

# The Impact of Bank Size on Profit Stability in China

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## Abstract

Hansen's (1999) panel threshold regression model is applied in this study to investigate the correlation between bank size and bank earnings volatility in 14 Chinese banks. These data were adopted after the Lehman Brothers bankruptcy was announced in 2009Q4. The data used in this study cover the period from 2009Q1 to 2013Q1. The dependent variable is bank earnings volatility, whereas bank size is the independent and threshold variable. Empirical results show the significance of a single threshold on bank size and return on asset (ROA) earnings volatility. Bank size and ROA earnings volatility are positively correlated when the bank size is less than or equal to 733,211,391 CNY. However, such bank size does not reach 0.1 significant levels. By contrast, bank size slope and ROA earnings volatility is  $-0.0002048$  significant at 0.1 levels when bank size is more than 733,211,391 CNY. Specifically, a larger bank size means less bank earnings volatility. Regarding return on equity (ROE), empirical results show an insignificant relationship between bank size and bank earnings volatility.

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**Keywords:** Bank Size, Bank Earnings Volatility, Lehman Brothers

## 1 Introduction

The 2007–2008 global financial crisis also known as economic crisis, credit crunch, or Wall Street crisis, was triggered on August 9, 2007. Given the outbreak of the subprime mortgage crisis, damaged investor confidence affected subprime mortgages and mortgage-related securities, causing liquid crises. By 2008, this economic tsunami had damaged the global economy, causing many large-scale financial institutions to collapse or were seized by the government. After the collapse of Lehman Brothers, many banks in the States and in Europe suffered from a financial crisis or aggravated credit squeeze, causing the global securities market to crash. Emerging markets were also involved in the

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crisis. Stock markets and currency markets in different countries, such as Iceland, Argentina, Ukraine, Hungary, South Korea, Brazil, and Russia, fell sharply. Thus, a global financial crisis was inevitable.

On September 14, 2008, the Lehman Brothers bank filed for bankruptcy protection after the Federal Reserve Bank declined to participate in creating a financial support facility for the bank. On the same day, Merrill Lynch agreed to be seized by Bank of America. Market values in global stock markets dropped dramatically on September 15 and 17. American International Group (AIG), a significant participant in credit default swaps markets, suffered a liquidity crisis on September 16 following the downgrade of the bank's credit rating. Buitert (2009) indicated that the 'too large to fail' category was sometimes extended to become the "too big to fail", "too interconnected to fail", "too complex to fail", and "too international" to fail problem; however, the real issue was size. Stiroh (2006b) found that banks that relied mostly on activities that generated non-interest income did not earn higher average equity returns but were significantly riskier with respect to return volatility (both total and idiosyncratic) and market betas. Albertazzi and Gambacorta (2009) suggested the existence of a link between business cycle fluctuations and banking sector profitability as well as the methods for causing an unstable capital structure.

However, Demsetz and Strahan (1997) and Couto (2002) argued that large bank holding companies (BHCs) were better diversified than small BHCs based on market measures of diversification, and that the risk-reducing potential of diversification at large BHCs was offset by lower capital ratios and larger commercial and industrial loan portfolios. Stiroh (2006a) indicated that new bank activities contributed more to the variance (risk) of a portfolio. Evidently, the higher weight on relatively volatile noninterest activities outweighed the diversification benefits.

Concerning the relationships between bank size and bank earnings volatility, Boyd and Runkle (1993) and Poghosyan and de Haan (2012) revealed the existence of a significantly negative correlation between bank size and standard deviation of ROA. However, Tabak et al. (2011) disputed that larger banks were associated to higher earnings volatility.

Stiroh and Rumble (2006) reported that bank size and bank earnings volatility were insignificantly correlated in finance holding companies. Similarly, Stiroh (2004) suggested that bank size was insignificantly related to ROE for US banks. De Nicoló (2000) indicated that a non-linear positive relationship existed between bank size and bank earnings volatility in small and medium sized banks, whereas the correlation was negative in large banks.

