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The Influence of Market Concentration on Bank Performance and the Test of TBTF Behavior in China

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Abstract

There are 16 listed commercial banks in total in China. Based on the annual specific data of those banks in China from 2008 to 2013, this research intends to find out how bank size and market concentration affect its market efficiency. This paper aims to test whether there exists a TBTF (Too Big to Fail) behavior in China. However, there is no clear evidence which shows that Chinese systemically important banks have a higher fragility than other banks. The results show that systemically important banks perform better than others on cost and profit efficiency and do not take too much risks under the same condition, even in a concentrated market where there are few dominant large banks and the majority of banks are in small size. However, regards to assets, if a banking market is highly unequaled, it does harm to smaller banks' performance and increases the instability of the whole banking system. The study argues that regulators should make an adjustment on market concentration according to reducing the gap of bank size between large and small banks, other than limiting the size of systemically important banks.

Keywords*: bank efficiency; market concentration; stochastic frontier analysis; TBTF*

1. Introduction

In recent years, market structure plays a singular role in banking systems, it attracts more research attention to analyze the impacts of concentration on banking market's stability and efficiency [1-6]. Furthermore, more debates focus on the evaluation of Too Big to Fail (TBTF) behavior in financial regulation field across different countries after the recent financial conjuncture between 2007 and 2009 [7]. This paper will address these concerns by testing the degrees of influences of market concentration and bank size on bank performance and financial stability in China from 2008 to 2013.

Since 2008, The U.S. occurred with financial crisis which makes the identification and mitigation of risk in systemically important banks (SIB) become the focus of the theory and practice [8]. Therefore the main countries and international organizations then strengthened the theoretical research of potential risks of the SIB and introduced relevant regulations to response this crisis. Some typical regulations included which requiring banks must construct capital defenses against systemic risks in Basel III rules, including additional capital of the SIB [9].

In July 2010, the United States puts forward that characteristics and scope of systemically important financial institutions should be limited by passing Dodd-Frank Wall Street Reform and Consumer Protection Act. Moreover, in June 2011, American federal deposit Insurance Corporation and other regulatory institutions put Dodd-Frank Wall Street Reform as well as Consumer Protection Act and Collins amendment into practice, requiring large U.S. Banks to comply with the same minimum capital standard as

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smaller Banks. Having these regulations put forward, the banks industry had more strict rules that helped to reduce the potential risks.

Swiss bank regulatory requires that common stock, contingent convertible bond and cancelled bond be absorbed into the capital composition of the SIB. Besides, the Chinese banking regulatory commission issued the Disclosure Guidance of Commercial Banks' Global Importance Evaluation Index System on 8 January 2014, and claimed that commercial banks meeting certain conditions must disclose 12 global systemically important indices from 2014. Moreover, the regulatory trends to the SIB in some countries are more stringent [10]. For instance, on 9 December 2014, the U.S. Federal Reserve took more strict additional capital requirements on the SIB to reduce the potential risks that they brought. This series of actions enhanced the sustainability and stability of the banking system.

As the Chinese banking industry develops and the sharp expansion of several large banks, Chinese financial institutions have been facing an increasing systemic risk. On 6 November 2014, Agricultural Bank of China added to the list of G-SIBs, according to the end of 2013 data and the updated assessment methodology published by the BCBS in July 2013, which definitely increased the total number of Chinese bank on the list of the G-SIBs from 2 to 3. Besides, the four state-owned banks: China Industrial and Commercial Bank, China Agricultural Bank, the Bank of China and China Construction Bank all in the top 70 of Fortune 500 in 2014. Up to now, SIBs have already playing an important role in Chinese financial system, which will necessarily improve concentration and maybe harm the efficiency. Therefore, to understand how should regulators or policy makers' deal with such issues is becoming important.

SIBs not only increase the risk of banking industry as a whole, but it is also costly to save them when they are in situation of crisis[11]. The collapses of America's three biggest investment Banks in crisis prompts people to consider whether there is a TBTF behavior in the very large financial institutions (particularly banking) or not. Consequently, research on the impact of banking market concentration on bank's efficiency and stability becomes a hot topic of some theorists.

When it comes to market concentration influencing banking efficiency, there is no consensus. Some scholars argue that the increase of market concentration can improve the efficiency of banking system [12-13]. As one of the market concentration approaches, mergers and acquisitions may be driven by various organizational strategies, such as maximizing profit, avoiding exceed pressure, and monopolizing [14]. While others believe the improving of banking concentration affect the operation and management of banking system in a negative way, as the management may lose the impetus to increase efficiency if the banking industry has excessive concentration [15]. Thus market concentration and bank size have different effects on the cost efficiency of the banking sector [16].

Moreover, there are two antagonistic opinions in the field of market concentration influencing banking system stability. Some researchers agree that concentration actually increase the banking systemic risk by imposing higher risk on borrowers. Due to that increased concentration, some banks will collude with each other, which will lead to higher interest rates of loans and higher reimbursement risks of borrowers. In addition, regulators tend to manage a market of higher concentration as it is easier to supervise a small number of banks, moreover, banks in the highly concentrated market obtain higher profits because of the low pressure and will get a buffer for the negative impact [17]. Combining two perspectives, [18] concluded two ideas are likely to be correct in different situations.

Based on the relevant annual specific data of 16 listed commercial banks in China between 2008 and 2013, this paper applies theoretical analysis and Stochastic Frontier Analysis [19] into influences of bank size, market concentration and risk on performance, in order to test whether there exists a TBTF behavior in Chinese banking system and to

understand the impact of concentration on financial stability. Specifically, this study elaborates the two influences factors affect, e.g. bank size and market concentration, on bank performance from the perspective of economies of scale and conspiracy theory first; secondly, it estimates the general form of cost and profit frontiers by the SFA model and then uses the same model to know the efficiency scores better, as well its determinants, e.g. market concentration (HHI), bank size and other bank specific variables. It then uses Z-score, standing for insolvency risk, to presents what causes bank's behavior of risk-taking. Finally, the paper addresses the problem by estimating influences of market concentration, also bank size on performance and its risk behavior, in order to provide theoretical foundation for increasing banking efficiency and stability in regulation.

