The effects of shadow banking on bank efficiency: Evidence from China

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Abstract

This study examines the effects of shadow banking on bank efficiency using data on Chinese commercial banks during the period 1998–2012. We focus on two aspects: shadow banking activities inside and outside the commercial banks. Stochastic frontier analysis (SFA) is used to analyse the effects of shadow banking on cost-efficiency. Empirical results indicate that the higher the relative size of shadow banking inside the commercial banks, the higher the bank cost-efficiency, while the higher the relative size of shadow banking outside the commercial banks, the lower the cost-efficiency. This shows that there are gains from shadow banking for the Chinese financial system. It is important for policymakers to realize this but at the same time understand that shadow banking likely implies a trade-off between flexibility for the banking sector and higher risks.

Keywords: Shadow banking; Cost-efficiency; Chinese commercial banks; Stochastic frontier analysis

1. Introduction

With the slowdown in China's economic growth[1], it is more and more important to improve efficiency in every major sector. This study focuses on commercial banks in China. However, a new form of financial activities called "shadow banking" has appeared in recent years and there is an ongoing debate about its pros and cons.[2] In this paper, we analyse the relationship between the size of the shadow banking sector and the cost-efficiency of commercial banks.

The International Monetary Fund (IMF) has defined shadow banking as: "*Financing of banks and nonbank financial institutions through noncore liabilities …, regardless of the entity that carries it out*" (International Monetary Fund, 2014). The concept "noncore liabilities" plays an important role in this definition, which was first introduced by Shin and Shin (2011). When an economic boom emerges, the weak level of traditional funding (core liabilities) is insufficient to satisfy the increasing bank credit due to the rapidly growing credit. In this case, funding from other sources (noncore liabilities) must be exploited to meet the increased credit. Thus, the core liabilities are supplemented by noncore liabilities. IMF captures nontraditional financial activities inside the traditional commercial banking sector, which fills a gap in the estimation of the size of the shadow banking system. Some other authors use a similar definition to that given by the IMF. For example, Lu, Guo, Kao and Fung (2014) underline the composition of the shadow banking system, containing components both inside and outside the commercial banks, on the condition that a large number of shadow banking activities are inside the commercial banking sector in China. Furthermore, shadow banking can be considered to be an integration of different types of risk including liquidity risk, solvency risk and moral hazard (see Lu et al., 2014).

Sun and Chang (2011) looked into the relationship between risk and cost-efficiency of banking in eight Asian countries. Manlagñit (2011) checked the cost-efficiency of Philippine commercial banks, specifically including risk measures. Li, Hsu and Qin (2014) analyzed risks in shadow banking system of China while Hsu, Li and Qin (2013) compared the shadow banking systems and the potential for systemic risk in the European and Chinese markets. Although some authors have studied the relationship between risk and the cost-efficiency of banks, and others have investigated the link between shadow banking and risks, as far as we know, there are no studies on the connection between shadow banking and the cost-efficiency of commercial banks.

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[1] China's economic growth slowed down to 7.4% in 2014, which is the slowest rate in decades.

[2] Paul McCulley introduced "shadow banking" in 2007 at the annual meeting of The Federal Reserve and, since then, this concept has been developed by many other bodies such as the Financial Stability Board (FSB) and the International Monetary Fund (IMF). Shadow banking is considered to play an important role in the global financial crisis of 2008.

Therefore, our paper aims to fill this gap in the literature by analysing the effects of shadow banking on the cost-efficiency of Chinese commercial banks. Using a stochastic frontier approach and data on Chinese commercial banks over the period 1998–2012, we obtain results indicating that there are gains from shadow banking for the Chinese financial system.

The structure of this paper is as follows. The literature on shadow banking, risks, bank regulation and cost-efficiency is reviewed in Section 2, while the research data and methodologies are discussed in section 3. Section 4 presents our empirical results and Section 5 includes a check of the robustness of these results. Section 6 gives a conclusion.