No consistent argument was found for the relationship between bank size and bank earnings volatility. Consequently, two issues related to China banking require further investigation. The first issue is to determine whether bank size would influence bank earnings volatility. The second issue involves determining whether a threshold effect exists in the relationship between bank size and bank earnings volatility. The research outcome could hopefully contribute to academic and practice fields.

## 2 Data

This study analyzes 14 Chinese banks, including 000001 Ping An Bank, 002142 Bank of Ningbo, 600000 Shanghai Pudong Development Bank, 600015 Huaxia Bank, 600016 China Minsheng Banking, 600036 China Merchants Banking, 601009 Bank of Nanjing, 601166 Industrial Bank, 601169 Bank of Beijing, 601328 Bank of Communications, 601398 Industrial and Commercial Bank of China, 601939 China Construction Bank, 601988 Bank of China, and 601998 China CITIC Bank, over the period of 2009Q1–2013Q1. The unit is thousand CNY, and the data source is China Database covered by Taiwan Economic Journal.

The 601288 Agricultural Bank of China, which went public on July 15, 2010, and 601818 China Everbright Bank, which went public on August 18, 2010, are not included because of insufficient data.

## 3 Methodology

Two approaches are performed in this study: panel unit root test and panel threshold model. Particularly, Hansen (1999) develops the panel threshold that presents non-linear relationships between two variables to improve the disadvantage of a linear relationship that fails to prove the existence of nonlinear relationships between two variables.

### 1. Panel Unit Root Test

Spurious regression could occur when a non-stationary process is used in a regression model without panel unit root test (Granger and Newbold, 1974). The reason is that the null hypothesis is over rejected for estimates to become meaningless. Thus, the panel unit root test should be employed before data analysis to provide a stationary time series.

The panel unit root test utilizes time series information and cross-sectional dimension to modify the traditional univariate unit root test, which covers a small sample size causing the power of the test to be inadequate. The earliest panel unit root test proposed by Abuaf and Jorion (1990) improves traditional single-equation unit root tests but loses statistical power. This study applies the Maddala and Wu (1999) test as well as the Im, Pesaran, and Shin (2003) test, which are both widely used tests.

### 2. Panel Threshold Model

Hansen (1999) proposes two-stage least-squares estimates in linear models for panel data model specification, estimation, and tests. First, the threshold value refers to  $(\gamma)$  and least squares, as well as the sum of square errors (SSEs) are calculated. The estimated threshold value  $(\gamma)$  is inversed via the SSEs. The estimated threshold value is then applied to analyze the intervals for the regression coefficients. The panel threshold model specification is

The single threshold model is

$$v_{it} = \begin{cases} \mu_i + \theta' h_{it} + \alpha_1 d_{it} + \varepsilon_{it} & \text{if } d_{it} \leq \gamma \\ \mu_i + \theta' h_{it} + \alpha_2 d_{it} + \varepsilon_{it} & \text{if } d_{it} > \gamma \end{cases} \quad (1)$$

$$\theta = (\theta_1, \theta_2, \theta_3, \theta_4)', \quad h_{it} = (s_{it}, m_{it}, g_{it}, c_{it})'$$

where  $v_{it}$  represents the bank earnings volatility;  $d$  represents the bank size defined as the independent and threshold variable;  $\gamma$  presents the threshold value; and  $h_{it}$  represents the control variable vector.  $\mu_i$  denotes the fixed effect to obtain heterogeneity among banks.  $\varepsilon_{it}$  represents the error term. The subscript  $i$  identifies the banks, and  $t$  is for the time period.

