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The impacts of risk-taking behaviour and competition on technical efficiency: evidence from the Chinese banking industry

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Abstract

This paper tests the impact of risk and competition on efficiency in the Chinese banking industry over the period 2003-2013. Comprehensive types of risk-taking behaviour are considered including credit risk, liquidity risk, capital risk, and insolvency risk. Competition is measured by the Lerner index. The results are cross-checked using an alternative econometric technique as well as an alternative competition indicator. The findings show that the technical and pure technical efficiencies of Chinese commercial banks are significantly and negatively affected by liquidity risk. They further show that greater competition precedes declines in technical and pure technical efficiencies of Chinese commercial banks. The results suggest that Chinese bank efficiency is significantly affected by bank diversification, banking sector development, stock market development, inflation and GDP growth rate. The findings also indicate that, compared to state-owned commercial banks, joint-stock commercial banks and city commercial banks have lower technical and pure technical efficiencies.

Keywords: technical efficiency; data envelopment analysis; bank risk; Chinese banks; bank competition

JEL classification: G21, C14, G32

1 Introduction

The banking sector in China plays an important role in the development of the country's economy. According to statistics from the World Bank, at the end of 2012, the domestic credit provided by the banking sector in China accounted for 155.1% of GDP[1]. Therefore, the performance of Chinese banks has attracted great attention from the government, banking regulatory authorities and academic researchers. Technical efficiency, as one important indicator of bank performance, measures the extent to which banks have the ability to minimize the amount of inputs used in producing a certain amount of outputs or use certain amounts of inputs to maximize output production. Two components of technical efficiency, namely pure technical efficiency and scale efficiency, provide more information with regard to the source of efficiency. More specifically, pure technical efficiency relates to the ability of bank managers to utilize banks' given resources. Higher ability is reflected by higher pure technical efficiency, while scale efficiency refers to exploiting scale economies by operating at a point where the production frontier exhibits constant returns to scale. Lower scale efficiency indicates that banks have more room to adjust their scale of operation, while the resulting increase in scale efficiency contributes to the overall improvement of technical efficiency.

Several rounds of banking reforms in China have increased competition in the Chinese banking sector. The traditional Structure-Conduct-Performance (SCP)[2] theory uses the concentration ratio as the measure of bank competition. According to the China Banking Regulatory Commission (CBRC), the share of the five state-owned commercial banks' (SOCBs) assets in total banking sector assets in China decreased to 43.3% between 2003 and 2013. However, joint-stock commercial banks (JSCBs) and city commercial banks (CCBs) have kept increasing in size and by 2013, they held 17.8% and 10.03% of total banking sector assets respectively. This shows that competitive conditions in the Chinese banking sector have increased. Table 1 summarizes the assets of SOCBs, JSCBs, CCBs and total banking institutions in China over the period 2003-2013.

<<Table 1---about here>>

Competition has a significant impact on efficiency in the banking industry according to the competition-efficiency and competition-inefficiency hypotheses. These hypotheses have been widely tested in the European and US banking sectors (Brissimis et al., 2008; Casu and Girardone, 2009 and Ariss, 2010); however, they have not been tested in the Chinese banking industry. Testing these hypotheses in the Chinese banking industry will produce policy implications for the Chinese government, as well as the banking regulatory authorities, concerning the enhancement of the performance of Chinese commercial banks.

Not only have the competitive conditions in the Chinese banking industry been improved, but the stability of the industry has been enhanced. According to the statistics released from the CBRC, the non-performing loan ratios (NPLs) over the period 2011-2013 were kept at 1%

[1] The data is from http://data.worldbank.org.

[2] The Structure-Conduct-Performance (SCP) theory argues that in a highly concentrated banking market where competition is low, the banks tend to collude with each other to obtain supernormal profits.

which were lower than the figures for 2008-2010; thus, the credit risk undertaken by the Chinese banking industry has fallen. Furthermore, capital risk undertaken by Chinese commercial banks has also been reduced. CBRC statistics show that over the period 2010-2013, the average capital adequacy ratio of Chinese commercial banks was over 12%, which was higher than the requirement of Basel III (11.5%). The condition of liquidity risk has been improved and, as reported by the CBRC, the liquidity ratio of Chinese commercial banks was 44% by the end of 2013. Although the ratio was lower than the figure for 2012, which was 45.8%, it was higher than the ones for 2010 and 2011, which were 42.2% and 43.3% respectively.

There are studies examining the impact of risk on bank efficiency (see Williams, 2004; Altunbas et al., 2007; Fiordelisi et al., 2011). However, most of them focus on the European banking sector; there are very few studies investigating the impact of risk on efficiency in the Chinese banking sector (see Ariff and Can, 2008; Tan and Floros, 2013; Zhang et al., 2013). In addition, all the above mentioned studies focus on credit risk and insolvency risk in the banking sector, while a consideration of different types of risk-taking behaviour in the Chinese banking industry provides not only policy implications for the Chinese government and banking regulatory authorities to reduce risk-taking behaviour but a way to improve bank performance.

This paper adds to the existing literature and extends the previous studies in the following three ways: 1) it investigates comprehensive types of risk in the Chinese banking sector including credit risk, capital risk, liquidity risk, as well as insolvency risk; 2) the insolvency risk is measured by stability inefficiency rather than Z-score, in order to provide more robustness results; and 3) using the Lerner index rather than the concentration ratio as the competition indicator, it builds on the work of Zhang et al. (2013) to provide more accurate results with regard to the impact of competition on efficiency; 4) the impacts of risk and competition on efficiency in the Chinese banking sector are cross checked by different econometric estimation techniques including bootstrap truncated regression and fractional logit regression; 5) the robustness of the results are also cross-checked by using an efficiency-adjusted Lerner index as an alternative competition indicator.

The results show that the technical and pure technical efficiencies of Chinese commercial banks are significantly and negatively affected by liquidity risk. Furthermore, the findings show that greater competition precedes declines in the technical and pure technical efficiencies of Chinese banks. The findings further report that the efficiency of Chinese commercial banks is significantly affected by bank diversification, banking sector development, stock market development, inflation and GDP growth rate. Finally, compared to the SOCBs, JSCBs and CCBs are found to have lower technical and pure technical efficiencies.

This paper is organized as follows: section 2 briefly reviews the structure of and reforms within the Chinese banking industry, which is followed in section 3 by a review of the literature on the impact of risk on bank efficiency, the competition-efficiency and competition-inefficiency hypotheses, as well as the empirical investigation of efficiency in the Chinese banking sector. Section 4 describes the main methodologies used to estimate the impacts of risk and competition on bank efficiency. Section 5 presents the data used and discusses the empirical

results. Section 6 presents a robustness check and finally section 7 provides a summary and conclusion.

2 The Chinese banking industry

The Chinese banking system followed a mono-bank model before 1978. The central bank - the Peoples' Bank of China (PBC) - took the function of a central bank, as well as engaging in commercial bank operations. A series of economic reforms was initiated by the Chinese government in 1979 to transform the planned economy to a market-based economy. The banking sector in China was also rebuilt and redesigned. A two-tier banking system was created during the period 1979-1993, with the PBC to serve as the Central Bank and four SOCBs[3] to engage in commercial bank lending. A number of JSCBs[4] and rural and urban credit cooperatives were also established during this period. The SOCBs made loans to state-owned enterprises under government direction with no consideration of credit checks and risk monitoring which led to the accumulation of non-performing loans. During this period, competition among Chinese banks was limited.

In order to alleviate the problem of large volumes of non-performing loans in SOCBs, three policy banks were established by the Chinese government in 1994. Their main functions were: 1) to take over the responsibilities undertaken by SOCBs previously and 2) to make loans in line with government policies. Thus, SOCBs were transformed gradually into true commercial banks and they had increasing freedom in terms of credit and lending decisions.

In order to reduce the volumes of non-performing loans in SOCBs, four asset management companies (AMCs) (Cinda AMC, Huarong AMC, Great Wall AMC and Oriental AMC) were established by the government in 1999, with each oriented to a specific state-owned bank. The AMCs purchased and managed non-performing loans and they were under the supervision of the PBC. There have been three non-performing loan write-offs by AMCs - in 1999, 2004 and 2005. In 1999, the four AMCs purchased RMB 1.4 trillion non-performing loans from the four SOCBs and China Development Bank. In 2004, non-performing loans worth RMB 278.7 billion were purchased by Cinda AMC from the Bank of China and the China Construction Bank. In 2005, non-performing loans worth RMB 142.4 billion were purchased by Oriental and Cinda AMC from the Bank of China, RMB 56.9 billion from the China Construction Bank and RMB 64 billion from the Bank of Communication. These purchases reduced the volumes of non-performing loans of Chinese SOCBs and increased their competitiveness in the world.

The Chinese government and banking regulatory authorities deal not only with the issue of non-performing loans, but take measures to increase competition in the banking sector, such as easing the licensing and entry requirements for new small and medium-sized domestic banks. A number of new JSCBs were established in 1996, 2004 and 2005[5]. Furthermore, in order for the

[3]They were the Bank of China (BOC), Agricultural Bank of China (ABC), China Construction Bank (CCB) and Industrial and Commercial Bank of China (ICBC).
[4] These banks include Citic Bank, China Merchant Bank, Shenzhen Development Bank, China Everbright Bank, Industrial Bank, Guangdong Development Bank, HuaXia Bank, Shanghai Pudong Development Bank and Evergrowing Bank.
[5]They are: China Minsheng Bank, China Zheshang Bank and China Bohai Bank.

banks to obtain external funds and additional monitoring and in an attempt to increase competition between them, they were encouraged to list on the stock exchange. By the end of 2013, all the SOCBs had completed successfully their initial public offerings (IPOs), with ICBC having raised US$21.9 billion on the Shanghai and Hong Kong stock exchanges in 2006, becoming the largest IPO at that time. The successful listing of the Agricultural Bank of China on the Shanghai and Hong Kong Stock Exchanges in 2010 broke the record made by the ICBC, and raised funds worth USD 22.1 billion, becoming the largest IPO at that time, while eight of the 12 JSCBs were listed on a variety of stock exchanges[6].