2. Literature review

2.1 The relationship between shadow banking and risk

Shadow banking plays an important role in Chinese financial activities, especially for small and medium-sized enterprises (SMEs). In this context, Lu et al. (2014) discussed many issues associated with shadow banking in China, including the type, size, risk and so on. When addressing the relationship between shadow banking and risk, Lu et al. (2014) highlighted two crucial aspects. Firstly, some banking activities were off-balance sheet and/or not subject to the traditional bank regulations, making these activities quite risky. Secondly, we need to consider the moral hazard of government, when the authorities have to step in to bail out the shadow banking agencies to avoid risks arising from shadow banking activities. Li et al. (2014) focused on the institutions of Chinese shadow banking, using a bank stress test to analyse solvency risk. Their results show that the risks of bankruptcy and liquidity shortages in the banking systems are linked to the huge amount of shadow banking. Hsu et al. (2013) analysed the shadow banking system and systemic risk by comparing the background and current situation of Chinese and European shadow banking, and by applying a technical analysis. They concluded that European shadow banking leads to systemic risk while Chinese shadow banking does not, due to the different development status of these shadow banking systems.

Bengtsson, E. (2013) studied the mechanism of the interrelation between shadow banking and financial stability, mainly by analyzing the behaviour of European money market funds in the context of the global financial crisis. A number of links remain to be demonstrated between the shadow banking system and financial stability, which provide us with an overall impression of the function of risk. Li, T. (2014) generally explored the definition, scale, structure and regulatory issues of shadow banking in China, stressing that certain off-balance sheet and informal bank lending activities were specific to the Chinese shadow banking system. This highlights the point that, according to the rationale behind this classification, such activities might increase systemic risks. With the increasing scale of shadow banking in China, challenging risks appear to be emerging combined with stricter regulations.

2.2 The connection between risk and efficiency

There are many articles dealing with the relationship between risk and banking efficiency. Sun et al. (2011) explored the influence of risk measures on the cost-efficiency of banks, using examples from eight Asian countries. These authors considered the measure of risk from three aspects, i.e., credit risk, operational risk and market risk, using a heteroscedastic stochastic frontier model to estimate the cost-efficiency of banks based on unbalanced panel data of 178 banks with a total of 738 bank-year observations covering 1998–2008 from eight emerging Asian countries. The results so obtained show that risks have significant effects on both the level and variability of bank efficiency. Manlagñit (2011) analysed the cost-efficiency, determinants and risk of Philippine commercial banks using the data of individual domestic commercial banks over the period

from 1990 to 2006. Consistent with earlier research, this latter author applied stochastic frontier analysis to estimate cost-efficiency and how it is affected by risk. Furthermore, this study covered the changing financial environment, including banking reforms, the financial crisis and bank restructuring.

Using a panel data framework of commercial banks in the European Union (EU-26) from 1995 to 2007, Fiordelisi, Marques-Ibanez and Molyneux (2011) explored the relationship between bank efficiency, capital and risk. Generally speaking, they found that lower bank efficiency was related to higher costs, mainly due to the control of operating expenses on inefficiency. Moreover, the higher costs, or lower efficiency, usually suggested a higher relative risk resulting from credit, operational, market and repetition-related problems. Similar results, showing that risk has a negative correlation with cost-efficiency, were reported by E. Mamatzakis (2015), who studied 11 Central and Eastern European (CEE) banks during the period from 1998 to 2005 using stochastic frontier analysis.

2.3 Studies on bank regulation and bank efficiency

There are also many studies relating to the relationship between banking regulations and banking efficiency. Using data of commercial banks in 74 countries during the period 2000 - 2004, Pasiouras, Tanna and Zopounidis (2009) examined the impact of banking regulations on bank costs and profit efficiency. To control for the country-specific characteristics, they analysed the effects of the regulatory and supervision framework by setting variables according to the regulatory aspects, macroeconomic environment, financial development, market structure and the state of economic development. Their results suggested that banking regulations increased both the costs as well as profit efficiency. Barth, Lin, Ma, Seade and Song (2013) also analysed the relationship between bank regulation and bank efficiency using unbalanced panel data that contained 4050 banks in 72 countries during the period 1999 to 2007. It is noteworthy that the conclusion of Barth et al. (2013) is slightly different from Pasiouras et al. (2009). To be more specific, Barth et al. (2013) observed that there was a negative correlation between tighter restrictions on bank activities and bank efficiency, but a positive correlation between rigorous capital regulation and bank efficiency. Furthermore, an enhanced official supervision accompanied by independent supervisory authorities would appear to increase bank efficiency.