1. Equation

$$\bar{v}_{it} = \mu_i + \beta' \bar{d}_{it}(\gamma) + \bar{\varepsilon}_{it} \quad (2)$$

recognizing  $\bar{v}_i = \frac{1}{T} \sum_{t=1}^T v_{it}$ ,  $\bar{\varepsilon}_i = \frac{1}{T} \sum_{t=1}^T \varepsilon_{it}$ , and

$$\bar{d}_i(\gamma) = \frac{1}{T} \sum_{t=1}^T d_{it}(\gamma) = \begin{pmatrix} \frac{1}{T} \sum_{t=1}^T d_{it} I(d_{it} \leq \gamma) \\ \frac{1}{T} \sum_{t=1}^T d_{it} I(d_{it} > \gamma) \end{pmatrix}$$

$$v_{it}^* = \alpha' d_{it}^*(\gamma) + \varepsilon_{it}^* \quad (3)$$

recognizing  $v_{it}^* = v_{it} - \bar{v}_i$ ,  $d_{it}^*(\gamma) = d_{it}(\gamma) - \bar{d}_i(\gamma)$ , and  $\varepsilon_{it}^* = \varepsilon_{it} - \bar{\varepsilon}_i$

The demeaned Equation (3) aims to remove the individual specific effect.

$$V_{it}^* = D_{it}^*(\gamma) \alpha + e_{it}^* \quad (4)$$

Equation (4) is the primary calculation for the threshold effect. First, the threshold value  $\gamma$  is placed, and OLS is applied to measure  $\hat{\alpha}$ , which is the estimate of  $\alpha$ :

$$\hat{\alpha}(\gamma) = \left( D^*(\gamma)' D^*(\gamma) \right)^{-1} D^*(\gamma) V^* \quad (5)$$

After measuring  $\hat{\alpha}$ , the data are divided into two groups, namely, those greater than the threshold value  $\gamma$  and those less than the threshold value  $\gamma$ . OLS is then applied to measure  $\alpha_1$  and  $\alpha_2$ . The residual value is calculated via  $\alpha = (\alpha_1', \alpha_2')$ .

$$\hat{e}^*(\gamma) = V^* - D^*(\gamma) \hat{\alpha}(\gamma) \quad (6)$$

The SSEs are then calculated.

$$\begin{aligned} SSE_1(\gamma) &= \hat{e}^*(\gamma)' \hat{e}^*(\gamma) \\ &= V^* \left( I - D^*(\gamma) \left( D^*(\gamma)' D^*(\gamma) \right)^{-1} D^*(\gamma)' \right) V^* \end{aligned} \quad (7)$$

The threshold estimate  $\hat{\gamma}$  is  $\gamma$ , which corresponds to the least SSE inverted:

$$\hat{\gamma} = \arg \min_r SSE_1(\gamma) \quad (8)$$

When the minimal  $\hat{\gamma}$  is determined, the coefficient estimate formula is  $\hat{\alpha} = \hat{\alpha}(\hat{\gamma})$ , the

residual vector formula is  $\hat{e}^* = \hat{e}^*(\hat{\gamma})$ , and the residual variance formula is

$$\hat{\sigma}^2 = \hat{\sigma}^2(\hat{\gamma}) = \frac{1}{n(T-1)} \hat{e}^{*'}(\hat{\gamma})\hat{e}^*(\hat{\gamma}) = \frac{1}{n(T-1)} SSE_1(\hat{\gamma}) \quad (9)$$

where  $n$  is the number of observations, and  $T$  is the time period.

## 2. Test

In this study, an up–down asymmetric nonlinear relationship is assumed to exist between bank size and bank earnings volatility. The null hypothesis refers to  $H_0$ , and the alternative hypothesis is  $H_1$ :

$$\begin{cases} H_0 : \alpha_1 = \alpha_2 \\ H_1 : \alpha_1 \neq \alpha_2 \end{cases}$$

If  $H_1$  is accepted, then  $\alpha_1 \neq \alpha_2$ ; coefficients  $\alpha_1$  and  $\alpha_2$  signify different implications between two intervals. Bank size  $d_i$  indicates the existence of the threshold effect in the volatility range of bank earnings that is an up–down asymmetric nonlinear relationship,

The Wald test for the null hypothesis is the sup–Wald statistic.

$$F = \sup F(\gamma) \quad (10)$$

The model is:

$$F(\gamma) = \frac{(SSE_0 - SSE_1(\hat{\gamma}))/1}{SSE_1(\hat{\gamma})/n(T-1)} = \frac{SSE_0 - SSE_1(\hat{\gamma})}{\hat{\sigma}^2} \quad (11)$$

## 4 Empirical Research

This study uses data from 2009Q1–2013Q1, which is after the announcement of the Lehman Brothers bankruptcy in 2009Q4, to investigate the relationships between bank size and bank earnings volatility in 14 Chinese banks. The study applies the threshold regression model. The dependent variable is bank earnings volatility; the independent variable is bank size; and the control variables are the ratio of non–interest cost to non–interest income, leverage ratio, diversification, and trend.