2. Size, Concentration and Efficiency

2.1. Size and Efficiency

Banking industry exists economies of scale, and this theory was supported by many literatures. This paper explains the relationships among size, concentration and efficiency of the banks, basing on this industrial organization theory founded by Harvard School. According to the different concentrations, the markets can split into four parts: (1) perfect competition; (2) monopolistic competition; (3) oligopoly monopoly; (4) perfect monopoly. This paper defines Chinese banking market as oligopoly monopoly[1].

Assuming a banking system consisted of two banks (X_1, X_2), the production of $X_1$and X_2 are y_1 and y_2 , respectively. The industry crop is $y= y_1 + y_2$. The reversed market demand curve is downward sloping and expressed as $p(y)=p(y_1+y_2)$.The cost curve of bank X_i is $C_i(y_i)=AF(k_i, n_i)$， i=1,2,A> 1， and the time point is 0 and 1.

At time t=0, the maximum profit of X_1 is

$\pi_1(y_1+y_2)= p (y_1+y_2) y_1-C_1(y_1)$, and the maximum profit of X_2 is

$\pi_2(y_1+y_2)= p (y_1+y_2) y_2-C_2(y_2)$.

When both banks decides to expands their production simultaneously at t=1, then the output of $X_i(i = 1,2)$ increases toy_i', andtotal cost will be equal to $C_i'(y_i')$ =A′F (k_i', n_i').

At time t=1, the maximum profit of X_1 is

$\pi_1'(y_1'+y_2')= p'(y_1'+y_2') y_1'-C_1'(y_1')$, and the maximum profit of X_2 is

$\pi_2'(y_1'+y_2')= p'(y_1'+y_2') y_2'-C_2'(y_2')$.

The net social welfare of X_1 is

$\Delta\pi_1'(y_1'+y_2')=\pi_1'(y_1'+y_2')-\pi_1(y_1+y_2)$， satisfying $\frac{\pi_1'(y_1'+y_2')}{\pi_1(y_1+y_2)} > \frac{C_1'(y_1')}{C_1(y_1)}$， and the net social welfare of X_1 is $\Delta\pi_2'(y_1'+y_2')=\pi_2'(y_1'+y_2')-C_2'(y_2')$， satisfying $\frac{\pi_2'(y_1'+y_2')}{\pi_2(y_1+y_2)} > \frac{C_2'(y_2')}{C_2(y_2)}$。

So the total increased social welfare of banking system is

$\Delta u_1 = \Delta\pi_1'(y_1'+y_2')+ \Delta\pi_2'(y_1'+y_2')$。 (1)

2.2. Concentration and Efficiency

Considered Marshallian demand function (p, y) and suppose there exist n demanders in the market, and the payment of each is different because of that different income level or preference. It ranks the payments of n demanders and will get the result as below:$v_1 \geq v_2 \geq v_3 \geq \cdots$. Assuming commodity price is p_0 and the maximum payment of consumer isv_i, the consumer will buy the commodity if and only if$v_i \geq p_0$.

[1]Chinese banking sector cannot to be the complete monopolize market or perfect competitive market. So the issue becomes whether the market is oligopolistic or monopolistic. In the perspective of industrial organization theory, the difference about oligopolistic or monopolistic is whether there exists substitute industry, obviously, China's four stated-owned commercial banks cannot to be substituted. Therefore, this research support the former view.

Define the consumer surplus of the first consumer is $v_1 - p_0$; the second consumer is $v_2 - p_0$. By this analogy, the total consumer surplus is $(v_1 - p_0)+ (v_2 - p_0) + \cdots + (v_n - p_0)$.When n tends to infinity, the ladder type demand function can be replaced by the continuous total demand function q=D(p), based on the inverse function of which, we can define the consumer surplus as below:

$CS^n= \int_0^{q^0} f_d(q)dq-p^0*q^0$,

And the producer surplus is

$PS^n=p^0*q^0-\int_0^{q^0} f_s(q)dq$. Consequently, the total social welfare is

$u=\int_0^{q^0}[f_d(q) - f_s(q)]dq$ (2)

Taking the example in section 2.1, the industry production is $y=y_1+y_2$. Define the reversed market demand curve is downward sloping and expressed as $p(y) = p(y_1+y_2)$. At time t=0, the maximum profit of X_1 is

$\pi_1(y_1+y_2)= p(y_1+y_2)\, y_1-C_1(y_1)$, and the maximum profit of X_2 is

$\pi_2(y_1+y_2)= p(y_1+y_2)\, y_2-C_2(y_2)$.

If collusion is not to be considered, the final social welfare is as equation (2). Otherwise, if two banks decide to maximize their joint profit by reducing the production and increasing price, the total profit of banking system becomes as below:

$\pi(y_1+y_2)= p(y_1+y_2)\,(y_1+y_2) - C_1(y_1)-C_2(y_2)$

The first order condition of maximum profit is

$\frac{\partial\pi}{\partial y_1}= p(y_1+y_2) + \frac{\partial p(y_1+y_2)}{\partial y_1}(y_1 + y_2)-\frac{dC_1(y_1)}{\partial y_1}=0$,

$\frac{\partial\pi}{\partial y_2}= p(y_1+y_2) + \frac{\partial p(y_1+y_2)}{\partial y_1}(y_1 + y_2)-\frac{dC_2(y_2)}{\partial y_2}=0$.