The CBRC, which is the primary government agency and point of control for commercial banks, was established by the State Council[7] in 2003. The CBRC is responsible not only for supervising commercial banking operations, but also for formulating rules and regulations, authorizing the establishment, changes, termination and business scope of banking institutions and conducting on-site examination and off-site surveillance of their operations. The objective is to protect the interest of depositors and maintain market confidence through prudent and effective supervision.

At the end of 2013, the Chinese banking sector consisted of three policy banks, five large-scale (state-owned) commercial banks[8], 12 JSCBs, 145 CCBs and a large number of other financial institutions, such as credit cooperatives, foreign banks, trust companies and the finance companies of enterprise groups.

3 Literature review

The main aim of this paper is to test the impacts of risk-taking behaviour and competition on technical efficiency in the Chinese banking industry. This section firstly reviews relevant literature on the impact of risk-taking behaviour on bank efficiency, and then the literature on the impact of competition on banking efficiency. Finally, it reviews the empirical literature investigating efficiency in the Chinese banking sector.

3.1 The impact of risk on bank efficiency

Risk is regarded as an endogenous variable by a number of studies which have investigated its effect on bank efficiency (see Berger and DeYoung, 1997; Zhang et al., 2013; Altunbas et al., 2007; Fiordelisi et al., 2011). These studies have mixed findings with regard to the impact of risk on bank efficiency. However, a number of studies treat risk as an exogenous variable (see Altunbas et al., 2000; Hughes et al., 2001; Chang and Chiu, 2006; Chiu et al., 2011). The results show that efficiency estimates are affected by taking into consideration the risk factor.

[6] They are: China Merchant Bank, China Citic Bank, Hua Xia Bank, China Everbright Bank, Shanghai Pudong Development Bank, China Minsheng Bank, Industrial Bank and Ping An bank (Shenzhen Development bank).
[7] The State Council is the chief administrative authority of the People's Republic of China.
[8] They are: Bank of China (BOC), China Construction Bank (CCB), Industrial and Commercial Bank of China (ICBC), Agricultural Bank of China (ABC) and Bank of Communication (BOCOM).

Berger and Humphrey (1997) argue that, whether or not risk should be included in the estimation of bank efficiency depends on whether "bad luck" [9] or "bad management" [10] dominates. In particular, if poor performance results from bad luck, risk should be treated as an exogenous variable in the efficiency estimation. On the other hand, if the poor performance results from bad management, the risk should be treated as an endogenous variable.

Berger and DeYoung (1997) argue that the hypotheses can be tested if non-performing loans are excluded from the estimation of bank efficiency. Furthermore, the impact of risk on the efficiency of the Chinese banking sector in the current study is examined in the second stage analysis; thus, the efficiency estimates in the first stage should not take into consideration the risk factor.

3.2 Competition-inefficiency and competition-efficiency hypotheses

Competition-inefficiency hypothesis

The competition-inefficiency hypothesis suggests that competition leads to a decline in bank efficiency for the following reasons. First, as argued by Boot and Schmeits (2005), the relationships between customers and banks are less stable and shorter in a highly competitive environment. Furthermore, greater bank competition increases customers' propensity to switch to other service providers. The information asymmetries are amplified by this phenomenon and additional resources for screening and monitoring borrowers are required. Second, Chan et al. (1986) argue that a shorter duration of bank relationships can be expected in a competitive environment; the reduction of relationship-building activities inhibits the reusability and value of information. The negative impact of competition on efficiency is supported by the empirical studies of Evanoff and Ors (2002), DeYoung et al. (1998) and Kumbhakar et al. (2001).

Competition-efficiency hypothesis

The competition-efficiency hypothesis is derived from the "efficient structure hypothesis" and suggests that there is a positive impact of competition on efficiency. This effect can be explained by Zarutskie (2013) who argues that greater competition induces banks to specialize and focus on certain types of loans or particular groups of borrowers. This induces bank managers to adjust their lending technologies. The costs of processing and originating loans can be lowered and the borrowers can be better monitored. This positive impact can also be explained by the "Quiet Life hypothesis" which argues that managers with monopoly power enjoy a share of monopoly rents, they are careless in their expense management and working effort is reduced which leads to a decline in efficiency. The existence of a positive impact of competition on efficiency is also supported by Chen (2007) and Dick and Lehnert (2010).

3.3 Investigation of efficiency in the Chinese banking sector

[9] According to the bad luck hypothesis, the increases in problem loans result from exogenous events; it does not have a strong relationship with managers' skills and their risk-taking appetite (Berger and DeYoung, 1997).

[10] According to the bad management hypothesis, banks with lower levels of efficiency are not well managed, while the bank manager has lower ability to control and monitor expenses; this leads to higher costs and a larger volume of non-performing loans (Berger and DeYoung, 1997; Williams, 2004).

There are a number of empirical studies published on the efficiency of the Chinese banking sector (Ariff and Can, 2008; Berger et al., 2009; Sufian and Habibullah, 2011; Sufian and Majid, 2009; Kumbhakar and Wang, 2007; Zhang et al., 2012; Du and Girma, 2011; Huang and Fu, 2013; Tan and Floros, 2013; Wang et al., 2014). The findings from most of these studies show that JSCBs have higher efficiency than SOCBs, while the efficiency of Chinese commercial banks can be improved by increasing foreign participation.

Few studies have investigated the impact of risk on efficiency in the Chinese banking industry. Using a non-parametric approach, Ariff and Can (2008) investigate the cost and profit efficiencies of 28 Chinese commercial banks over the period 1995-2004. The findings suggest that improving risk management is helpful in increasing the efficiency of Chinese banks[11]. Berger et al. (2009) use a stochastic frontier approach to investigate the cost and profit efficiencies of 38 Chinese commercial banks with different ownership types over the period 1994-2003. The findings suggest that large volumes of non-performing loans precede declines in efficiency in SOCBs[12]. Tan and Floros (2013) use a three-stage least square estimator to investigate the inter-relationships between bank efficiency, risk and capitalization over the period 2003-2009. The empirical results suggest that there is a positive and significant relationship between risk and efficiency[13]. Using a sample of commercial banks from China, India, Russia and Brazil, Zhang et al. (2013) test the impact of risk on bank efficiency. The results indicate that banks with lower levels of risk have higher efficiency[14].

There is only one study testing the impact of competition on bank efficiency in China. Zhang et al. (2012) use an output-oriented stochastic distance function approach to evaluate the total factor productivity of 150 Chinese commercial banks over the period 1999-2008. They also investigate the effect of competition on bank profit efficiency. The empirical results suggest that efficiency in the Chinese banking industry is significantly affected by competition in the financial services industry[15].

In summary, there are extensive pieces of research investigating efficiency in the Chinese banking sector; however, few studies also examine the impact of risk on efficiency in the Chinese banking sector. This paper contributes to the empirical literature by comprehensively investigating risk conditions in the Chinese banking sector. In addition, insolvency risk, which was measured by Z-score in previous studies (Iannotta *et al*., 2007; Liu and Wilson 2013, Liu *et al*., 2013), is measured by stability inefficiency in the current paper, which will provide more accurate results (see section 4.2 for detail). Furthermore, by using the Lerner index rather than the concentration ratio and the index of competition in financial markets (Zhang et al., 2013; Zhang et al., 2012) as the competition indicator, this study provides more accurate results with regard to the impact of competition on efficiency in the Chinese banking industry. Finally, this

[11] This study focuses on credit risk, liquidity risk and capital risk.
[12] This study focuses on credit risk only.
[13] This study focuses on credit risk and insolvency risk.
[14] Quite a few risks have been investigated including credit risk, liquidity risk, capital risk, market risk as well as overall risk.
[15] An index of competition in financial markets is provided in the study which is very rarely used in the empirical literature.

study uses bootstrapped truncated regression to test the impacts of risk and competition on bank efficiency in China. This is then cross checked by fractional logit regression.

4 Methodology

Due to the fact that the main aim of this paper is to test the impacts of risk-taking behaviour and competition on technical efficiency in the Chinese banking industry, this section is structured as follows: first, the method used to estimate the technical efficiency, pure technical efficiency and scale efficiency is presented, which is followed by the presentation of the method used to measure bank risk. This study investigates different types of risk-taking behaviour in the Chinese banking industry; namely credit risk, liquidity risk, capital risk, as well as insolvency risk. The former four types of risk mentioned are measured by relevant accounting ratios. Credit risk is measured by the ratio of non-performing loans to total loans, where the higher figure of this ratio indicates higher credit risk (see Fiordelisi et al., 2011; Beck et al., 2013; Pan and Wang, 2013; Craig and Dinger, 2013; Liang et al., 2013; Abedifar et al., 2013; Farruggio and Uhde, 2015). Liquidity risk is measured by the ratio of liquid assets to total assets, where the higher figure of this ratio shows that the bank has lower liquidity risk (see Altunbas et al., 2000; Demirguc-Kunt and Huizinga., 2004; Altunbas et al., 2007; Brissimis et al., 2008; Goddard et al., 2009; Radic et al., 2012). Capital risk is measured by the total regulatory capital ratio, where a higher total regulatory capital ratio indicates that the bank has lower capital risk (see Kleff and Weber, 2008; Francis and Osborne, 2012; Distinguin et al., 2013; Molyneux et al., 2014; Onali, 2014). The last type of risk-taking behaviour investigated is insolvency risk; rather than using an accounting ratio, namely the Z-score, we use a translog specification to estimate stability inefficiency since it is more robust (see Fang et al., 2011; Tabak et al., 2012). This estimation is illustrated in Section 4.2. Section 4.3 discusses the method used to measure competition in the Chinese banking industry. Further, Section 4.4 explains the method used to test the impacts of risk and competition on technical efficiency, while Section 4.5 discusses the possible impacts of the relevant controlled variables on the technical efficiency of Chinese commercial banks.