3. Data and methodology

3.1 Data description

There are different opinions about the measurement of outputs and inputs in a special service industry such as banking. For the outputs, on one hand, banks provide their customers with different kinds of facilitating and competitive services, and on the other hand, they also act as intermediaries with inherent functions such as channeling funds from savers to borrowers (Colwell and Davis, 1992). In keeping with the theory of the "production approach", we choose to focus here on the total loans and the total deposits as outputs. For the inputs, we refer to the methods of Hasan and Marton (2003) by using an extensive database (Bankscope) to measure the price of inputs, i.e., the price of capital and the price of funds in a situation with difficulty of data acquisition (see Bonin, J. P., Hasan and Wachtel, 2005; Berger, Hasan and Zhou, 2009).

When dealing with inefficiency factors, numerous articles address the influence on banking efficiency from different aspects. Based on the financial and economic environment of China and the indications given by Jiang, Yao and Zhang (2009), we represent the inefficiency factors in terms of three aspects (see Table 1), i.e., shadow banking, macroeconomic environment and bank characteristics.

Table 1: Inefficiency factors of Chinese banks.

Aspects	Variables	Definition
Shadow banking	RSSB-CBS	Relative size of shadow banking inside the commercial banks.
	RSSB-Macro	Relative size of Chinese shadow banking.
Macroeconomic environment	WTOEntry	China's participation in WTO in 2001.
	FinancialCrisis	Global financial crisis in 2008.
	CBRCInitial	Initiation of China Banking Regulatory Commission (CBRC).
Bank characteristics	TA	Logarithm of total assets.
	LA	Liquid assets to total assets.
	LTD	Loan-deposit ratio.

More particularly, Lu et al. (2014) summarized four major types of shadow banking products, but due to the restriction of data, we merge them into two categories, i.e., shadow banking inside and outside Chinese commercial banks. For the former, Lu et al. (2014) concluded that many services and activities in traditional commercial banks showed the characteristics of shadow banking, and a large part of these services and activities corresponded to off-balance sheet items. Hence, we use the off-balance sheet items given by Bankscope as representing the shadow banking activities inside commercial banks and define our variable as the relative size of shadow banking inside commercial banks (RSSB-CBS) = total amount of off-balance sheet items (OFBS)/total assets. As regards the relative size of Chinese shadow banking (RSSB-Macro), this is defined as the size of Chinese shadow banking/gross domestic product (GDP). The data presented here on the relative size of shadow banking system is obtained directly from Li and Xu (2014), who used a method of calculation based on Li (2010).

3.2 Sample

The sample is an unbalanced panel of financial data on 166 Chinese commercial banks during the period 1998-2012, representing a total of 873 observations. The major data source is Bankscope – Fitch's International Bank Database – while some data are taken from annual Issues of the China Statistical Yearbook, 1999-2013. Descriptive statistics of the total costs, outputs and price of inputs are reported in Table 2. All monetary values are deflated using the Chinese GDP deflator with 1998 as the base year.

Table 2: Descriptive statistics of outputs and price of inputs.

Description		Mean	St.dev	Min	Max
Outputs	Total cost	4178.748	12223.53	1.188406	75599.47
	Total loans	83064.86	252969.8	23.25055	1718868
	Total deposits	133503.9	436342.6	27.66994	3093330
Price of inputs	Price of funds	0.02371	0.02807	0.00016	0.44272
	Price of capital	2.47194	3.93760	0.12694	43.67774

Note:1. All variables in RMB million except for input prices;
2. All values are deflated to 1998 price level.

3.3 Model

This stochastic frontier model is widely applied in research on bank efficiency. Berger et al. (2009) used this model to explore the relationship between bank ownership and efficiency. Based on this model, Jiang, Yao and Feng (2013) studied the static effects of ownership and the dynamic effects of privatization on bank performance in China. Gaganis and Pasiouras (2013) analysed the connection with the framework of government using a stochastic frontier model. Following Battese and Coelli (1995), a single-step stochastic frontier model can be expressed as follows:

$$Y_{it} = \exp(x_{it}\beta + U_{it} + V_{it}), \tag{1}$$

$$V_{it} \sim N(0, \sigma_v^2), \tag{2}$$

$$U_{it} = z_{it}\delta + W_{it}. \tag{3}$$

where:

Y_{it} denotes the cost at the t-th year for the i-th bank; x_{it} represents a vector of the output quantities and price of inputs at the t-th year for the i-th bank; β denotes a vector of unknown parameters; V_{its} denotes random errors which are independent and identically distributed following a normal distribution; U_{its} denotes the inefficiency effects, which are not less than zero and distributed independently with respect to V_{its}. The values of U_{its} are obtained by truncation (at zero) of the normal distribution. The mean of U_{its} is $z_{it}\delta$ and the variance is σ_u^2; W_{it} denotes the random variable in equation (3), which is defined by truncation of the normal distribution. The mean of W_{it} is zero and the variance is σ_u^2; zit is a vector of variables that influences the inefficiency of bank i at year t; δ is a vector of unknown coefficients.