### 1. Symbols Description:

- (1) Absolute size represents bank size = ln (total assets).
- (2) Cost/income represents the ratio of non–interest cost to non–interest income = noninterest cost/noninterest income.
- (3) Leverage represents leverage ratio = total assets/stockholders' equity.
- (4) Diversification represents levels of diversification= noninterest cost/total revenue.
- (5) ROA represents return on assets = net income/total assets.
- (6) ROE represents return on equity = net income/stockholders' equity.
- (7) Trend represents tendency.

$$\text{Standard Deviation of ROA} = \text{ROA volatility}_{i,t} = \sqrt{\frac{1}{T-1} \sum_{s=1}^T (ROA_{i,t-s} - \frac{1}{T} \sum_{s=1}^T ROA_{i,t-s})^2}$$

$$\text{Standard Deviation of ROE} = \text{ROE volatility}_{i,t} = \sqrt{\frac{1}{T-1} \sum_{s=1}^T (ROE_{i,t-s} - \frac{1}{T} \sum_{s=1}^T ROE_{i,t-s})^2}$$

## 2. Figure Analysis

Figure 2 shows that both ROA and ROE volatilities are at lower levels, and that the leverage ratio is low. The Size\_Absolute chart shows a distinct trend; therefore, the influence of the trend would be uninvolved to avoid overestimating  $R^2$ . Furthermore, the ROA and ROE volatilities would provide appropriate definitions with the independent variable, that is, Size\_Absolute.