4.1 Estimation of technical efficiency in the Chinese banking sector

The efficiency estimates in this study are obtained using Data Envelopment Analysis (DEA). DEA, which is a linear programming technique originated by CCR (Charnes, Cooper and Rhodes, 1978). The CCR model measures the efficiency of each Decision Making Unit (DMU) which is obtained as a maximum of a ratio of weighted outputs to weighted inputs. This denotes that the less are the inputs invested in producing given outputs, the more efficient is the production. The CCR model presupposes that there is no significant relationship between the scale of operation and efficiency by assuming constant returns to scale (CRS). The CRS assumption is only suitable when all DMUs are operating at an optimum scale.

Banker *et al*. (1984) extend the CCR model by relaxing the CRS assumption. The resulting "BCC" model was used to assess the efficiency of DMUs characterized by variable returns to scale (VRS). The VRS assumption provides the measurement of pure technical efficiency (PTE), which is the measurement of technical efficiency devoid of the scale efficiency effect. In other words, the difference between technical efficiency and pure technical efficiency lies in the

fact that the latter measures purely the inefficiency derived from managerial underperformance. The CCR model can be expressed as follows:

$$\min_{\theta,\lambda} \theta, subjectto - y_i + Y\lambda \geq 0, \theta X_i - X\lambda \geq 0, \lambda \geq 0 \quad (1)$$

Where θ is a scalar and λ is a N×1 vector of constants, Y represents all input and output data for N firms, X_i are individual inputs and y_i the outputs for the ith firm. The efficiency score for each DMU is given by θ; it takes a value between 0 and 1, which indicates the efficiency level.

The CRS linear programming problem can be easily modified to account for VRS by adding the convexity constraint, $N1'\lambda = 1$, to provide:

$$\min_{\theta,\lambda} \theta, subjectto - y_i + Y\lambda \geq 0, \theta X_i - X\lambda \geq 0, N1'\lambda = 1, \lambda \geq 0 \quad (2)$$

Where N1 is an N×1 vector of ones. This approach forms a convex hull of intersecting plans which envelop the data points more tightly than the CRS conical hull; this provides pure technical efficiency scores which are greater than or equal to those obtained using the CRS model. If the efficiency scores obtained from the CRS model and the VRS model are different, this indicates that the DMU has scale inefficiency, and that the scale inefficiency can be calculated from the difference between the VRS technical efficiency (TE) score and the CRS TE score. The relationship between CRS and VRS is given below:

$$TE_{CRS} = TE_{VRS} * SE \quad (3)$$

The main argument for using the DEA rather than parametric techniques, such as SFA, lies in the fact that it works particularly well with small samples. Furthermore, it is able to handle multiple inputs and outputs stated in different measurement units and it does not necessitate knowledge of any functional form of the frontier (see Charnes *et al*., 1995). Most empirical papers show that using DEA to estimate the efficient frontier can yield robust results (see Seiford and Thrall, 1990). Therefore, this study uses the DEA CCR and BCC models to measure the technical, pure technical and scale efficiencies of Chinese banks (Tan and Floros, 2013; Chortareas et al., 2012; Chorareas et al., 2013).

The intermediation approach for the selection of inputs and outputs is taken rather than the production approach, with the latter suited to branch evaluation. Banks are viewed as financial intermediaries which accumulate deposits and purchase funds and then intermediate these funds (Sealey and Lindley, 1977). In selecting the input and output variables, this study follows the suggestions made by Berger and Humphrey (1997); they argue that deposits have a dual role and should be regarded as both an input (which is used to fund loans) and an output (through which it provides services to depositors). The inputs and outputs used in this study and their statistics are shown in Table 2. To be more specific, this study uses two inputs price of deposit (measured by the ratio of interest expenses to total deposits) and the price of capital (measured by the ratio of non-interest expenses to fixed assets). Two input prices are considered due to the fact that non-interest expenses include the labour cost as well (Hasan and Morton, 2003). In

other words, the price of capital considers the factors relating to the price of physical capital as well as the price of human capital. There are four outputs selected in the current study, which are total loans, securities, non-interest income and total deposit. This selection follows the study of Fu and Heffernan (2007)

4.2 Estimation of stability in the Chinese banking sector-stability inefficiency

Fang et al. (2011) argue that the potential stability of banks cannot necessarily be reflected by the Z-score[16]. The deviation from the banks' current stability and the maximum stability must be considered. This study provides a measure of a bank's stability inefficiency by estimating a stochastic frontier (Aigner et al., 1977; Meeusen and Van den Broeck, 1977) with the Z-score as the dependent variable of a translog specification. The equation used to estimate the frontier can be expressed as follows:

$$LN(\frac{Z-score}{W_2})_{it} = \delta_0 + \sum_j \delta_j LNY_{jit} + \frac{1}{2}\sum_j \sum_k \delta_{jk} LNY_{jit} LNY_{kit} + \beta_1 LN(\frac{W_1}{W_2})_{it} + \frac{1}{2}\beta_{11} LN(\frac{W_1}{W_2})_{it} LN(\frac{W_1}{W_2})_{it} + \sum_j \theta_j LNY_{jit} LN(\frac{W_1}{W_2})_{it} + \varepsilon_{it} \quad (4)$$

W represents the input price; this study considers two input prices which are the price of funds (the ratio of interest expenses to total deposits) and the price of capital (the ratio of non-interest expenses to total assets). Y represents four outputs which are total loans, total deposits, securities and non-interest income. The sub-indices i and t represent bank i operates at time t, while j and k represent different outputs. The error term ε_{it} equals $\nu_{it} - \upsilon_{it}$. The first term ν_{it} captures the random disturbance which is assumed to be normally distributed and represents the measurement errors and other uncontrolled factors, i.e. ν_{it} ~N(0, σ_v^2). The second term υ_{it} captures the technical and allocative inefficiency, both under managerial control, and it is assumed to be half-normally distributed, i. e. $\upsilon_{it} \sim N^+(\mu_{it}, \sigma_v^2)$. Higher stability inefficiency indicates higher risk, while lower stability inefficiency means the risk is lower.

4.3 Estimation of competition in the Chinese banking sector-Lerner index

Previous studies have used a variety of methods to investigate the competitive conditions in the banking industry (see Al-Muharrami et al., 2006; Matthews et al., 2007; Jeon et al., 2011;

[16] The Z-score reflects the extent to which banks have the ability to absorb losses. Thus, a higher value of Z-score indicates lower risk and greater stability. The Z-score has been widely by empirical studies used to measure the stability of financial institutions (see Hesse and Cihak, 2007; Iannotta *et al*. 2007; Beck *et al*. 2009; Liu and Wilson 2013; Liu *et al*., 2013; Fiordelisi and Mare, 2014). The Z-score can be expressed as follows:

$$Z = \frac{ROA + E/A}{\sigma(ROA)} \quad (5)$$

where ROA is banks' Return on Assets, E/A is the ratio of equity to total assets, and $\sigma(ROA)$ is the standard deviation of Return on Assets.

Olivero et al., 2011; Tabak et al., 2012; Cipollini and Fiordelisi, 2012; Fungacova et al., 2014; Fu et al., 2014). The measurement of competition in the above mentioned studies mainly includes Panzar-Rosse H statistics, the Boone indicator and the Lerner index.

Although there are a number of studies which have used the Panzar-Rosse H statistic to investigate competition in the banking sector, it suffers from two main drawbacks. First, the H statistic was developed on the basis of a static model and there are no predictions of the H-statistic (Leuvensteijn et al., 2011). In other words, the estimate is surrounded by a degree of uncertainty. Secondly, the overall market equilibrium required by the test cannot be fulfilled because of market entry and exit, which leads to further limits on the interpretation of such an analysis (Claessens and Laeven, 2004).

The Boone indicator also suffers from two disadvantages. First, it makes the assumption that part of the efficiency gains achieved by banks is passed onto consumers. In addition, this indicator also suffers from idiosyncratic variation, i.e. uncertainty (see Tabak et al., 2012).

The Lerner index is used in this study mainly because: 1) it can be estimated by each bank in each year; 2) it can estimate the competitive conditions (market power) for three different ownership types of Chinese banks; 3) it does not suffer from the limitations of other competition indicators such as the Panzar-Rosse H statistic and the Boone indicator (see Claessens and Laeven, 2004; Leuvensteijn et al., 2011; Tabak et al., 2012).

The Lerner index is defined as the difference between a bank's price and the marginal cost, divided by the price. The index value ranges from a maximum of 1 to a minimum of zero, with higher numbers indicating greater market power and hence lower competition. The Lerner index represents the extent to which a particular bank has market power to set its price above the marginal cost.

The price is computed by estimating the average price of bank production as the ratio of total revenue to total assets (Fernandez de Guevara et al., 2005; Carbo et al., 2009a, b). The marginal cost is estimated on the basis of a translog cost function as follows:

$$LN(\frac{C}{W_2})_{it} = \delta_0 + \sum_j \delta_j LNY_{jit} + \frac{1}{2}\sum_j\sum_k \delta_{jk} LNY_{jit} LNY_{kit} + \beta_1 LN(\frac{W_1}{W_2})_{it} + \frac{1}{2}\beta_{11} LN(\frac{W_1}{W_2})_{it} LN(\frac{W_1}{W_2})_{it} + \sum_j \theta_j LNY_{jit} LN(\frac{W_1}{W_2})_{it} + \varepsilon_{it} \quad (6)$$

where C represents total cost of the bank, Y represents four outputs including total deposits, total loans, non-interest income and securities, W stands for two input prices with W1 representing the price of funds which is measured by the ratio of interest expenses to total deposits, W2 represents the price of capital, which is measured by the ratio of non-interest expenses to fixed assets The linear homogeneity is ensured by normalizing the dependent variable and W1 by anther input price W2.