The measure of relative inefficiency variation can be obtained by the following expression:

$$\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2} \tag{4}$$

3.4 Efficiency measures

Cost-efficiency is a measure of the extent of a bank's efficiency as regards costs. It is obtained by comparing a given bank with a "best performance bank" with the same outputs and external environment (Berger et al., 2009). Normalization is carried out to reduce the heteroskedasticity using the bank's total assets, and also serves to control the scale biases. To restrict the linear homogeneity of input prices, we need to impose the price of funds to be removed. Hence, we estimate the stochastic frontier cost function using the commonly-used translog functional form as follows:

$$\begin{aligned}
\ln\left(\frac{TC}{n \cdot p_2}\right)_{it} &= \alpha_0 + \sum_{j=1}^{2} \alpha_j \ln\left(\frac{y_j}{n}\right)_{it} + \frac{1}{2}\sum_{j=1}^{2}\sum_{k=1}^{2} \alpha_{jk} \ln\left(\frac{y_j}{n}\right)_{it} \ln\left(\frac{y_k}{n}\right)_{it} \\
&+ \beta_1 \ln\left(\frac{p_1}{p_2}\right)_{it} + \frac{1}{2}\beta_{11} \ln\left(\frac{p_1}{p_2}\right)_{it} \ln\left(\frac{p_1}{p_2}\right)_{it} \\
&+ \sum_{j=1}^{2} \theta_j \ln\left(\frac{y_j}{n}\right)_{it} \ln\left(\frac{p_1}{p_2}\right)_{it} \\
&+ \eta_0 Year + \frac{1}{2}\eta_{11} Year^2 + \sum_{j=1}^{2} \eta_j \ln\left(\frac{y_j}{n}\right)_{it} Year + \eta_3 \ln\left(\frac{p_1}{p_2}\right)_{it} Year + U_{it} + V_{it}
\end{aligned} \tag{5}$$

Where the inefficiency effects are specified as:

$$U_{it} = \omega_0 + \omega_1 \text{RSSB\_CBS}_{it} + \omega_2 \text{RSSB\_Macro}_t + \omega_3 WTOEntrance_t + \omega_4 CBRCInitiate_t + \omega_5 FinancialCrisis_t + \omega_6 TA_{it} + \omega_7 LA_{it} + \omega_8 LTD_{it} + W_{it} \quad (6)$$

where:

ln denotes the natural logarithm; TC represents total cost, including interest expenses and non-interest expenses (see Sun et al., 2011); y_1 represents loans; y_2 represents deposits; p_1 (price of funds) is defined as the ratio between interest expenses and total deposits; p_2 represents price of capital and is defined as the ratio between non-interest expenses and total fixed assets; n represents total assets; Year indicates the year of the observation in question; RSSB-CBS represents the relative size of shadow banking inside the commercial banks; RSSB-Macro represents the relative size of the Chinese shadow banking system; WTOEntry is a dummy variable which uses 1 to represent the year from 2002 to 2012 and 0 to represent the year from 1998 to 2001; CBRCInitial is a dummy variable set at 1 to represent the year from 2003 to 2012 and 0 to represent the year from 1998 to 2002; FinancialCrisis is also a dummy variable set at 1 to represent the year from 2008 to 2012 and 0 to represent the year from 1998 to 2007; TA is the logarithm of total assets; LA is the ratio of liquid assets to total assets; LTD is the ratio of loans to deposits. U_{it}, V_{it} and W_{it} are as defined in the previous section.

4. Empirical results

4.1 Results of estimation

4.1.1 Brief introduction

Given the model expressed in equations (5) and (6), we estimate the parameters of these two equations using a one-step maximum likelihood approach. The estimation is performed using the package "frontier" in R (Coelli and Henningsen, 2011). Table 3 shows the estimation of parameters for this model. According to equation (5), the inefficiency term U_{it} and its constituent variables (usually known as z-variables) are positively correlated when the estimated parameter is positive, which also means that the bank is less efficient when the estimated values of the z-variables are higher and *vice versa*.