Then the price of goods in the market rises from $p_0$to $p_1(p_1 > p_0)$, and the change of consumer surplus is

$\Delta CS^n=[\int_0^{q^1} f_d(q)dq-p^1*q^1] - [\int_0^{q^0} f_d(q)dq-p^0*q^0]$,

The change of producer surplus is

$\Delta PS^n=[p^1*q^1-\int_0^{q^1} f_s(q)dq] - [p^0*q^0-\int_0^{q^0} f_s(q)dq]$

The change of total welfare is

$\Delta u_2=\Delta CS^n+\Delta PS^n=\int_0^{q^1}[f_d(q) - f_s(q)]dq+\int_0^{q^0}[f_s(q) - f_d(q)]dq$

$=\int_{q^0}^{q^1}[f_d(q) - f_s(q)]dq$

$=-\int_{q^1}^{q^0}[f_d(q) - f_s(q)]dq$ (3)

Considering$f_d(q) - f_s(q) \geq 0, q^0 > q^1$, it can easily get $\Delta u< 0$.

Therefore from the theory above, it is found that the concentration reduces efficiency. Also by employing the approach of Stochastic Frontier Analysis to prove this theory. According to the oligopoly market theory, the solution to this problem is the instability of collusion. Base on this, banking industry regulators should carry out efficient policy to preserve an effective competition market structure and take necessary restrictions to the collusion in the market.

3. Methodology

3.1. Efficiency Measurement and Variable Selection

Scholars generally use two kinds of methods in terms of measuring efficiency model: data envelopment analysis (DEA), and SFA. This paper adopts the latter model because the possible error of it can be divided into two parts, which is closer to the reality and more valid. This study estimates the cost efficiency and profit efficiency by the SFA model proposed by [19], which decompose the error into two parts by estimating translog

cost (profit) function. One part is the random disturbances v which obeys the normal distribution, and represents the measurement of error and uncontrollable factors ,*i.e.*,$v_{i,t} \sim N(0,\sigma_v^2)$; the other part is the technical and allocative inefficiency which belongs to the management control and is assumed to obey the half-normal distribution, *i.e.*,$\upsilon_{i,t} \sim N^+(\mu_{it},\sigma_v^2)$[2]. The SFA model allows this study to compare different listed commercial banks based on the same benchmark [20] and estimate the degree of efficiency and the coefficients of exogenous variable simultaneously by one-step model [21]. The one-step model in [21] overcomes the inherent defects of the two step model, as the efficiency is assumed to be half-normally distributed in the first step but assumed to be normally distributed in the second step.

In SFA model, the degree of efficiency refers to the gap between the cost or the profit of a bank and the lowest cost or the maximum profit, *i.e.*, the stochastic frontiers. Cost inefficiency measures the degree that the cost of a bank is higher than the frontier; while profit inefficiency measures the degree that the profit of a bank is lower than the frontier given the output level. In current literatures, the best performance bank in a sample decides the lowest cost and the maximum profit respectively. Also make a comparison with other banks.

This study uses a selectable profit function rather than the standard profit function as Berger and Mester (1997) did, in order to evaluate the market force better by choosing output amount instead of output prices. The translog function to estimate cost efficiency is as follows:

$$\ln\left(\frac{C}{W_2}\right)= \delta_0 + \sum_j \delta_j \ln y_{jit} + \frac{1}{2}\sum_j \sum_k \delta_{jk} \ln y_{jit} \ln y_{kit} + \beta_1 \times \ln\left(\frac{W_1}{W_2}\right)_{it} + \frac{1}{2}\beta_{11} \ln\left(\frac{W_1}{W_2}\right)_{it} \ln\left(\frac{W_1}{W_2}\right)_{it} + \sum_j \theta_j \times \ln y_{jit} \ln\left(\frac{W_1}{W_2}\right)_{it} + v_{it} + \upsilon_{it},$$

Where i and t represent bank and year, respectively; the total cost of a bank is represented by C; y refers to three outputs: total loans, total deposits and non-interest income, which represents non-traditional business activities of banks[3]; w includes two input prices: interest income to total deposits W_1 and non-interest income to total assets W_2 .In order to ensure the linear homogeneity of cost function, the explained variable and one input priceW_1 are standardized by another input priceW_2, and$v_{it}+\upsilon_{it}$is the error term.

The profit translog function is dealt with the same methods cost translog function. There is minor difference that it explained variable becomes the bank's total profit and the error term is$v_{it}-\upsilon_{it}$[4], The function is as below:

$$\ln\left(\frac{P}{W_2}\right)= \delta_0 + \sum_j \delta_j \ln y_{jit} + \frac{1}{2}\sum_j \sum_k \delta_{jk} \ln y_{jit} \ln y_{kit} + \beta_1 \times \ln\left(\frac{W_1}{W_2}\right)_{it} + \frac{1}{2}\beta_{11} \ln\left(\frac{W_1}{W_2}\right)_{it} \ln\left(\frac{W_1}{W_2}\right)_{it} + \sum_j \theta_j \times \ln y_{jit} \ln\left(\frac{W_1}{W_2}\right)_{it} + v_{it} - \upsilon_{it},$$

Where P stands for the bank's total profit. When it takes the logarithm of variables, it chooses the method which aims to add a variable-the Negative Profit Indicator (NPI)-to the function in order to avoid negative situations, and the value of NPI is 1 when profit$\geq$0 and is the absolute value of profit when profit$\leq$0. When the explained variable is negative, this study defines its value as 1 as [24] did.

Refer to [21] model, this study estimates the translog function and inefficient term simultaneously. The average inefficient terms (υ_{it}) of cost and profit translog function are as follows:

[2] SFA and DEA methods are widely used in lots of literatures. The advantage of SFA approach is that the error term is divided into two parts, while DEA put all deviations on the inefficiency term, ignoring the random error term affect [22]. Also, SFA should do some assumptions about relevant variables distribution of technology efficiency.