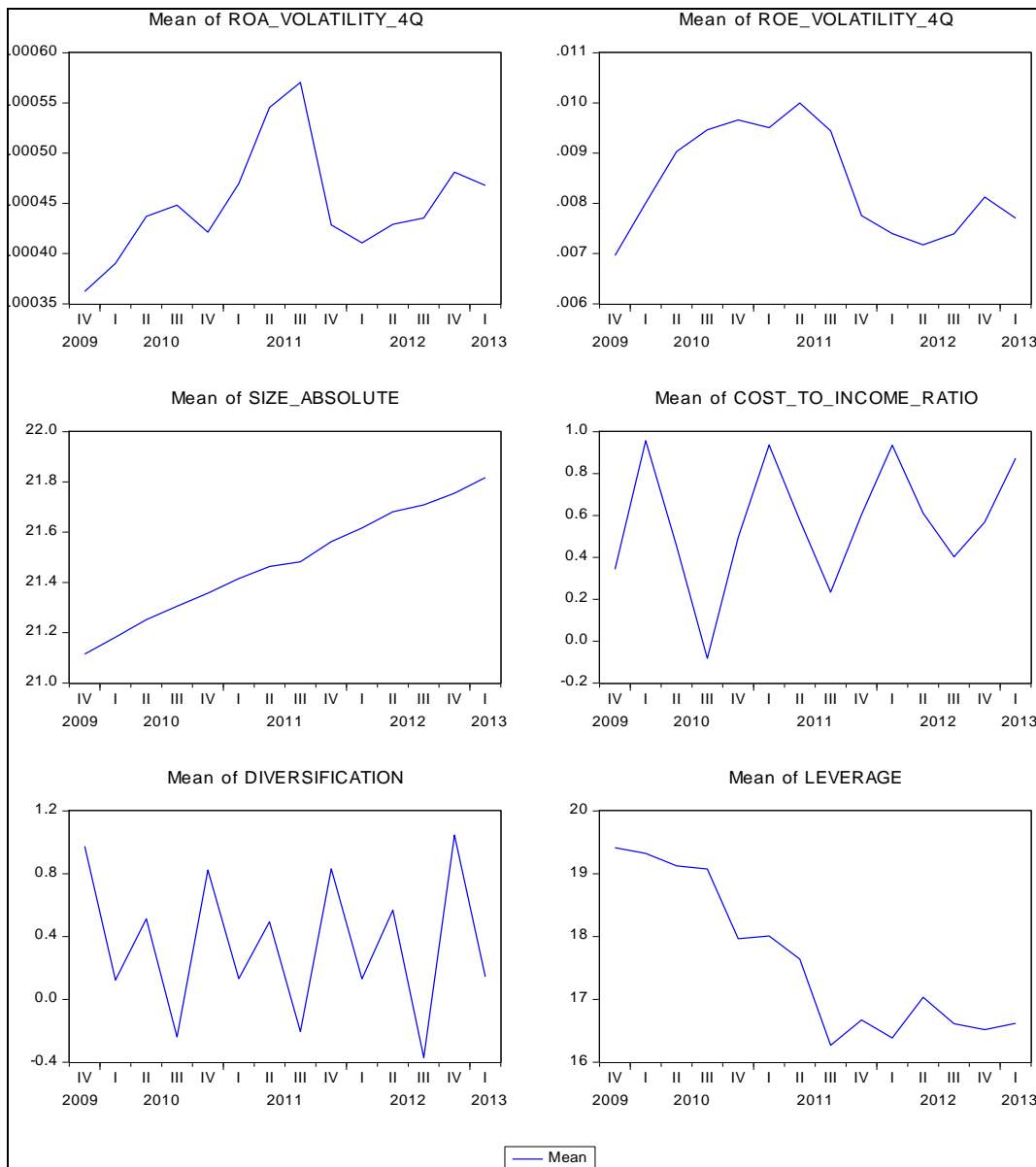


Figure 2: Trend Charts of Variables

### 3. Panel Root Unit Test

Table 1 indicates that the panel root unit test refers to IPS and MW, and all variables reject the null hypothesis of the panel root unit test. The stationary series avoids the problem of spurious regression in the following analyses. The trend should be considered for the Size\_Absolute variable to satisfy the condition of stationary series. Accordingly, the subsequent estimates apply the trend.

Table 1: Results of Panel Root Unit Test

Variable	IPS		MW	
	Statistic (Prob.)	Model	Statistic (Prob.)	Model
ROA_volatility_4q	-2.21486 (0.0134)	intercept	42.1887 (0.0416)	intercept
Size_Absolute	-1.35717 (0.0874)	intercept and trend	74.4473 (0.0000)	intercept and trend
Cost_to_income_ratio	-16.2810 (0.0000)	intercept	129.611 (0.0000)	intercept
Diversification	-5.30311 (0.0000)	intercept	266.667 (0.0000)	intercept
Leverage	-1.65635 (0.0488)	intercept	42.2152 (0.0414)	intercept

#### 4. The threshold model for bank size and ROA volatility

Table 2 reports a significant single threshold effect in the relationship between bank size and ROA volatility. The threshold value is  $-0.9352$ . Specifically, 733,211,391 CNY according to the equation  $[EXP(-0.9352+21.14+0.0526*4)]$ . If the bank size is less than 733,211,391 CNY, the slope coefficient on the ROA volatility is 0.0001227 and is below the 0.1 significance level. By contrast, when the bank size is greater than the threshold value, the slope coefficient on the ROA volatility is  $-0.0002048$  significant at the 0.1 level. A larger bank size indicates smaller ROA volatility. Regarding control variables, a smaller ratio of noninterest cost to noninterest income generates greater earnings volatility. Greater leverage ratio and diversification means better earnings volatility. Figure 3 shows the single Size\_Absolute threshold.