The marginal cost of loans can be obtained by taking the first derivative of the dependent variable in the above equation in relationship to the output loans as follows:

$$MC_{ilt} = (\frac{C_{it}/W_2}{Y_{ilt}})(\delta_{j=l} + 2\delta_{ll}LNY_{ilt} + \sum_{k-1....k,k\neq l}\delta_{lk}LNY_{ikt} + \theta_l LN(\frac{W_1}{W_2})) \qquad (7)$$

The summary statistics of the variables used to estimate efficiency and Lerner index are provided in Table 2

<<Table 2---about here>>

4.4 Estimation of the impacts of risk and competition on technical efficiency-bootstrap truncated regression

This study follows the estimation method proposed by Simar and Wilson (2007) who investigate the determinants of bank efficiency using the bootstrap technique. Before illustrating the estimation procedure, the following model is given:

$$\hat{\delta}_i = Z_i\beta + \varepsilon_i \qquad (8)$$

Where Z_i is a vector of explanatory variables which are supposed to have impacts on bank efficiency and β refers to a vector of parameters with some statistical noise ε_i. Simar and Wilson (2007) argue that the advantage of bootstrapped truncated regression lies in the fact that it produces, with bias corrected estimates of δ, valid estimates for the parameters in the regression model.

The bootstrap algorithm is described in the following steps:

1) Calculate the DEA technical efficiency score $\hat{\delta}$ for each bank in each year:

$$\hat{TE} = \min imize_{\theta,\lambda}\theta, subjectto - Y_i + Y\lambda \geq 0, \theta X_i - X\lambda \geq 0, \lambda \geq 0$$

2) Use the maximum likelihood method to estimate the truncated regression of $\hat{TE}$ on Z_i to provide an estimate $\hat{\beta}$ of β and an estimate $\hat{\sigma}_\varepsilon$ of σ_ε

3) For each bank i=1……,I, repeat the next four steps (1-4) L times to yield a set of bootstrap estimates as $A = \{(\hat{\beta}^*, \hat{\sigma}^*_\varepsilon)_b\}_{b=1}^L$

a. Draw ε_i from the N(0, $\hat{\sigma}^2_\varepsilon$)distribution with left truncation at $(1-\hat{\beta}Z_i)$.

b. Compute $TE^*_i = \hat{\beta}Z_i + \varepsilon_i$

c. The maximum likelihood method is used to estimate the truncated regression of TE^*_i on Z_i, yielding estimates ($\hat{\beta}^*, \hat{\sigma}^*_\varepsilon$).

4) Use the bootstrap results to construct confidence intervals.

4.5 Determinants of the technical efficiency of Chinese banks

In addition to investigating the impacts of risk and competition on technical efficiency, this study also controls for various bank-specific, industry-specific and macroeconomic variables which are supposed to have impacts on technical efficiency. The bank-specific determinants include bank size, bank diversification, and bank profitability. In addition, banking sector development and stock market development are included as industry-specific variables, while inflation and GDP growth rate are the macroeconomic determinants of technical efficiency.

Bank size is measured by the natural logarithm of total assets. This measure is used widely in the empirical literature (see Goddard et al., 2004; Athanasoglou et al., 2008; Dietrich and Wanzenried, 2011). Banks with larger size are able to reduce costs from economies of scale and scope. The cost reduction precedes an improvement in efficiency; hence, it is expected that size is significantly and positively related to the technical efficiency of Chinese banks. Bank diversification is measured by the ratio of non-interest income to gross revenue (see Tan and Floros, 2012a; 2012b; 2012c). An increase in the variety of business engaged in by banks can decrease the operational cost from the economies of scope; the resultant reduction in cost precedes an increase in bank efficiency; thus, it is expected that this variable has a significant and positive sign. This study investigates comprehensive types of risk in the Chinese banking industry, including the following: credit risk, liquidity risk, capital risk, and insolvency risk. According to the bad luck hypothesis, increases in risk result in additional costs and managerial effort which further precede declines in bank efficiency (Berger and DeYoung, 1997). So, it is expected that risk has a significant and negative impact on bank efficiency. Profitability is measured by the traditional accounting indicator- Return on Assets (ROA); ROA is chosen as the profitability indicator due to the fact that it has emerged as the key ratio for the evaluation of bank profitability (Golin, 2001; Athanasoglou et al., 2008; Garcia-Herrero et al., 2009; Lee and Hsieh, 2013). It is expected that ROA affects bank efficiency positively. The profitable banks are more able to control all aspects of costs which leads to higher efficiency (Girardone et al., 2004).

Bank competition is measured by the Lerner index. Following the competition-efficiency and competition-inefficiency hypotheses discussed in the literature review, there is no prior expectation of this variable. Further, banking sector development is measured by the ratio of banking sector assets to GDP (see Tan and Floros, 2012a; 2012b; 2012c). A more developed banking market indicates that the demand for banking services is large, due to the fact that it is quite difficult for new banks to enter the market; hence, the relative short supply and increase in demand lifts the prices for banking services. The resulting improvement in bank profitability induces bank managers to be less careful in controlling costs which leads to a decline in bank efficiency. Therefore, it is expected that this variable has a significant and negative impact on bank efficiency. Stock market development is measured by the ratio of stock market capitalization to GDP (see Tan and Floros, 2012a; 2012b; 2012c). It is expected to be significantly and positively related to bank efficiency. A more highly developed stock market provides more valuable information to the banks in terms of credit conditions of different companies, and hence, the resulting reduction in monitoring costs leads to an improvement in bank efficiency.

Inflation is expected to affect bank efficiency negatively due to the fact that under inflationary conditions, banks might feel less pressure to control their inputs, and therefore they become less efficient (Lozano-Vivas and Pasiouras, 2010). Higher GDP growth stimulates investment; the resulting increase in the volumes of banking business in terms of traditional loan-deposit services and non-interest generating activities reduces bank costs and leads to an improvement in bank efficiency. Therefore, it is expected that GDP growth rate affects technical efficiency positively. Table 3 presents the variables used in the paper.

<<Table 3---about here>>

5 Data and Empirical results

The banking data includes 100 Chinese commercial banks (5 SOCBs, 12 JSCBs and 83 CCBs) over the period 2003-2013. Due to the fact that not all the selected banks have available information for all years, an unbalanced panel dataset is chosen in order not to lose degrees of freedom. The bank-specific variables are selected from the Bankscope database. The banking sector development is collected from the CBRC annual reports, while both the stock market development and the macroeconomic data (inflation and annual GDP growth rate) are collected from the World Bank database. Table 4 shows the summary statistics of the independent variables used. The table shows that the differences in liquidity risk undertaken by Chinese commercial banks are smaller than the ones for credit risk and capital risk, while the higher levels of credit risk undertaken by Chinese commercial banks are attributed to the fact that during 2003-2006, there were large volumes of non-performing loans in SOCBs, especially in the Agricultural Bank of China. Further, the large difference in capital risk is attributed to the opening of one joint-stock commercial bank; namely, the China Bohai Bank in 2006 which had a total regulatory capital ratio of over 60%. The data indicates that Chinese banks have big differences in the degree of diversified activities engaged in, while the differences in profitability are smaller. The difference in bank size is attributed to the fact that SOCBs are bigger than JSCBs, while CCBs are the smallest. The competition indicator shows that Chinese banks have quite high competitive power, while the difference in the competitive power between banks is not large. The statistics show further that there is a stronger volatility with regard to the development of the stock market than of the banking sector and the macroeconomic environment. The stronger volatility of stock market development can be attributed mainly to the segregation reform initiated by the Chinese government in 2005 which led to a substantial amount of companies being listed on the stock exchange. By the end of 2007, there were 1550 listed companies on the Shanghai and Hong Kong Stock Exchanges, the value of which reached RMB 32.71 billion, accounting for 132.6% of GDP in that year.

<<Table 4--about here>>

5.1 Technical efficiency of state-owned, joint-stock and city commercial banks in China

Table 5 shows the technical efficiency, pure technical efficiency and scale efficiency scores of Chinese SOCBs, JSCBs and CCBs derived from the non-parametric DEA CCR and BCC models. The results show that the SOCBs have the highest technical efficiency over the period

examined, followed by the CCBs. The JSCBs are found to be the least technically efficient. The highest technical efficiency of SOCBs can be attributed to the fact that all of them finished their initial public offerings over the period examined. The initial public offerings improve bank management and further precede improvements in bank efficiency, while the lowest technical efficiency of JSCBs can be explained by the fact that they mainly service the small and medium size enterprises over the country, easily outnumbering the large state-owned enterprises. The resulting greater competition leads to a decline in efficiency.

Based on the decomposition of technical efficiency into pure technical efficiency and scale efficiency, the results suggest that SOCBs are most pure technically efficient, followed by JSCBs, while CCBs have the lowest pure technical efficiency. It is further noticed that scale efficiency is higher than pure technical efficiency which indicates that scale efficiency contributes more than pure technical efficiency to the overall technical efficiency of the Chinese banking sector. In other words, the inefficiency of Chinese commercial banks is attributed to pure technical inefficiency rather than scale inefficiency.