[3]Although there are a lot of controversies on this issue, some literatures focus on the impact of some non-traditional activities on bank's efficiency actually catches theorists' attention [23].

[4]If this research adopt the after-tax profits, it will lead to the wrong inference of efficiency, so it is necessary to use total profits which is the same as previous studies.

$$u_{it}=\delta_0+\sum_n \delta_{nit}z_{nit}$$

Where z is the variable vector consisted of n banks' specific indicators, representing the efficiency of bank i at time t. This study uses the maximum likelihood estimation approach to estimate the cost or profit translog function and their inefficiency terms.

On the side of the inefficiency term, the composed variables of z vector are as follows: equity ratio (EQ), which is shareholders' equity to total assets to evaluate the impacts of shareholders' equity on the cost efficiency and the profit efficiency of bank; the bank's market share (MS), representing bank's systemic importance; reserve for bank debts to bank's total loan (LLR) refers to bank's risk. It is obvious that the weaker the ability that bank bear risk, the lower the bank's efficiency is due to the higher expected loss of bank; return on asset (ROA).

To test whether market concentration influences cost and profit efficiency or not and to what extent, this study takes the adjusted HHI index representing market concentration as [25-26] did in investigating the empirical problem of banking market concentration. The index is constructed by comparing X series of the original market with Y series, and the assumptions are as follows:

(a)Y series has the same number with the original market, including m constant observations which are equal to K and n-m constant observations which are equal to 0;

(b)$\sum_{i=1}^{n} x_i=\sum_{i=1}^{n} y_i$, the total number of X series is equal to that of Y series;

(c) $HHI_Y=HHI_X$, market concentration remains the same in that measuring process;

Y is a fictional banking market, which has the same structure with the original market and can be divided into two parts. One contains m banks which has equal market share (but not zero), the other one contains n-m banks which has zero market share. Therefore, the HHI index of Y banking market is the same as that of X banking market (the original market) due to the assumptions above. Then it defines d=1-m/n, which represents the proportion of banks that have no market share in the total bank number. Consequently, the equation m=1/HHI can be derived and d can be defined as follows:

$$d=HHI^D=1-\frac{1}{n\cdot HHI}$$

Where n refers to the amount of banks; HHI represents the summation of the squares of bank market shares (MS_i), *i.e.,* $HHI=\sum_{i=1}^{n} MS_i^2$, $0 \le d \le 1-1/n$, and the HHI index is a monotone decreasing function of the number of Banks. The reasons of adopting the HHI index are as follows.

In this formula, d is still an index representing market concentration, but is standardized and dimensionless. The concentration levels in different markets can be compared by their d indices; the concentration levels in different years and areas can be compared by their d indices because the d index is independent of the number of banks. The d index is especially important when this study is dealing with the market concentration across different countries. Because if this study chooses a non-standardized index, the calculation results will be seriously bias due to the fact that the index is depended on the number of banks across different countries and times. Noted that the extremity of d is 1, in order to ensure the value of d is located in the open interval (0, 1), this study will adopt the $HHI^{D^*}=HHI^D/(1-1/n)$ to replace d.

The indexes above could also be used in the analysis of "TBTF" behavior, and one of the most important dimensions of the SIBs is substitutability [27]. Furthermore, the d index is inversely proportional to the substitutability of banks, which the traditional HHI index does not contain this situation.

This study devised the following four models to test the impact of market concentration on bank performance: (1)HHI^{D^*} of asset; (2)HHI^{D^*} of asset and the product of $HHI^{D^*}$and MS; (3)HHI^{D^*} of asset and the product of $HHI^{D^*}$and LLR; (4)HHI^{D^*} of asset, the product of HHI^{D^*}, LLR and MS and the products of any two variables among HHI^{D^*}, LLR and MS. It then apply the four models into the analyses of efficient frontiers of cost and profit.

The second model intends to examine whether the impact of market concentration on cost and profit is depended on the bank size or not. On the condition that the impact of product term of HHI^{D^*} and MS on u_{it} is negative significantly, large banks can make profit due to the irrelative importance in concentrated market. The third model explains how the banks make decisions when facing more risks in that concentrated market. For example, the positive value of the product term means more risk-taking banks will find it hard to keep the same performance and become more cautious in concentrated market. The final model explores how the bank size influences the inefficiency items of cost and profit when the market concentration and the risks of banks are settled. Although the test is complex, it can reveal whether the systematically important banks in China are expanding beyond the optimal size or not.

3.2. The Analysis of Efficient Frontier

This study analyzes the factors leading to the risk-taking behavior of banks. The analysis not only focuses on the impact of market concentration on risk-taking behavior but also includes how banks change and influence by market concentration. In particular, if the study can prove that there is evidence of SIBs show more risk-taking behavior in highly concentrated market, then there must be "TBTF" behavior in Chinese banking sector. If large banks realize that they are so big that when they are in crisis, the governmental authority will help them recover some losses definitely and take some excessive risk behaviors, then the "TBTF" behavior will take place [28]. While in non-concentrated market, large banks may realize that other banks will take their positions when they are in crisis, from which this study can conclude that market structure is very important to the judgement of "TBTF" behavior.

Many literatures [29-31] use the Z-value standing for risk level. Z-value describes standard deviation of bank's behavior by reducing its ROA to lower its ruin probability, and can be called inverse ruin probability. In general, the higher the Z-value is, the more stable the bank is. The computation formula of Z value is as follows:

$$\text{Z-score}_i=\frac{\overline{\text{ROA}_i}+\overline{\text{Equity Ratio}_i}}{\sigma_{\text{ROA}_i}}=\text{RAR}+\frac{\overline{\text{Equity Ratio}_i}}{\sigma_{\text{ROA}_i}}$$

Where $\overline{\text{ROA}_i}$ and $\overline{\text{Equity Ratio}_i}$ refer to the average return on assets and average equity ratio of the shareholders', respectively;σ_{ROA_i} is standard deviation of ROA_i.This study also takes $\text{RAR}_i=\frac{\overline{\text{ROA}_i}}{\sigma_{\text{ROA}_i}}$as another risk measuring index simultaneously.