Table 2: Threshold Effects in the Relationship between Bank Size and ROA Volatility

Dependent variable: ROA\_volatility\_4q

Independent variable: Size\_Absolute

Threshold variable: Size\_Absolute

#### Panel A. threshold effect test

Statistic	Single threshold	Double threshold
Threshold -value	-0.9352*	-2.0303 -0.9352
F	34.56505	11.224959
p-value	0.0606	0.6896
Critical Value of F		
1%	42.796218	24.375729
5%	31.446687	27.574654
10%	27.100815	34.790295

Notes: F Statistics and p-values result from repeating the bootstrap procedure 5000 times for each of the two bootstrap tests. \* represents significance at the 10% level.



Panel B. Estimation of Coefficients

Symbol	Coefficient	OLS se	$t_{OLS}$	White se	$t_{White}$
$\hat{\alpha}_1$	0.0001227	0.0001247	0.983962	0.00009775	1.255243
$\hat{\alpha}_2$	-0.0002048*	0.0001430	-1.43217	0.0001187	-1.72536

Note:  $\hat{\alpha}_1$  and  $\hat{\alpha}_2$  are the coefficient estimates for regimes of  $m_{it} \leq \hat{\gamma}_1$  and  $m_{it} > \hat{\gamma}_2$ .

Panel C. Estimation of Coefficients of Control Variables

Symbol	Coefficient	OLS se	$t_{OLS}$	White se	$t_{White}$
$\hat{\theta}_1$	-0.00006246***	0.00002706	-2.3082	0.00002575	-2.42563
$\hat{\theta}_2$	0.00003328**	0.00002022	1.645895	0.00001649	2.018193
$\hat{\theta}_3$	0.00001375***	0.00000402	3.420398	0.00000399	3.446115
$\hat{\theta}_4$	0.00000511*	0.00000266	1.921053	0.00000296	1.726351

- Notes: 1.  $\hat{\theta}_1$ ,  $\hat{\theta}_2$ ,  $\hat{\theta}_3$ , and  $\hat{\theta}_4$  represent the estimated coefficients: Cost\_to\_Income\_Ratio, Diversification, Leverage, and Trend.  
 2. OLS se and White se represent conventional OLS standard errors (considering homoscedasticity) and white-corrected standard errors.  
 3. \*\*\*, \*\*, and \*, represent the significant at 1%, 5%, and 10% levels, respectively.