σ_2 and γ are significant, while γ is close to 1 but not so close to the boundary, which means the inefficiency item U_{it} has a significant effect on bank cost-efficiency. From Table 3, we can see that the estimation of the stochastic frontier model is generally quite good and most variables have a significant effect on the model.

Table 3: results of model estimations.

Variable	Par.	Estimate	Std. Error	z value	Pr(>|z|)
Intercept	α_0	-0.51813	0.12625	-4.1041	4.058e-05 ***
ln(y_1/n)	α_1	-0.37113	0.14353	-2.5857	0.00972 **
ln(y_2/n)	α_2	1.71973	0.33657	5.1096	3.229e-07 ***
ln(p_1/p_2)	β_1	0.78637	0.03937	19.9755	< 2.2e-16 ***
ln(y_1/n)^2	α_{11}	-0.42413	0.11478	-3.6952	0.00022 ***

ln(y2/n)^2	α_{22}	0.42922	0.20291	2.1153	0.03440 *
ln(p1/p2)^2	β_{11}	-0.00640	0.00843	-0.7594	0.44762
ln(y1/n)ln(y2/n)	α_{12}	0.73614	0.17243	4.2691	1.962e-05 ***
ln(y1/n) ln(p1/p2)	θ_1	-0.00705	0.02492	-0.2829	0.77724
ln(y2/n) ln(p1/p2)	θ_2	-0.00706	0.04353	-0.1621	0.87121
Year	η_0	0.05007	0.01345	3.7229	0.00020 ***
Year^2	η_{11}	-0.00363	0.00091	-4.0055	6.189e-05 ***
ln(y1/n)Year	η_1	0.01118	0.01021	1.0944	0.27376
ln(y2/n)Year	η_2	-0.02031	0.01275	-1.5924	0.11130
ln(p1/n)Year	η_3	0.00580	0.00248	2.3426	0.01915*
Inefficiency equation:					
Intercept	ω_0	-4.96616	3.43133	-1.4473	0.14781
RSSB-CBS	ω_1	-1.78564	0.84178	-2.1213	0.03390 *
RSSB-Macro	ω_2	45.12848	18.42132	2.4498	0.01429 *
WTOEntry	ω_3	4.76615	2.00339	2.3790	0.01736 *
CBRCInitial	ω_4	-2.48541	1.01767	-2.4423	0.01460 *
FinancialCrisis	ω_5	1.19020	0.55235	2.1548	0.03118 *
TA	ω_6	-0.90182	0.31558	-2.8576	0.00427 **
LA	ω_7	0.87908	0.46824	1.8774	0.06046 .
LTD	ω_8	0.47179	0.20782	2.2701	0.02320 *
sigmaSq		0.51442	0.21871	2.3521	0.01867 *
gamma		0.97364	0.01197	81.3383	< 2.2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
log likelihood value: 302.0671

4.1.2 Tests of likelihood ratio and monotonicity

Table 4 reports the results of a likelihood ratio test[3] with two null hypotheses. The first null hypothesis that all banks are efficient is strongly rejected according to the p-value. The second null hypothesis is that the eight inefficiency factors have no effect on the inefficiency of banks; from the p-value, we can also strongly reject this null hypothesis.

Table 4: Likelihood ratio tests of hypotheses for parameters.

Null hypothesis	Test statistics	p-value

[3] The likelihood ratio test statistic is: -2(log(likelihood(H_0))-log(likelihood(H_1))).

H_0: $\gamma = \omega_0 = \omega_1 = \cdots = \omega_8 = 0$	282.43	< 2.2e-16 ***
H_0: $\omega_1 = \cdots = \omega_8 = 0$	160.48	< 2.2e-16 ***

Note: 1. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1;

Next, we check for violation of the monotonicity assumption. Monotonicity is a conceptually important condition in Stochastic Frontier Analysis (SFA) using a translog function. However, given the problems of measuring concepts such as input prices, output quantities and costs, some violations of economic theory are usually acceptable, but only to a certain extent. In practice, if we want to obtain a logical result, the characteristic of monotonicity is important when estimating the efficiencies of individual banks. Here, we calculate the number and percentage of observations violating the monotonicity assumption as follows:

Table 5: Monotonicity for outputs and price of input in the model.