This study has employed the model proposed by [32] to estimate the impact of market concentration on financial stability. [32] proposed that Z-value does not necessarily reflect the potential stability that banks can achieve. However, this study found that it is essential to consider the deviation degree to the current stability and the most stability under a given condition, *i.e*. stabilization efficiency, in estimating potential stability. Moreover, [32] put forward the "stabilization frontier model" and take it as a more efficient risk measuring method than analyzing stability purely[5]. This method and the one used in this study are similar to the former approach of estimating frontier function of profit. And the dependent variables in "stabilization frontier model" are Z-value and RAR.

[5][7] adopted the same method in another paper.

4. Empirical Analysis

4.1. Data

In this paper the annual data from 2008 to 2013 of 16 listed commercial banks are from the Wind database. According to the method of defining the SIBs[6], banks can be categorized into three types: SIBs, middle banks, small banks. SIBs must meet the following conditions: (1) Market share is higher than 5%; (2) The combined market share of the banks whose market shares are higher than this bank is higher than 1/3 (66%). Middle bank must meet the following conditions: (1) Market share is higher than0.5%; (2) The combined market share of the banks whose market shares are higher than this bank is higher than 80%. Banks except the above two situations belong to small bank. Table 1 shows the specific data of those three banks.

Table 1. Specific Data of those Three Banks

	SIBs			Middles banks			Small banks		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Equity Ratio（%）	6.12	3.86	6.99	5.64	3.18	7.23	5.56	3.41	12.11
ROA	1.23	0.82	1.47	1.19	1	1.46	1.05	0.75	1.72
Z-score	30.6	10.5	49.8	22.4	16.5	26.8	25.6	10.1	79.8
Loans/Assets	0.51	0.44	0.56	0.53	0.48	0.6	0.52	0.34	0.62
Deposits/Assets	0.8	0.72	0.87	0.7	0.66	0.8	0.71	0.55	0.83
NII/Total income	0.45	0.32	0.76	0.26	-1.8	0.49	0.21	1.02	-2.05
LLR（%）	2.79	2.21	4.46	2.11	1.95	2.47	1.54	2.82	-2.42

From table 1, we can see that middle banks' Z-value is the lowest and LLR is higher than small banks, which indicates that middle banks in China are the most fragile. However, the stability of the SIBs is higher than middle banks, and that of small banks is the highest among those three categories.

Table 2. The HHI、$HHI^{D}$and HHI^{D^*}Indexes of asset in Chinese Banking

Year	2013	2012	2011	2010	2009	2008
HHI	0.121	0.123	0.128	0.133	0.139	0.142
HHI^{D}	0.484	0.492	0.512	0.531	0.55	0.559
HHI^{D^*}	0.516	0.525	0.546	0.566	0.587	0.597

Table 2 are the HHI,HHI^{D} and HHI^{D^*} indexes of asset, which all tell us that the market concentration of Chinese banking industry from 2008 to 2013 is declining.

[6] Besides adopt that SFA model, we also use OLS method to test that robustness results. However, the result of OLS model show us that costs, profits and risks can change with bank's scale and concentration. These conclusion cannot reflect the potential stability, profitability and cost that banks can realize under certain conditions. But this research finds the regression results of OLS model are the same as the main model of this study. In concentrated market, the cost of SIBs are higher while the profit and risk have not changed significantly. So the result of this study is robust.

4.2 Results

(1) Estimating frontier function of cost and profit

Referring to the above description, we use HHI^{D^*} of asset standing for market concentration, MS standing for market share and LLR standing for risk level. Depending on these three indexes the followings explain the possible effect of market concentration on bank's performance.

$\ln\left(\frac{C}{W_2}\right)$ =-12.1439+4.770842 $\ln y_1$ -0.98926 $\ln y_2$ -1.14792 $\ln y_3$ + 2.587687 $(\ln y_1 * \ln y_1)$ +2.753019 $(\ln y_2 * \ln y_2)$ -0.0604205 $(\ln y_3 * \ln y_3)$ -5.712893 $(\ln y_1 * \ln y_2)$ +0.1223772 $(\ln y_2 * \ln y_3)$ +0.1866438 $(\ln y_1 * \ln y_3)$ +0.5890325 $\ln(\frac{W_1}{W_2})$ +0.1179055 $\ln[\left(\frac{W_1}{W_2}\right) * \left(\frac{W_1}{W_2}\right)]$ -1.049767 $[\ln y_1 * \left(\frac{W_1}{W_2}\right)]$ +0.9622294$[\ln y_2 * \left(\frac{W_1}{W_2}\right)]$+0.020014$[\ln y_3 * \left(\frac{W_1}{W_2}\right)]$

The inefficiency term of cost function is:

$\mu_{i,t}$=0.0173492-1.471385$ROA_{i,t}$-0.3121291$MS_{i,t}$-0.1381404$LLR_{i,t}$+ 0.357589$EQ_{i,t}$

The profit translog function is as follows:

$\ln\left(\frac{P}{W_2}\right)$= -0.7994168+1.77673 $\ln y_1$ -0.353051 $\ln y_2$ -1.89554 $\ln y_3$ -1.927934 $(\ln y_1 * \ln y_1)$ -0.0126152 $(\ln y_2 * \ln y_2)$ + 3.725116 $(\ln y_3 * \ln y_3)$ 0.0059738 $(\ln y_1 * \ln y_2)$ +0.1043247 $(\ln y_2 * \ln y_3)$ -0.743828 $(\ln y_1 * \ln y_3)$ +0.1587149 $\ln(\frac{W_1}{W_2})$ -0.0214658 $\ln[\left(\frac{W_1}{W_2}\right) * \left(\frac{W_1}{W_2}\right)]$ +0.1422974 $[\ln y_1 * \left(\frac{W_1}{W_2}\right)]$ -0.1060281 $[\ln y_2 * \left(\frac{W_1}{W_2}\right)]$+0.0229519$[\ln y_3 * \left(\frac{W_1}{W_2}\right)]$

The inefficiency term of profit function is:

$\mu_{i,t}$=1.043759-0.7900824$ROA_{i,t}$-0.0078513$MS_{i,t}$+0.0425306$LLR_{i,t}$-0.0192017$EQ_{i,t}$

Table 3 shows the coefficients of explanatory variable of the inefficiency term of cost efficient function, and Table 4 shows the coefficients of explanatory variable of the inefficiency term of profit efficient function.