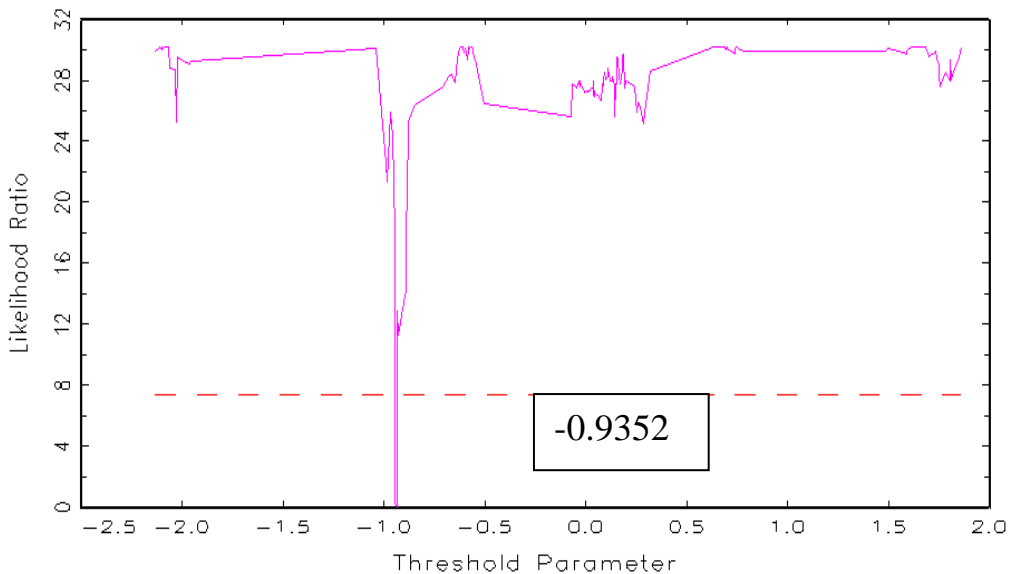


Figure 3: Single Threshold of Size\_Absolute

## 5. The threshold model for bank size and ROE volatility

Figure 3 reports that no significant single threshold effect exists in the relationship between bank size and ROE volatility. Consequently, panel data OLS is applied; the Chi-Sq. statistic is 2.453259, and the P-value is 0.653 in terms of the cross section and period random effects in the Hausman test to reveal that the random effect performs better. Table 5 shows the absence of a significant relationship between bank size and ROE volatility.

Table 3: Threshold Effects in the Relationship between the Bank Size and ROE Volatility

Dependent variable: ROE\_volatility\_4q

Independent variable: Size\_Absolute

Threshold variable: Size\_Absolute

Panel A. threshold effect test

Statistic	Single threshold
Threshold -value	-2.0206323
F	13.209309
p-value	0.602
Critical Value of F	
1%	51.309358
5%	38.429432
10%	33.171564

Note: F Statistics and p-values result from repeating the bootstrap procedure 5000 times.

Panel B. Estimation of Coefficients

Symbol	Coefficient	OLS se	$t_{OLS}$	White se	$t_{White}$
$\hat{\alpha}_1$	0.00158400	0.00331027	0.478511	0.00321588	0.492556
$\hat{\alpha}_2$	-0.00202366	0.00345097	-0.5864	0.00343776	-0.58866

Note:  $\hat{\alpha}_1$  and  $\hat{\alpha}_2$  are the coefficient estimates for regimes of  $m_{it} \leq \hat{\gamma}_1$  and  $m_{it} > \hat{\gamma}_2$ .

Panel C. Estimation of Coefficients of Control Variables

Symbol	Coefficient	OLS se	$t_{OLS}$	White se	$t_{White}$
$\hat{\theta}_1$	-0.00139612	0.00071856	-1.94294	0.00071555	-1.95111
$\hat{\theta}_2$	0.00080566*	0.00053808	1.497287	0.00046100	1.747636
$\hat{\theta}_3$	0.00014976	0.00010702	1.399365	0.00011208	1.336188
$\hat{\theta}_4$	0.00005714	0.00007055	0.809922	0.00006867	0.832096

Notes: 1.  $\hat{\theta}_1$ ,  $\hat{\theta}_2$ ,  $\hat{\theta}_3$ , and  $\hat{\theta}_4$  represent the estimated coefficients: Cost\_to\_Income\_Ratio, Diversification, Leverage, and Trend. \* represents significance at the 10% level.

2. OLS se and White se represent conventional OLS standard errors (considering homoscedasticity) and white-corrected standard errors

Table 4: Results of Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section and period random	2.453259	4	0.653

Table 5: Results for Panel Data OLS on ROE\_VOLATILITY\_4Q

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Size_Absolute	-0.00035	0.000548	-0.62916	0.53
Cost_to_Income_Ratio	-5.00E-05	0.000791	-0.06322	0.9497
Diversification	-0.00055	0.000621	-0.87744	0.3814
Leverage	-0.00019	0.000127	-1.49537	0.1365
Trend	-0.00014*	8.10E-05	-1.6693	0.0967
C	0.012843	0.002577	4.984378	0

Note: \* represents significance at the 10% level.

## 5 Conclusion

A significant single threshold effect is observed in 14 Chinese banks from 2009Q1 to 2013Q1 in the relationship between bank size and ROA volatility. If the bank size is equal to or less than 733,211,39 CNY, then the relationship between bank size and ROA earnings volatility is positive but is below the 0.1 significance level. If the bank size is more than 733,211,39 CNY, then the slope of the bank size and ROA earnings volatility is  $-0.0002048$  significant at 0.1 level. In particular, a larger bank size means smaller bank earnings volatility. Considering ROE, the empirical results show the existence of an insignificant relationship between bank size and bank earnings volatility.

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