Variable	Number of observations violating the monotonicity assumption	Percentage of observations violating the monotonicity assumption
Loans	6	0.687%
deposits	24	2.749%
Price of funds	0	0%

In our study, we observe some cases of loans and deposits violating the monotonicity assumption. However, Kellermann (2014) and Olsen and Henningsen (2011) record observations of variables violating the monotonicity assumption with maximum percentages of 15.9% and 44.5%, respectively. Hence, we consider the violations to be in an acceptable range and expect no substantial consistency problems regarding monotonicity.

4.1.3 Explanation of the effects of outputs, price of input and variables on efficiency

As noted before, and according to the calculation of monotonicity, almost all the elasticities of outputs and prices of input are positive. This means that, if banks want more outputs or have a high input price, then more costs are incurred, which agrees with the facts as well as logic. Hence, these results indicate that the higher the price, the more outputs are produced, and the higher the total costs.

When RSSB-CBS shows a negative sign, this means there exists a negative correlation between RSSB-CBS and bank inefficiency; in other words, the higher the RSSB-CBS, the higher the bank cost-efficiency. There are two aspects to consider for the potential explanations. Firstly, the generation of Chinese shadow banking is a spontaneous financial innovation of Chinese commercial banks in the context of an inhibiting financial environment. This behaviour expands the boundaries of traditional financial services and, to some extent, shadow banking eases the negative impact of financial repression, and also increases the resource allocation efficiency and conversion capacity between savings and investment in the financial system (Zhang, 2013). Secondly, Chinese shadow banking provides necessary liquidity buffers for all kinds of companies, which, under certain conditions, alleviates the negative impact of macroeconomic regulation at the level of enterprises. RSSB-Macro shows a positive sign, indicating that higher RSSB-Macro leads to lower cost-efficiency. Since we merge the two parts of the Chinese shadow banking system, i.e., inside and outside commercial banks, combining the conclusions of RSSB-CBS potential evidence that shadow banking outside the commercial banks has a negative correlation with the cost-efficiency of commercial banks. Potential

explanations should take account of two aspects: financial disintermediation and risk. Firstly, the rapid development of Chinese shadow banking has led to the acceleration of financial disintermediation. Usually, shadow banking raises funds through various channels under different names or methods such as WMPs. However, these activities are similar in nature to depositing and lending. And as there are higher deposit rates and lower thresholds of loans for shadow banks compared to traditional commercial banks, shadow banking generally shows an alternative characteristic. Taken together, this intense asymmetric competition decreases the cost-efficiency of traditional commercial banks. Secondly, we need to consider risk. Shadow banks give rise to many potential risks including liquidity risk, solvency risk and moral hazard (see Lu et al., 2014). The risks caused by a greater amount of shadow banking outside commercial banks will finally effect the cost-efficiency of commercial banks.

Turning to WTOEntry and CBRCInitial, we observe that the entry of China into the WTO has a significantly negative impact on cost-efficiency and the initial values of CBRC show a positive relationship with cost-efficiency. Potential explanations can be given considering two aspects. First, after the entry into the WTO, there was a five-year interim period for most Chinese commercial banks to prepare and adapt the coming competition from foreign banks. After these five years, foreign banks would be subject to the same national treatment. During this period, many Chinese commercial banks invested in many projects and undertook a series of comprehensive reforms. However, these activities temporarily lowed the efficiency to a certain extent (Deng, 2013). Secondly, with the launch of CBRC in 2003, the regulatory framework of banks in China changed because of the official identity of CRBC. Under the new and stricter supervisory environment, the cost-efficiency of Chinese commercial banks has been generally improved (Jiang et al., 2013). The next element is the financial crisis of 2008, when the CRBC showed a negative relationship with the cost-efficiency of banks. In 2008, when the serious worldwide financial crisis began to affect China, the harmful influence was amplified owing to domestic problems and inappropriate policies (see Overholt, 2010).