<<Table 5---about here>>

5.2 Competitive conditions in the Chinese banking industry

Figure 1 shows the competitive conditions in the Chinese banking industry over the period examined. The Lerner index suggests that over the period 2003-2013, SOCBs had the greatest market power. In other words, the competition among SOCBs in China is lower than for JSCBs and CCBs. This finding can be attributed mainly to the following factors: 1) the number of SOCBs is very low i.e. there are only five SOCBs (the low number of banks in this bank ownership type limits the competition between them); 2) government support to these banks significantly reduces the competitive conditions among the banks in this banking ownership type. Due to the "too big to fail" issue, the government provided different kinds of support to these banks, such as non-performing loan write-offs and capital injections. This support significantly reduced the banks' incentives to improve efficiency and further decreased competition among them; 3) although there have been several rounds of banking reforms in China, each of the SOCBs has not limited their business to the specific economic sector, they established long-run relationships with specific large-scale enterprises. In other words, each of the SOCBs conducts their business with specific enterprises and the link between the enterprises and the specific SOCB reduces competition.

Figure 1 shows that after 2005, CCBs had greater market power than JSCBs. In other words, there was lower competition among CCBs compared to JSCBs. The lower competition among this banking ownership type can be explained as follows: 1) most of the CCBs had not offered their initial public offerings yet, while the lower pressure of obtaining funds from the general public further reduced the competition between them. Furthermore, one of the characteristics of this banking ownership type is that most of the CCBs are still operating within the city where they were established (although the geographical limitation for operation has already been removed for CCBs with higher performance). In other words, each city commercial bank just serves the enterprises within their own city. This results in a

decline in bank competition. Finally, Figure 1 shows that the competition among JSCBs is the highest over the period 2005-2013. The finding is attributed mainly to the fact that most of the JSCBs have already been listed on the stock exchange and the incentive to obtain more funds from the general public induces an increase in bank competition. Secondly, JSCBs mainly serve small and medium size enterprises which account for over 90% of total enterprises in China. In addition, the JSCBs have comprehensive branches all over the country; this leads to an increase in competition among the banks in this banking group. Thirdly, through several rounds of banking reforms in China, Chinese JSCBs have successfully attracted a number of foreign investors. The participation of foreign banks in Chinese banking operations not only brings more advanced technology and experience in risk management, but it also induces bank managers to further improve bank performance which then leads to an increase in competition among the banks in this banking group.

<<Figure 1---about here>>

5.3 Risk conditions in the Chinese banking sector over the period 2003-2013

Figures 2a, 2b, 2c, and 2d report the risk conditions of Chinese banks over the period 2003-2013, as measured by credit risk, liquidity risk, capital risk, and insolvency risk. Figure 2a shows that, over the period 2003-2008, the credit risk of SOCBs is substantially higher than the ones for JSCBs and CCBs, while the large volume of non- performing loans in SOCBs is attributable mainly to the fact that one of the banks (the Agricultural Bank of China) had non-performing loan ratios of more than 23% over the period 2003-2007. Although the figure shows that, after 2008, all the three different ownership types of Chinese commercial banks have little difference with regard to the levels of credit risk undertaken, the credit risk of CCBs is still higher than the one for JSCBs between 2005 and 2010. The lowest credit risk of JSCBs is attributed mainly to the fact that the participation of foreign investors in domestic JSCBs improves the techniques of risk management and further precedes a decline in credit risk. The significant lower amount of credit risk for all three different ownership types of Chinese banks after 2008 is attributed to the financial crisis, which induced the government and banking regulatory authorities to improve the process of credit checking, risk monitoring and risk management.

<<Figure 2a---about here>>

Liquidity risk, another risk indicator, is represented in Figure 2b, and shows that in general, the ratio of liquid assets to total assets of SOCBs is the lowest compared to the ones for JSCBs and CCBs. In other words, the SOCBs have the highest liquidity risk. This can be explained by the fact that SOCBs mainly make loans to large enterprises around the country, the loan demand for which is substantially higher than for medium and small enterprises, which are served by JSCBs and CCBs. On the other hand, the liquidity is the highest in CCBs over the period 2005-2008; this can be explained by the fact that the loans made by CCBs focus on small enterprises within the city, the amount of which is much smaller than

the one for SOCBs. It is clear that the JSCBs have the highest liquidity after 2010. This can be explained by the fact that the annual meeting of directors of JSCBs was held in 2010 and the CBRC emphasized the importance of further increasing the liquidity of JSCBs.

<<Figure 2b---about here>>

The capital levels of SOCBs and JSCBs increased in 2010 compared to the previous year. This was due to two banks listing on the stock exchange - the Agricultural Bank of China (one of the SOCBs) and the China Everbright Bank (one of the JSCBs). Although the capital level of CCBs decreases in some of the years over the period examined, it increases for most of the years. This increase in the capital levels is attributed to the contribution from city level government.

<<Figure 2c---about here>>

This study looks at the insolvency risk of the Chinese banking industry on a year by year basis, which is reflected by the stability inefficiency shown in Figure 2d. There is a strong volatility regarding the risk conditions in the Chinese banking sector over the period 2003-2006, while during 2007-2013 the Chinese banking sector has lower risk volatility. The stronger volatility over the period 2003-2006 can be explained by the fact that there is a large amount of non-performing loans in the Chinese commercial banks, especially in SOCBs, and the capital level of SOCBs is quite low. Furthermore, the Chinese government initiated a number of measurements to deal with it, such as capital injection and non-performing loan write-off, while the financial crisis which occurred in 2007-2008 induced bank managers to be more careful in conducting business. The 2008 Olympic Games held in Beijing further promoted the economic growth of China. The resultant decline in the probability of default decreased the risk and the increase in the capital level of Chinese commercial banks further improved the stability of the Chinese banking sector.

<<Figure 2d---about here>>

5.4 The impacts of risk and competition on efficiency in the Chinese banking sector

Table 6 reports the impacts of risk and competition on the technical efficiency of Chinese banks under a bootstrap truncated regression analysis. The findings suggest that lower liquidity risk and lower insolvency risk precede an improvement in both the technical efficiency and the pure technical efficiency of Chinese banks. With regard to other bank-specific determinants of efficiency, the findings suggest that bank diversification is significantly and positively related to technical, pure technical and scale efficiencies, i.e. Chinese banks with more diversified activities have higher efficiency scores. This result is in line with the finding of Sufian (2009) for a sample of banks in Malaysia. However, it is in direct contrast with the finding of Stiroh and Rumble (2006) for US finance companies. The result can be explained by the fact that Chinese banks engaging in more diversified activities have the ability to reduce their costs via economies of scope which further precedes an improvement in efficiency.

The Lerner index, as a measure of bank competition, has significant and positive signs for technical and pure technical efficiencies, suggesting that greater competition precedes a decline in the technical and pure technical efficiencies of Chinese banks. This is in line with the competition-inefficiency hypothesis. In the Chinese banking industry, greater competition induces bank managers to lower the credit requirement for making loans to different enterprises; the resulting increase in monitoring costs precedes a decline in efficiency. The findings suggest that banking sector development in China has significant and positive impacts on the technical and pure technical efficiencies of Chinese banks as reflected by the significant and positive signs of this variable. This result indicates that the technical and pure technical efficiencies of Chinese banks are greater in a more developed banking sector. A more highly developed banking sector reflects the fact that the demand for banking services is large. The increased volumes of traditional loan-deposit services and non-interest generating activities engaged in by Chinese banks reduce the costs of banks via economies of scale and economies of scope; hence, the cost reduction leads to improvements in technical and pure technical efficiencies.

Stock market development is found to be significantly and negatively related to the technical and pure technical efficiencies of Chinese banks, indicating that Chinese banks have lower technical and pure technical efficiencies in a more developed stock market. This result can be explained by the fact that in a more highly developed stock market, firms obtain funds from the stock market rather than from banks. Therefore, the incentives for bank managers to increase the volumes of business engaged in increases competition. As discussed in the competition variable, the increase in competition precedes a decline in efficiency.

In terms of the macroeconomic variables, the results suggest that in a high inflation environment, the technical efficiency and pure technical efficiency of Chinese banks is greater, as reflected by the significant and positive signs of this variable. This finding is in direct contrast with the results reported by Lozano-Vivas and Pasiouras (2010) for several commercial banks from 87 countries. The Chinese government and the banking regulatory authorities use different measures to battle higher inflation, such as increasing the interest rate and increasing the bank reserve ratio. A higher interest rate on loans and a higher reserve ratio reduces the volumes of loans made by banks which reduces the cost of monitoring and managing risk. Thus, the efficiency of Chinese banks is improved.

The results show that GDP growth rate is significantly and positively related to the technical and pure technical efficiencies of Chinese banks, indicating that Chinese banks have higher technical and pure technical efficiencies during periods of economic boom. During these periods, the demand for banking services becomes larger and the quality of borrowers improves significantly; the resulting reduction in the cost of monitoring risk and the reduction in cost from economies of scale and scope precede improvements in efficiency. Finally, it shows that compared to the SOCBs, JSCBs and CCBs have lower technical efficiency and lower pure technical efficiency.

<<Table 6---about here>>

6 Robustness check

This paper uses various ways to check the robustness of the result. First, we use the fractional logit regression proposed by Papka and Wooldridge (1996). The rationale for using this econometric technique is based on the argument of McDonald (2009) that DEA efficiency is the outcome of a fractional logit process rather than a truncated process. As well as using an alternative econometric technique, the current study also uses an alternative competition indicator; namely an efficiency-adjusted Lerner index to test the robustness of the results. Kotter et al. (2012) argue that the traditional price-cost margins derived from the Lerner index do not measure correctly the true extent of market power; they proposed another better measurement of competition namely an efficiency-adjusted Lerner index[17]. Tables 7 and 8 show the results of the robustness check. Both of these tables confirm the findings reported in Table 6 as follows: 1) lower liquidity risk leads to improvements in the technical and pure technical efficiencies of Chinese banks; 2) higher bank diversification improves the technical, pure technical and scale efficiencies of Chinese banks; 3) higher banking sector competition in China reduces the technical and pure technical efficiencies of Chinese banks; 4) a more highly developed banking sector in China is helpful in increasing the technical and pure technical efficiencies of Chinese banks; 5) Chinese banks had lower technical and pure technical efficiencies when there was a more developed stock market; 6) higher inflation precedes an improvement in technical efficiency of Chinese banks; 7) during the periods of economic boom, Chinese banks have higher technical and pure technical efficiencies; 8) the results confirm that compared to the state-owned commercial banks, joint-stock commercial banks have lower technical and pure technical efficiencies.

