	0.108	0.345	0.660*	1.844	0.180
	(1.902)	(2.448)	(1.390)	(0.295)	(0.783)	(0.367)	(1.132)	(0.258)
CAPLOW	27.320***	-2.669	1.687***	-0.221***	-5.288***	-1.157	-0.022***	0.006***
	(2.741)	(1.493)	(0.422)	(0.053)	(1.516)	(0.736)	(0.002)	(0.001)
CVS	YES	YES	YES	YES	YES	YES	YES	YES

For CCBs and RCBs, capital regulation pressure makes banks that do not meet minimum capital regulatory requirements less profitable and efficient. This may be due to the fact that those banks have inherent limitations in raising capital and regulatory pressures that force them to keep more non-profitable capital, thus lowering the profit efficiency. In addition, in the case of CCBs, capital regulatory pressure makes well-capitalized commercial banks more cost-efficient, and for RCBs, capital regulation makes undercapitalized commercial banks more cost-efficient. Therefore, there is a need for differentiated regulation as the efficiency of different banks varies considerably in the face of capital regulation.

3.4. Robustness test

Since bank efficiency is consistent with the measurement principle of SFA and the operating conditions of the banks, the efficiency scores measured in this study are robust [8]; only the relationship between capital regulation and bank efficiency is tested for robustness. In the study, the GMM method is used to reduce the endogeneity problem, and the two-step systematic method is constructed to measure it. Due to space limitations, the regression results are not shown.

$$PERT_{it} = \beta_0 + \beta_1 PERT_{it-1} + \beta_2 CAPH_{it} + \beta_3 CAPL_{it} + \beta_4 CVS_{it} + \mu_i + \varepsilon_{it} \tag{6}$$

$$CERT_{it} = \delta_0 + \delta_1 CERT_{it-1} + \delta_2 CAPH_{it} + \delta_3 CAPL_{it} + \delta_4 CVS_{it} + \mu_i + \varepsilon_{it} \tag{7}$$

From the *p* values of AR (2) and Hansen test, it is concluded that all instrumental variables that have been selected are valid. The coefficients of core variables and control variables are generally consistent with **Table 1**. Therefore, the results of the previous test can be considered as robust.

4. Conclusion

This study selects data of banks in China from 2013 to 2019 to measure the impact of capital regulation on bank efficiency and test the heterogeneity. The results show that the ability of banks to control costs is generally higher than the ability to create profits. Second, there is a difference in response of efficiency to capital regulation among different types of commercial banks. Capital regulation significantly makes state-owned commercial banks more profitable and efficient. For city and rural commercial banks with insufficient capital, capital regulation reduces profit efficiency. Therefore, in terms of implication, a differentiated capital regulation strategy is necessary. Banks should strengthen financing channels, technological innovation, improve the evaluation system of bank efficiency, and focus on improving profit efficiency.

Disclosure statement

The author declares that there is no conflict of interest.

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