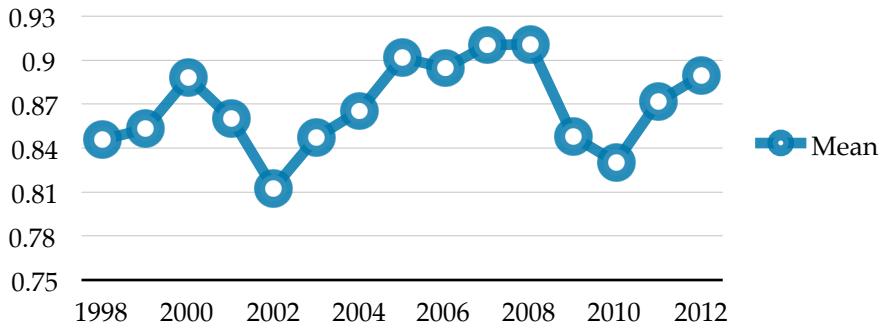
Let us consider three variables describing the characteristics of banks. The first variable is TA, which is a measure of bank size; from Table 3, we can see that TA has a positive relationship with the cost-efficiency of banks. According to Hasan et al. (2003), with more total assets, banks will cooperate with special-purpose institutions and develop different banking and financing products to invest and help new business. Along with the innovative products and the expanded scale and scope of banking activities, the overall efficiency will show a relative increase. The same conclusion also can be drawn from DeYoung and Nolle (1996). The second variable is LA, which equals liquid assets/total assets; from Table 3, we can see that LA has a negative relationship with cost-efficiency. Based on the explanation summarized by Altunbas, Liu, Molyneux and Seth (2000), when banks hold a large number of liquid assets and not conduct investment and other financial activities, the relative costs will increase and the cost-efficiency will show a relative decrease, compared to the "best performance bank". The final variable is LTD, which is an indication of liquidity risk. According to our estimation, we find that the higher the value of LTD, the higher the liquidity risk and the lower the cost-efficiency. As mentioned above, LTD=loans/deposits, so when we increase LTD, we would expect to increase loans and/or decrease deposits. Under conditions of increasing LTD, banks need more deposits to support relatively high loans, while the actual situation contradicts the banks' requirements. Then, the liquidity risk rises and the cost-efficiency falls (see Jiang et al., 2009).

4.2 Cost-efficiency scores

In this study, we calculate the cost-efficiency score according to the method of Olsen et al. (2011). The overall cost-efficiency score for the full sample is 0.8743984, which implies the average bank could reduce its costs by 12.56016% compared to the "best performance bank". The highest and lowest scores are

obtained for 2008 and 2002 with values of 0.910681384 and 0.812633167, respectively. Furthermore, we find that the average cost-efficiency score decreases[4] for certain years such as 2001, 2002, 2009 and 2010. Regarding the situation in 2001 and 2002, a potential explanation is that China's entry into the WTO in 2001 had a significantly negative impact on cost-efficiency, giving rise to a "V"-type efficiency dynamic pattern[5] (see Figure 1), which is consistent with the bank reforms spurred by joining the WTO. The same pattern observed around 2009 and 2010 can be explained by the impact of the financial crisis in 2008.

Figure 1: Cost-efficiency of Chinese commercial banks over the 1998~2012 period.



5. Robustness check

In this section, we check the robustness of the model from two points of view. Firstly, we carry out normalization to reduce heteroskedasticity using the bank's total assets (n) and check for scale biases in the original model (function 5 and 6). Here, we use the bank's total earning assets instead of the bank's total assets to test the robustness. The second point of view concerns the inefficiency factors. As discussed above, we analyse the inefficiency according to three aspects, i.e.: shadow banking, the macroeconomic environment and bank characteristics. Moreover, since this study is concerned with the effects of shadow banking on bank efficiency, we use three models to check the robustness from these three aspects, i.e., the effects of shadow banking alone, the effects of shadow banking and the macroeconomic environment and the effects of shadow banking and bank characteristics.

5.1 Robustness check on normalization

From Table 6, we can see that RSSB-CBS and RSSB-Macro show negative and positive coefficients, respectively. This means that there is a positive relationship between RSSB-CBS and bank efficiency and a negative relationship between RSSB-Macro and bank efficiency, which is consistent with the original model. However, RSSB-CBS is insignificant and we note that the estimation of RSSB-Macro is robust when we use the bank's total earning assets to reduce heteroskedasticity and check for scale biases.

Table 6: Robustness check on normalization with respect to estimation results.

Variable	Par.	Estimate	Std. Error	z value	Pr(>|z|)
RSSB-CBS	ω_1	-0.96395	0.94620	-1.0188	0.30831
RSSB-Macro	ω_2	47.18759	16.91122	2.7903	0.00527 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

[4] We ignore the decrease from 2005 to 2006 as the slight decrease from 0.901841147 to 0.894559597.
[5] Details can be seen in Deng (2013) page 192.

5.2 Robustness check on inefficiency factors

We use three models to check the robustness with respect to inefficiency factors according to three aspects. Here, we keep equation (5) in the same form and only change the inefficiency factors in equation (6). Details are given in Table 7:

Table 7: Robustness check models.