<<Table 7---about here>>

<<Table 8---about here>>

7 Summary and conclusions

The banking sector is the most important component of the Chinese economy. The Chinese government and the banking regulatory authorities have attached great importance to bank performance and the healthy development of the banking sector. The 2007 financial crisis made the Chinese government and banking regulatory authorities focus on reducing the levels of risk undertaken by Chinese commercial banks. The empirical literature has documented that risk has a significant impact on bank efficiency and a number of pieces of research have investigated this issue in the European banking sector. The empirical research examining the impact of risk on efficiency in the Chinese banking sector is relatively scarce (see Ariff and Can, 2008; Tan and Floros, 2013 and Zhang et al., 2013). Several rounds of banking reforms in China have improved competitive conditions, which are designed to have a significant impact on the efficiency of Chinese commercial banks.

[17] The efficiency-adjusted Lerner index used in this paper can be expressed as follows: $efficiencyadjustedindex_i = \frac{\pi_i + tc_i - mc_i + q}{\pi_i + tc_i}$, π represents bank profit (net income), tc represents total cost (non-interest expenses and interest expenses); mc stands for marginal cost, q stands for earning assets (loans and total securities),i represents specific bank.

This paper investigates the impacts of risk and competition on the efficiency of 100 Chinese banks over the period 2003-2013. The study is the first piece of research which comprehensively examines different types of bank risk, including credit risk, liquidity risk, capital risk, and insolvency risk. In addition, this paper is the first to use the Lerner index as a competition indicator to investigate the competition-efficiency and competition-inefficiency hypotheses in the Chinese banking sector. This study also controls for various bank-specific, industry-specific and macroeconomic variables which are supposed to have significant impacts on bank efficiency. In order to check the robustness of the results, an alternative econometric technique (fractional logit regression) and an alternative competition indicator (efficiency-adjusted Lerner index) are used.

The findings show that technical and pure technical efficiencies of Chinese commercial banks are significantly and negatively affected by liquidity risk. Furthermore, the results show that in the Chinese banking industry, the competition-inefficiency hypothesis holds. It is reported that Chinese bank efficiency is significantly affected by bank diversification, banking sector development, stock market development, inflation and GDP growth rate, while the results show that compared to the state-owned commercial banks, joint-stock and city commercial banks have lower technical and pure technical efficiencies.

Future research can extend the current study in the following ways: 1) liquid risk is measured by the ratio of liquid assets to total assets, while further study should take into account the maturity of assets and liabilities, and calculate the maturity gap to check the robustness of the results; 2) the capital risk should be estimated using the value at risk model to see whether our results hold; 3) the robustness of our results can also be checked by using an alternative competition measure such as the Boone indicator; 4) rather than using the non-parametric DEA analysis to evaluate the efficiency, the parametric SFA can be used, depending on the size of the sample.

The results are helpful for the Chinese government and banking regulatory authorities to make relevant policies to improve the efficiency of Chinese banks, as follows: 1) relevant skills should be improved by bank managers in China to better allocate the inputs and outputs in banking operation; 2) certain regulation should be made to require the Chinese commercial banks to further increase the level of liquidity; 3) Chinese banks should be encouraged to engage in larger volumes of security business; 4) relevant policies should be made to encourage Chinese commercial banks to engage in more diversified activities; 5) joint-stock commercial banks and city commercial banks should further improve their management, as the resulting improvement in pure technical efficiency has a positive impact on the overall technical efficiency of these two ownership types.

References:

Abedifar P, Molyneux P, Tarazi A. (2013), 'Risk in Islamic Banking', *Review of Finance* 17, 2035-2096.

Aigner D, Lovell CA, Schmidt P. (1977), 'Formulation and estimation of stochastic frontier production function models', *Journal of Econometrics* 6, 21-37.

Al-Muharrami S, Matthews K, Khabari Y. (2006), 'Market structure and competitive conditions in the Arab GCC banking system', *Journal of Banking and Finance* 30, 3487-3501.

Altunbas Y, Liu MH, Molyneux P, Seth R. (2000), 'Efficiency and risk in Japanese banking', *Journal of Banking and Finance* 24, 1605-1628.

Altunbas Y, Carbo S, Gardener EPM, Molyneux P. (2007). 'Examining the relationships between capital, risk and efficiency in European Banking', *European Financial Management* 13, 49-70.

Ariff M, Can L. (2008). 'Cost and profit efficiency of Chinese banks: a non-parametric analysis', *China Economic Review* 19, 260-273.

Ariss, RT. (2010), 'On the implications of market power in banking: evidence from developing countries', *Journal of Banking and Finance* 34, 765-775.

Athanasoglou PP, Brissmis SN, Delis MD. (2008), 'Bank-Specific, Industry-Specific and Macroeconomic Determinants of Bank Profitability', *Journal of International Financial Markets, Institutions and Money* 18, 121-136.

Banker RD, Charnes A, Cooper WW. (1984), 'Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis', *Management Science* 30, 1078-1092.

Beck T, Hesse H, Kick T, Von Westernhagen N. (2009), 'Bank ownership and stability: evidence from Germany', Bundesbank Working Paper Series.

Beck T, Demirguc-Kunt A, Merrouche O. (2013), 'Islamic vs. conventional banking: Business model, efficiency and stability', *Journal of Banking and Finance* 37, 433-447.

Berger AN, DeYoung R. (1997), 'Problem loans and cost efficiency in commercial banks', *Journal of Banking and Finance* 21, 849-870.

Berger AN, Humphrey DB. (1997), 'Efficiency of financial institutions: international survey and directions for future research', *European Journal of Operational Research* 98,175-212.

Berger AN, Hasan I, Zhou M. (2009), 'Bank ownership and efficiency in China: what will happen in the world's largest nation?', *Journal of Banking and Finance* 33, 113-130.

Boot A, Schmeits A. (2005), 'The Competitive Challenge in Banking', Amsterdam Center for Law and Economics Working Paper Series No. 2005-08.

Brissimis SM, Delis MD, Papanilolaou NI. (2008), 'Exploring the nexus between banking sector reform and performance: Evidence from newly acceded EU countries', *Journal of Banking and Finance* 32, 2674-2683.

Carbo S, Humphery D, Maudos J, Molyneux P. (2009a), 'Cross-country comparisons of competition and pricing power in European banking', *Journal of International Money and Finance* 28, 115-134.

Carbo S, Rodriguez-Fernandez F, Udell GF. (2009b), 'Bank Market Power and SME Financing Constraints', *Review of Finance* 13, 309-340.

Casu B, Girardone C. (2009), 'Testing the relationship between competition and efficiency in banking: A panel data analysis', *Economics Letters* 105, 134-137.

Chan Y, Greenbaum S, Thakor A. (1986), 'Information reusability, competition and bank asset quality', *Journal of Banking and Finance* 10, 255-276.

Chang TC, Chiu YH. (2006), 'Affecting factors on risk-adjusted efficiency in Taiwan's banking industry', *Contemporary Economic Policy* 24, 634-648.

Charnes A, Cooper WW, Rhodes E. (1978), 'Measuring the efficiency of decision making units', *European Journal of Operational Research* 2, 429-444.

Charnes A, Cooper WW, Lewin AY, Seiford LM. (1995), *Data Envelopment Analysis: theory, methodology and applications*. Kluwer, Boston.

Chen, X. (2007), 'Banking deregulation and credit risk: evidence from the EU', *Journal of Financial Stability* 2, 356-390.

Chiu Y, Chen Y, Bai X. (2011), 'Efficiency and risk in Taiwan banking: SBM super-DEA estimation', *Applied Economics* 43, 587-602.

Chortareas GE, Girardone C, Ventouri A. (2012), 'Bank supervision, regulation, and efficiency: evidence from the European Union', *Journal of Financial Stability* 8, 292-302.

Chortareas GE, Girardone C, Ventouri A. (2013), 'Financial freedom and bank efficiency: evidence from the European Union', *Journal of Banking and Finance* 37, 1223-1231.

Cipollini A, Fiordelisi F. (2012), 'Economic value, competition and financial distress in the European banking system', *Journal of Banking and Finance* 36, 3101-3109.

Claessens S, Laeven L. (2004), 'What Drives Bank Competition? Some International Evidence', *Journal of Money, Credit and Banking* 36, 563-584.

Craig BR, Dinger V. (2013), 'Deposit market competition, wholesale finding and bank risk', *Journal of Banking and Finance* 37, 3605-3622.

Demirguc-Kunt A, Huizinga H. (2004), 'Market discipline and deposit insurance', *Journal of Monetary Economics* 51, 375-399.

DeYoung R, Hasan I, Kirchhoff B. (1998), 'The Impact of Out-of-State Entry on the Cost Efficiency of Local Commercial Banks', *Journal of Economics and Business* 50, 191-203.

Dick A, Lehnert A. (2010), 'Personal bankruptcy and credit market competition', *Journal of Finance* 65, 655-686.

Dietrich A, Wanzenried G. (2011), 'Determinants of bank profitability before and during the Crisis: Evidence from Switzerland', *Journal of International Financial Markets, Institutions and Money* 21, 307-327.

Distinguin I, Roulet C, Tarazi A. (2013), 'Bank regulatory capital and Liquidity: Evidence from US and European Publicly traded banks', *Journal of Banking and Finance* 37, 3295-3317.

Du J, Girma S. (2011), 'Cost economies, efficiency and productivity growth in the Chinese banking industry: evidence from a quarterly panel dataset', *Empirical Economics* 41, 199-226.