Table 3. Cost Inefficiency Correlates

	Cost ineff.(1)	Cost ineff.(2)	Cost ineff.(3)	Cost ineff.(4)
Intercept	0.966***	0.997***	0.909***	0.837***
	（0.015）	(0.171)	(0.300)	(0.022)
EQ	-0.597***	-0.597***	-0.597***	-0.6***
	（0.0008）	(0.004)	(0.004)	（0.0003）
ROA	-0.506***	-0.495***	-0.495***	-0.49***
	(0.003)	(0.021)	(0.021)	（0.002）
LLR	0.035***	0.028***	0.087	0.082***
	(0.001)	(0.005)	(0.103)	(0.01)
MS	-3.277***	-2.380***	-3.205***	-0.12***
	(0.009)	(0.723)	(0.057)	(0.105)
HHI^{D^*}	-0.014	-0.060	0.094	0.224***
	(0.116)	(0.144)	(0.456)	(0.036)
HHI^{D^*}*MS		-1.480		-5.78***
		(1.292)		(0.209)
HHI^{D^*}*LLR			-0.105	-0.09***
			(0.183)	(0.017)
LLR*MS				-1.14***

				(0.051)
HHI^{D^*}*MS*LLR				2.066***
				(0.092)
σ^2	0.0003	0	0.00001	1.00E-05
γ	13.982	1.66	1.955	1.955

Note：$\sigma^2$is the sum of the variance of the error terms in Eq. (1), i.e. $\sigma^2=\sigma_u^2+\sigma_v^2$, $\gamma=\sigma_u^2/(\sigma_u^2+\sigma_v^2)$。The standard errors are presented in parentheses of Table 3. Tables as below are the same

*p<0.1; **p<0.05; ***p<0.01

In Table 3 above, it indicates that excluding the invalid coefficient value of HHI^{D^*} indexes, the other HHI^{D^*} indexes are significantly positive, which shows that the increasing of market concentration will lower the total cost efficiency. This is similar to the study by [15], by which it can conclude that regulation authority should encourage the mergers and reorganizations among small banks to increase cost efficiency. The spillover effect will stimulate large banks who haven't taken part in the merger and reorganization progress to take measures to increase their cost efficiencies, which is forced by the competition pressure of the new rivals. Furthermore, the coefficient of equity ratio is negative, which indicates that the higher of common stock equity ratio, the higher the bank's cost efficiency. The coefficient of bank's market share (MS) is significantly negative, which means that the higher the systemic importance of bank, the higher the bank's cost efficiency. The LLR's positive coefficient shows that the less risk the bank is facing with, the higher the bank's cost efficiency.

The 2th column shows the result of adding the product of HHI index and MS to the model. The coefficients of explanatory variables are similar to that of the 1th column. The product of the coefficient of HHI index and MS is negative but not significant. The 3th column shows the result of adding the product of HHI index and LLR to the model to test whether the impact of market concentration on bank's performance will change at different risk levels, and the product of the coefficient of HHI index and LLR is negative but not significant. Other coefficients of explanatory variables are the same as the previous two models.

The 4th column shows the result of adding the product of HHI index, MS and LLR to the model to investigate the impact of bank size on total cost efficiency given the market structure and risk controlled, and we can see that product of the coefficient of three explanatory variables is significantly positive. The product of the coefficient of HHI index and MS is significantly negative and the HHI^{D^*} index's coefficient is significantly positive, which indicates large bank's performance is better than small banks in concentrated market, therefore large banks can benefit from mergers and acquisitions. The product of the coefficient of HHI index and LLR is significantly negative, which means that the cost efficiencies of SIBs who owns more loan loss reserves (LLR) are higher, and those LLRs are not the bank's cost burden.

Table 4. Profit Inefficiency Correlates

	Profit ineff.(1)	Profit ineff.(2)	Profit ineff.(3)	Profit ineff.(4)
Intercept	0.990236***	0.9012338***	1.042327***	0.8403776***
	（0.022）	(0.020)	(0.058)	(0.020)
EQ	-0.5980148***	-0.5979024***	-0.5980468***	-0.5977456***

	（0.001）	(0.001)	(0.001)	（0.0003）
ROA	-0.5007753***	-0.5011929***	-0.5013614***	-0.4935641***
	(0.006)	(0.005)	(0.006)	（0.002）
LLR	0.0347761***	0.035138***	0.0131576	0.0802091***
	(0.001)	(0.001)	(0.022)	(0.01)
MS	-3.283165***	-1.965309***	-3.282691***	-0.1046843
	(0.016)	(0.158)	(0.016)	(0.100)
HHI^{D^*}	-0.0334598	0.1263623***	-0.1238447	0.2237191***
	(0.033)	(0.032)	(0.098)	(0.035)
HHI^{D^*}*MS		-2.365244***		-5.83891***
		(0.283)		(0.193)
HHI^{D^*}*LLR			0.0381979	-0.0814812***
			(0.039)	(0.015)
LLR*MS				-1.118417***
				(0.050)
HHI^{D^*}*MS*LLR				2.047504***
				(0.094)
σ^2	0.0000854	0.0000495	0.0000846	0.00000703
γ	0.0183775	0.0259694	0.0163956	0.0230377

Table 4 above shows the impacts of explanatory variables on the inefficiency term of profit. From 2th and 4th column, we can see that the impact of market concentration on bank profit efficiency is significantly positive, which means that the strengthening of market concentration will lead to an overall drop in bank profit efficiency. The impact of equity ratio on bank profit efficiency is significantly negative, which indicates that the higher of common stock equity ratio, the higher the bank's profit efficiency. Moreover, the significant negative coefficient of MS shows that the bigger the bank size, the higher the bank's profit efficiency.