Models	Aspects	Variables
RobustnessCheckModel_1	shadow banking	RSSB-CBS, RSSB-Macro
RobustnessCheckModel_2	shadow banking and macroeconomic environment	RSSB-CBS, RSSB-Macro, WTOEntry, FinancialCrisis, CBRCInitial
RobustnessCheckModel_3	shadow banking and bank characteristics	RSSB-CBS, RSSB-Macro, TA, LA, LTD

According to the estimation results in Table 8, we find that, under the corresponding conditions, RobustnessCheckModels 1 to 3 yield a negative coefficient for RSSB-CBS and a positive coefficient for RSSB-Macro, consistent with the results of the original model. However, all the variables are insignificant whatever the conditions. Hence, we apply the likelihood ratio test in the following section to test the combined effects of shadow banking factors on bank efficiency in different models.

Table 8: Estimation results for robustness check on inefficiency factors.

Models	Variable	Par.	Estimate	Std. Error	z value	Pr(>|z|)
RobustnessCheckModel_1	**RSSB-CBS**	ω_1	-1.0617E+03	1.2255E+03	-0.8664	0.38628
	RSSB-Macro	ω_2	2.7218E+03	3.1473E+03	0.8648	0.38714
RobustnessCheckModel_2	**RSSB-CBS**	ω_1	-1.0344E+03	1.0741E+03	-0.9630	0.33554
	RSSB-Macro	ω_2	7.7181E+03	8.0168E+03	0.9627	0.33568
RobustnessCheckModel_3	**RSSB-CBS**	ω_1	-4.02951	2.13868	-1.8841	0.05955
	RSSB-Macro	ω_2	20.92254	13.26441	1.5773	0.11472

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

From the results presented on Table 9, we can strongly reject the null hypothesis that there are no joint effects of shadow banking factors on bank efficiency. Hence, the results are robust under the condition that the inefficiency factors include shadow banking alone, shadow banking + macroeconomic environment and shadow banking + bank characteristics.

Table 9: Likelihood ratio test for robustness check on inefficiency factors.

Model and condition of inefficiency	Null hypothesis	Test statistics	p-value
RobustnessCheckModel_1	H_0: $\omega_1=\omega_2=0$	30.899	1.951e-07 ***
RobustnessCheckModel_2	H_0: $\omega_1=\omega_2=0$	41.953	7.762e-10 ***
RobustnessCheckModel_3	H_0: $\omega_1=\omega_2=0$	9.0912	0.01061 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

In summary, the relationship between shadow banking and the (in)efficiency of commercial banks is robust when we change the measure of (in)efficiency according to three aspects. The robustness check on normalization shows that the relationship between relative size of the shadow banking system and the (in)efficiency of commercial banks is robust, while this may not be the case for the relationship between relative size of shadow banking inside the commercial banks. Hence, we can generally conclude that the original model of the relationship between shadow banking and the (in)efficiency of Chinese commercial banks yields robust results.

6. Conclusion

This study explores the effects of shadow banking on bank cost-efficiency using data for Chinese commercial banks during the period 1998–2012. The empirical results all point towards positive effects on cost-efficiency due to shadow banking. The larger the relative size of shadow banking inside the bank, the better the efficiency, while the higher the relative amount of shadow banking outside the bank, the lower the cost-efficiency.

This shows that there are gains from shadow banking for the Chinese financial system. It is important for policymakers to realize this, but at the same time understand that shadow banking likely implies a trade-off between flexibility for the banking sector and higher risks.

We should stress one policy implication given by the results of this paper. As shadow banking inside the commercial banks can promote bank efficiency, policymakers and banks should stimulate financial innovation to enhance the size of shadow banking. Simultaneously, policymakers have to be aware about the increased risks this can cause. Appropriate policies should be made to supervise shadow banking actions and control them within a reasonable and legitimate scope.

There are many extensions for future research based on the research presented here. For example, the trade-off between more shadow banking and higher risk. In our analysis, we show that the financial crisis had a negative effect on the cost-efficiency of banks. However, we do not discuss how, and if, this is linked to shadow banking. Evidently, higher risk plays an important role in times of financial turmoil. It is essential to find a balance between the size of shadow banking and the risks that may accumulate over time. For example, it would be interesting to compare financial systems in different countries to compare risks, regulations and the effects both on efficiency and how the systems cope during times of crisis.

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