Evanoff D, Ors E. (2002), 'Local Market Consolidation and Bank Productive Efficiency', FRB of Chicago Working Paper Series No. 2002-25.

Fang Y, Hasan I, Marton K. (2011), 'Market reforms, legal changes and bank risk-taking: evidence from transition economies', Bank of Finland Discussion Paper Series no. 7.

Farruggio C, Uhde A. (2015), 'Determinants of loan securitization in European banking', *Journal of Banking and Finance*, forthcoming.

Fernandez de Guevara J, Maudos J, Perez F. (2005), 'Market power in European Banking Sectors', *Journal of Financial Services Research* 27, 109-137.

Fiordelisi F, Marques-Ibanez D, Molyneux P. (2011), 'Efficiency and risk in European banking', *Journal of Banking and Finance* 35, 1315-1326.

Fiordelisi F, Mare DS. (2014), 'Competition and financial stability in European cooperative banks', *Journal of International Money and Finance* 45, 1-16

Francis WB, Osborne M. (2012), 'Capital requirements and bank behaviour in the UK: are there lessons for international capital standards', *Journal of Banking and Finance* 36**,** 803-816.

Fu X, Heffernan S. (2007), 'Cost X-efficiency in China's banking sector', *China Economic Review* 18, 35-53.

Fu X, Lin Y, Molyneux P. (2014), 'Bank competition and financial stability in Asia Pacific', *Journal of Banking and Finance* 38, 64-77.

Fungacova Z, Solanko L, Weill L. (2014), 'Does competition influence the bank lending channel in the Euro area?', *Journal of Banking and Finance* 49, 356-366.

Garcia-Herrero A, Gavila S, Santabarbara D. (2009), 'What explains the low profitability of Chinese banks?', *Journal of Banking and Finance* 33, 2080-2092.

Girardone C, Molyneux P, Gardener E. (2004), 'Analysing the determinants of bank efficiency: the case of Italian banks', *Applied Economics* 36, 215-227.

Goddard J, Molyneux P, Wilson JOS. (2004), 'Dynamic of growth and profitability in banking', *Journal of Money, Credit and Banking* 36, 1069-1090.

Goddard J, Molyneux P, Wilson JOS. (2009), 'The financial crisis in Europe: evolution, policy responses and lessons for the future', *Journal of Financial Regulation and Compliance* 17, 362-380.

Golin J. (2001), *The Bank Credit Analysis Handbook: a guide for Analysts, Bankers and Investors.* John Wiley and Sons, Asia.

Hasan, I. and Morton, K. (2003), 'Development and efficiency of the banking sector in a transitional economy: Hungarian experience', *Journal of Banking and Finance* 27, 2249-2271.

Hesse H, Cihak M. (2007), 'Competitive banks and financial stability', International Monetary Fund Working Paper Series No. 2007-02.

Huang M, Fu T. (2013), 'An examination of the cost efficiency of banks in Taiwan and China using the metafrontier cost function', *Journal of Productivity Analysis* 40, 387-406.

Hughes JP, Mester L, Moon C. (2001), 'Are scale economies in banking elusive or illusive: evidence obtained by incorporating capital structure and risk-taking into models of bank production', *Journal of Banking and Finance* 25, 2169-2208.

Iannotta G, Nocera G, Sironi A. (2007), 'Ownership structure, risk and performance in the European banking industry', *Journal of Banking and Finance* 31, 2127-2149.

Jeon BN, Olivero MP, Wu J. (2011), 'Do foreign bank increase competition? Evidence from emerging Asian and Latin American banking markets', *Journal of Banking and Finance* 35, 856-875.

Kleff V, Weber M. (2008), 'How do banks determine capital? Evidence from Germany', *German Economic Review* 9, 354-372.

Koetter M, Kolari WJ, Spierdijk L. (2012), 'Enjoying the quiet life under deregulation: evidence from adjusted Lerner indices for US banks', *Review of Economics and Statistics* 94, 462-480.

Kumbhakar SC, Lozana-Vivas A, Lovell CAK, Hasan I. (2001), 'The effects of deregulation on the performance of financial institutions: the case of Spanish savings banks', *Journal of Money, Credit and Banking* 33, 101-121.

Kumbhakar S, Wang D. (2007), 'Economic reforms, efficiency and productivity in Chinese banking', *Journal of Regulatory Economics* 32, 105-129.

Lee C, Hsieh M. (2013), 'The impact of bank capital on profitability and risk in Asian banking', *Journal of International Money and Finance* 32, 251-281.

Leuvensteijn MV, Bikker JC, Rixtel AARJMV. Sorensen, C.K. (2011), 'A new approach to measuring competition in the loan markets of the euro area', *Applied Economics* 43, 3155-3167.

Liang Q, Xu P, Jiraporn P. (2013), 'Board characteristics and Chinese bank performance', *Journal of Banking and Finance* 37, 2953-2968.

Liu H, Molyneux P, Wilson JOS. (2013), 'Competition and stability in European banking: a regional analysis', *Manchester School* 81, 176-201.

Liu H, Wilson JOS. (2013), 'Competition and risk in Japanese banking', *European Journal of Finance* 19, 1-18.

Lozano-Vivas A, Pasiouras F. (2010), 'The impact of non-traditional activities on the estimation of bank efficiency: international evidence', *Journal of Banking and Finance* 34, 1436-1449.

Matthews K, Murinde V, Zhao T. (2007), 'Competitive conditions among the major British banks', *Journal of Banking and Finance* 31, 2025-2042.

Mcdonald, J. (2009), 'Using least square and Tobit in second stage DEA efficiency analyses', *European Journal of Operational Research* 197, 792-798.

Meeusen W, Van de Broeck J. (1977), 'Efficiency estimation from Cobb-Douglas production functions with composed error', *International Economic Review* 18, 435-444.

Molyneux P, Liu H, Jiang C. (2014), 'Bank capital, adjustment and ownership: Evidence from China', Bank of Finland Discussion Paper Series No. 2014-16.

Olivero MP, Li Y, Jeon BN. (2011), 'Competition in banking and the lending channel: Evidence from bank-level data in Asia and Latin America', *Journal of Banking and Finance* 35: 560-571.

Onali, E. (2014), 'Moral Hazard, Dividends, and Risk in Banks', *Journal of Business Finance and Accounting* 41, 128-155.

Pan H, Wang C. (2013), 'House prices, bank instability and economic growth: evidence from the threshold model', *Journal of Banking and Finance* 37, 1720-1732.

Papke LE, Wooldridge, JM. (1996), 'Econometric methods for fractional response variables with an application to 401(k) plan participation rates', *Journal of Applied Econometrics* 11, 619-632.

Radic N, Fiordelisi F, Girardone C. (2012), 'Efficiency and Risk-Taking in Pre-Crisis Investment Banks', *Journal of Financial Services Research* 41, 81-101.

Sealey CE, Lindley JT. (1977), 'Inputs, Outputs and a Theory of Production and Cost at Depository Financial Institutions', *Journal of Finance* 32, 1251-1266.

Seiford LM, Thrall RM. (1990), 'Recent development in DEA: the mathematical programming approach to frontier analysis', *Journal of Econometrics* 46, 7-38.

Simar L, Wilson PW. (2007), 'Estimation and inference in two-stage, semi-parametric models of production processes', *Journal of Econometrics* 136: 31-64.

Stiroh KJ, Rumble A. (2006), 'The dark side of diversification: the case of US financial holding companies', *Journal of Banking and Finance* 30: 2131-2161.

Sufian, F. (2009), 'Determinants of bank efficiency during unstable macroeconomic environment: empirical evidence from Malaysia', *Research in International Business and Finance* 23, 54-77.

Sufian F, Habibullah M. (2011), 'Navigating the Impact of Globalization on Bank Efficiency in China', *China and World Economy* 19, 85-101.

Sufian F, Majid M. (2009), 'Bank efficiency and share prices in China: empirical evidence from a three-stage model'. *International Journal of Computational Economics and Econometrics* 1, 23-45.

Tabak BM, Fazio DM, Cajueiro DO. (2012), 'The relationship between banking market competition and risk-taking: do size and capitalization matter?', *Journal of Banking and Finance* 36, 3366-3381.

Tan Y, Floros C. (2012a), 'Bank profitability and inflation: the case of China', *Journal of Economic Studies* 39, 675-696.

Tan Y, Floros C. (2012b), 'Bank profitability and GDP growth in China: a Note', *Journal of Chinese Economic and Business Studies* 10, 267-273.

Tan Y, Floros C. (2012c), 'Stock market volatility and bank performance in China', *Studies in Economics and Finance* 29, 211-228.

Tan Y, Floros C. (2013), 'Risk, capital and efficiency in Chinese banking', *Journal of International Financial Markets, Institutions and Money* 26, 378-393.

Williams J. (2004), 'Determining management behaviour in European banking', *Journal of Banking and Finance* 28, 2427-2460.

Zarutskie R. (2013), 'Competition, financial innovation and commercial bank loan portfolios', *Journal of Financial Intermediation* 22, 373-396.

Zhang J, Qu B, Xu Z, Wang P. (2012), 'Market development and bank profit efficiency in China: application of the generalized Malmquist productivity index', *Asia-Pacific Journal of Accounting and Economics* 19, 181-197.

Zhang J, Jiang C, Qu B, Wang P. (2013), 'Market concentration, risk-taking, and bank performance: evidence from emerging economies', *International Review of Financial Analysis* 30, 149-157.