Table 4 also presents the results of adding HHI^{D^*}*MS and HHI^{D^*}*LLR to the model. The coefficient of the product of HHI^{D^*} and MS is significantly negative which means that the higher of MS, the higher of profit efficiency in relatively concentrated market. The negative coefficient of MS means that the impact of bank size on profit efficiency is stronger in highly concentrated market. The significantly negative coefficient of the product of HHI^{D^*} and LLR in the 3th column shows that the profit efficiency of SIBs who owns more loan loss reserves is higher. The 4thcolumn shows the results of adding the product of HHI^{D^*}、 MS and LLR to the model, and the coefficient is significantly positive. The coefficient of the product of HHI^{D^*} and LLR is significantly negative.

From the analyses in Table 3 and Table 4, it shows that the cost and profit efficiencies of large banks in concentrated market are higher than other banks, therefore large banks in China have not reached their optimal scale and there is still a space for them to expand.

However, small banks are so small that their cost and profit efficiencies are lower, from which it can be seen that the big banks in China had not shown a TBTF behavior. In fact, the operation efficiency of small banks are so negligible to their cost and profit efficiencies that they cannot compete with big banks. Next section this paper will present the findings from the aspect of risk-taking.

4.3. Risk-Taking Analysis

In this section it will interpret the empirical results of banks' risk-taking activity, which aims to demonstrate whether bank size and market concentration will uncover excessive risk behavior or not. Regarding the Z-value and RAR as explained variables, this research devises four models as follows based on whether the model has the product of HHI^{D^*} and MS:

Table 5. The Coefficient of Z-Value and RAR Variables

	Z-Score(1)	Z-Score(2)	RAR(1)	RAR(2)
Intercept	1.003***	1.004***	0.883***	0.883***
	（0.259）	（0.258）	（0.000）	（0.000）
MS	-0.089**	1.057	-0.074***	-0.089***
	（0.033）	（0.738）	（0.000）	（0.000）
HHI^{D^*}	-1.146**		0.015**	
	（0.740）		（0.000）	
HHI^{D^*}*MS		-1.146		0.015***
		（0.740）		（0.000）
σ^2	0.028	0.028	0.165	0.165
γ	0.015	0.021	0.004	0.042

The banks that have a higher Z-value and RAR are supposed to be more stable. Table 5 above shows the coefficients of the explanatory variables in models. The 1th column shows that the impact of market concentration on bank stability is significantly negative, which proves the idea of 'Concentration – vulnerability'.

The product of the coefficient of Z-value and RAR in the 2th column is negative but not significant. The 1th column and 2th column show that the impacts of bank size and market concentration on bank stability both are negative, but the impact of their product is not significant. The coefficient of MS in 3th is the same as in the 1th column except the indistinctive coefficient of HHI^{D^*} is not significant. The coefficient of the product of HHI^{D^*} and MS in the 4th column is significantly positive, but the coefficient of MS is significantly negative in the same column, which indicates that larger banks are more stable than small banks in concentrated market.

This result verifies the hypothesis in section 1[7] that the SIBs have not presented excessive risk-taking behavior in China. Therefore, the problem is not about size, but concentration. So there is no TBTF behavior in Chinese banking industry, and large banks have not reached their optimal maximum scale. Banking regulators should improve the competitive condition in highly unfair concentrated market by adjusting market

[7]Besides adopt that SFA model, we also use OLS method to test that robustness results. However, OLS model show us that costs, profits and risks can change with bank's scale and concentration. These conclusion cannot reflect banks can realize the potential stability, profitability and cost under certain conditions. But this research find the regression results of OLS model are the same like this study's main model. In concentrated market, SIBs cost are higher while the profit and risk have not changed significantly. So the result of this study is robust

concentration to increase bank efficiencies, but should not limit the size of SIBs. Because the key problem is that small banks are too small to compete with large banks, rather than the scales of large banks are too large.

4.4. Robustness Analysis of Results

In this section, this research assumes the market shares of all SIBs are 1, and take advantage of the stochastic frontier model again. The estimated results are in Table 6 and Table 7.

Table 6. Cost Inefficiency Correlates (Emphasized on the Sibs)

	Cost ineff.(1)	Cost ineff.(2)	Cost ineff.(3)	Cost ineff.(4)
Intercept	0.953***	0.783***	0.355	0.831***
	（0.367）	(0.126)	(0.459)	(0.021)
EQ	-0.580***	-0.596***	-0.580***	-0.598***
	（0.005）	(0.001)	(0.005)	（0.0003）
ROA	-0.603***	-0.510***	-0.595***	-0.494***
	(0.032)	(0.007)	(0.032)	（0.002）
LLR	0.039***	0.036***	0.286**	0.083***
	(0.005)	(0.001)	(0.119)	(0.009)
SI	-0.491***	-0.046***	-0.494***	-0.005*
	(0.013)	(0.010)	(0.013)	(0.003)
HHI^{D^*}	-0.086	0.326***	0.950*	0.235***
	(0.180)	(0.038)	(0.528)	(0.035)
HHI^{D^*}*SIFI		-5.357***		-5.977***
		(0.114)		(0.047)
HHI^{D^*}*LLR			-0.437**	-0.087***
			(0.210)	(0.016)
LLR*SI				-1.153***
				(0.036)
HHI^{D^*}*SIFI*LLR				2.110***
				(0.060)
σ^2	0.003	0.0001048	0.002	0.000013
γ	0.001	0.004	0.001	1.648

Table 7. Profit Inefficiency Correlates（Emphasized on the Sibs）

	Profit ineff.(1)	Profit ineff.(2)	Profit ineff.(3)	Profit ineff.(4)
Intercept	-0.467***	-0.558***	-0.605***	-0.544***
	（0.000）	（0.009）	（0.000）	（0.000）
EQ	-0.252***	-0.256***	-0.252***	-0.256***
	（0.000）	（0.000）	（0.000）	（0.000）
ROA	-0.218***	-0.205***	-0.221***	-0.199*
	（0.000）	（0.002）	（0.000）	（0.000）
LLR	-0.011***	-0.009***	0.063***	0.006
	（0.000）	（0.000）	（0.000）	（0.066）
SI	-0.167***	-0.016***	-0.167***	-0.002***
	（0.000）	（0.004）	（0.000）	（0.100）
HHI^{D^*}	-0.070***	0.110***	0.174***	0.080***
	（0.000）	（0.014）	（0.000）	（0.000）
HHI^{D^*}*SIFI		-1.834***		-2.055***
		（0.040）		（0.000）
HHI^{D^*}*LLR			-0.131***	-0.029***
			（0.000）	（0.000）
LLR*SI				-0.390***
				（0.000）
HHI^{D^*}*SIFI*LLR				0.717***
				（0.000）
σ^2	0.001	0.000	0.001	0.000
γ	0.002	1.031	0.000	0.022

This result prove the conclusion in Table 4. The coefficients of MS in 1th column of Table 6 and Table 7 are significantly negative, which indicates that the cost and profit

efficiency of SIBs are higher than other banks. The coefficients of the product of HHI^{D^*} and MS in the 2th column of Table 6 and Table 7 is significantly negative, which indicates that the efficiencies of larger banks are closer to cost efficiency frontier and profit efficiency frontier in concentrated market. In accordance with the analysis in Table 4, the coefficients of the product of HHI^{D^*} and LLR in the 3th column of Table 6 and Table 7 is significantly negative, and the coefficients of the product ofHHI^{D^*}, MS and LLR in the 4th column of Table 6 and Table 7 is significantly positive.

Table 8. The Coefficients of Z-Value and RAR Variables (Emphasized on the Sibs)

	Z-Score(1)	Z-Score(2)	RAR(1)	RAR(2)
Intercept	1.113***	1.210***	0.937***	0.048***
	（0.285）	（0.000）	（0.000）	（0.000）
SIFI	-0.032	-2.809***	-0.052***	-3.581***
	（0.217）	（0.000）	（0.000）	（0.000）
HHI^{D^*}	-1.066		0.000441	
	（0.758）		（0.000）	
HHI^{D^*}*SIFI		2.499***		3.233***
		（0.000）		（0.000）
σ^2	0.03	0.067	0.179	0.083
γ	0.015	0.314	1.041	0.022

Table 8 above shows that market concentration influences the speed of adjusting to stable frontier of large banks, which is the same as the previous analysis in table 5. Although the coefficients of HHI^{D^*} in most models are significantly negative, and those SIBs are significantly negative, the coefficients of the product of HHI^{D^*} and MS are significantly positive. Overall, this result further prove that there is no TBTF behavior in Chinese SIBs, and their expanding are not the root cause of the instability in Chinese banking industry.

5. Conclusion

Based on the relevant annual specific data of 16 listed commercial banks in China from 2008 to 2013 and the method of stochastic frontier function analysis, this paper makes theoretical analysis and empirical test of the impacts of bank size and market concentration on bank performance successively from the perspectives of economies of scale, conspiracy theory and SFA model, which provides evidence for the theories mentioned in the literature of “concentration-vulnerability” and “concentration decreases performance”. On one hand, the impacts of market concentration on bank performance and risk-taking behavior have long been controversial; on the other hand, under the influence of the financial crisis, countries all over the world have to take into account the impacts of SIBs on financial stability under different concentration levels to improve the stability of financial system, which is the contribution of this paper. This research make theoretical derivation and empirical analysis of the research question from the perspective of industrial organization theory and the SFA model respectively and to test the TBTF behavior of Chinese banking industry simultaneously.

The research results are summarized as follows: (1) Banks will choose to expand their scales because of the scale economies effect, which will increase market concentration and then damage bank performance from the perspective of collusion; (2) The increase of

market concentration will lead to the loss of cost efficiency, which is in accordance with the study of [15]. The increase of market concentration will also cause the loss of social welfare and increase banks' risk, which is in accordance with the study of [3]. Therefore, this research supports the conclusion of "concentration-vulnerability" and opposes the conclusion of "concentration-stability"; (3) The efficiencies of SIBs are higher than other banks in concentrated market, because SIBs can increase the efficiencies of cost and profit due to the fact that they have the scale but take the same level risk as or lower than other banks. Theoretically, the emerging of TBTF behavior will lead to moral hazard and reduce the efficiency, however, the last conclusion proves that there is no TBTF behavior in Chinese SIBs.

To sum up, banking regulators should focus on the adjustment of market concentration to maintain effective competition and keep close watch on the collusion actions of systematically important banks, but not on limiting the scales of systematically important banks to decrease the systematically important risks they bring. Moreover, the scales of large banks in China have not reached their theoretical maximum no matter in efficiency or in risk-taking. If the regulator limit the expansion of the bank blindly, it maybe lead to the result that neither the efficiency of banking industry can be increased nor the stability of banking system can be improved.

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