Figure 1 Competitive conditions of Chinese banks over the period 2003-2013 (Lerner index)

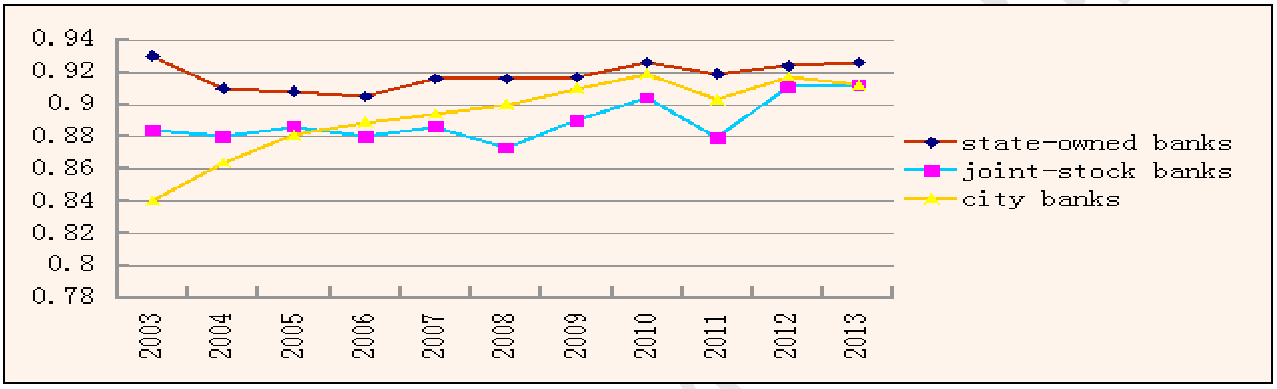

Figure 2 Risk conditions in the Chinese banking sector: 2003-2013

Figure 2a Credit risk in the Chinese banking industry: 2003-2013

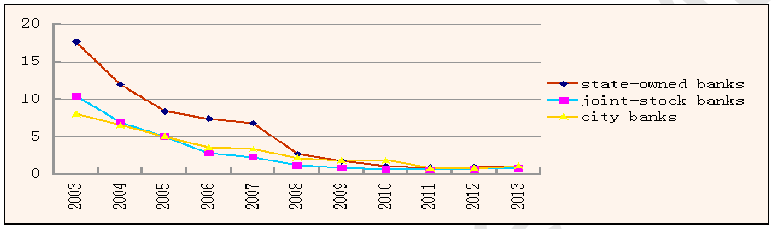

Figure 2b Liquidity risk in the Chinese banking industry: 2003-2013

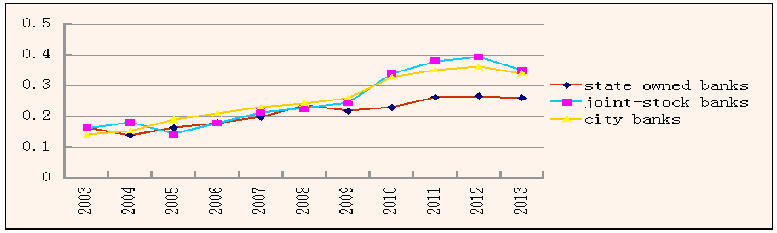

Figure 2c Capital risk in the Chinese banking industry: 2003-2013

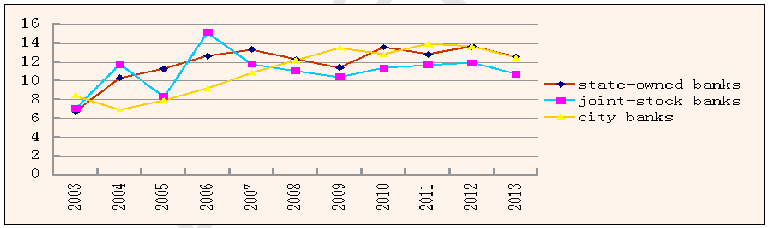

Figure 2e Insolvency risk (stability inefficiency) in the Chinese banking industry: 2003-2013

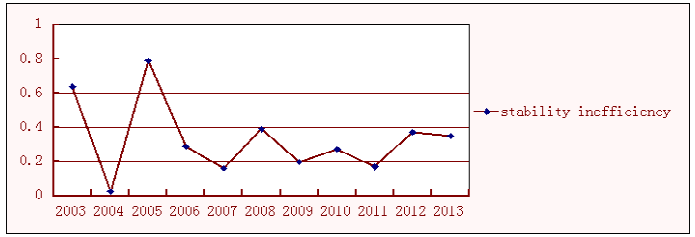

Table 1 Total assets of SOCBs, JSCBs and CCBs and all banking institutions over the period 2003-2013 (RMB 100 million)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
SOCBs	**160512**	**179817**	**210050**	**242364**	**285000**	**325751**	**407998**	**468943**	**536336**	**600401**	**656005**
JSCBs	**29599**	**36476**	**44655**	**54446**	**72742**	**88337**	**118181**	**149037**	**183794**	**235271**	**269361**
CCBs	**14622**	**17056**	**20367**	**25938**	**33405**	**41320**	**56800**	**78526**	**99845**	**123469**	**151778**
Banking institutions	**276584**	**315990**	**374697**	**439500**	**531160**	**631515**	**795146**	**953053**	**1132873**	**1136224**	**1513547**

Table 2 Summary statistics of inputs and outputs used to estimate the efficiency scores

Variables	Observations	Mean	S.D	Min	Max
Inputs					
Total cost (interest expenses and non-interest expenses)	777	3.35	0.97	-0.79	6.86
Price of funds (the ratio of interest expenses over total deposits)	777	1.27	0.18	0.74	1.96
Price of capital (the ratio of non-interest expenses over fixed assets)	776	1.92	0.26	0.68	2.83
Outputs					
Total loans	784	4.59	0.99	0.34	7.95
Securities	782	4.21	1.04	-0.41	7.87
Non-interest income	767	2.34	1.1	-2.4	5.81
Total deposits	784	4.85	0.98	0.66	8.26

Table 3 Description of the variables used in the bootstrap truncated regression model

Variables	Description	Hypothesized relationship with efficiency	Data source
Risk variables			
Credit risk	The ratio of impaired loans to gross loans	-	Bankscope
Liquidity risk	The ratio of liquid assets to total assets	+	Bankscope
Capital risk	Total regulatory capital ratio	+	Bankscope
Insolvency risk	Stability inefficiency	-	Bankscope
Other bank-specific variables			
Bank size	Natural logarithm of total assets	+	Bankscope
Bank diversification	Ratio of non-interest income to gross revenue	+	Bankscope
Bank profitability	Return on assets	+	Bankscope
Industry-specific variables			
Banking sector competition	Efficiency-adjusted Lerner index	?	Bankscope
Banking sector development	Ratio of banking sector assets to GDP	-	China Banking Regulatory Commission
Stock market development	Capitalization of stock market to GDP	+	World Bank
Macroeconomic environment			
Inflation	Annual inflation rate	-	World Bank
GDP growth rate	Annual GDP growth rate	+	World Bank

Table 4 Descriptive statistics of all variables considered in this study

Variables	Observations	Mean	S.D	Min	Max
Credit risk	632	2.78	4.48	0	41.86
Liquidity risk	777	0.27	0.11	0.02	0.67
Capital risk	637	11.91	4.7	0.62	62.62
Insolvency risk	1100	0.33	0.21	0.025	0.789
Bank profitability	806	0.009	0.007	-0.04	0.106
Bank size	843	4.9	0.992	0.71	8.51
Bank diversification	828	13.98	13.31	-12.94	79.4
Banking sector development	1100	2.22	0.24	1.98	2.66
Stock market development	1027	71.2	43.49	31.9	184.1
Inflation	1227	2.86	1.92	-0.77	5.86
GDP growth rate	1199	10.19	1.87	7.7	14.2

Table 5 Mean values of technical efficiency, pure technical efficiency and scale efficiency for all Chinese commercial banks: 2003-2013

Banks/efficiency scores	Technical efficiency	Pure technical efficiency	Scale efficiency
State-owned commercial banks	0.97	0.975	0.995
Joint-stock commercial banks	0.913	0.928	0.977
City commercial banks	0.915	0.926	0.974

Table 6 Results of the bootstrap truncated regression on the impacts of risk and competition on bank efficiency

	Dependent variable=technical efficiency		Dependent variable=pure technical efficiency		Dependent variable=scale efficiency	
Independent variables	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
Risk variables						
Credit risk	0.001	1.31	0.0008	0.84	-0.0005	-0.55
Liquidity risk	0.08**	2.04	0.06*	1.93	0.035	0.70
Capital risk	-0.0004	-0.37	-0.0006	-0.76	0.0008	0.44
Insolvency risk	-0.023*	-1.73	-0.025*	-1.90	-0.004	-0.20
Other bank-specific variables						
Bank size	-0.004	-0.76	0.005	0.92	-0.009	-0.93
Bank diversification	0.001***	5.16	0.001***	5.86	0.002***	3.99
Bank profitability	-0.27	-0.41	-0.27	-0.48	0.47	0.85
Industry-specific variables						
Lerner index	0.61***	6.85	0.56***	7.47	0.14	1.44
Banking sector development	0.19***	8.08	0.18***	8.44	-0.02	-0.71
Stock market development	-0.0005***	-5.89	-0.0006***	-8.81	0.0001	1.08
Macroeconomic variables						
Inflation	0.004***	2.61	0.002*	1.73	0.002	0.94
GDP growth rate	0.017***	8.50	0.018***	9.90	0.001	0.36
Joint-stock banks	-0.06***	-4.14	-0.04**	-2.53	-0.08***	-3.05
City banks	-0.08***	-5.70	-0.055***	-3.32	-0.08***	-2.53
Constant	-0.18**	-2.21	-0.15*	-1.86	0.99***	7.71
No. of observations	377		358		354	
Log likelihood	754.47		765.53		1155.53	
Wald chi square	642.01***		392.18***		30.93***	

Notes:*, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 7 Results of fractional logit regression on the impacts of risk and competition on bank efficiency

	Dependent variable=technical efficiency		Dependent variable=pure technical efficiency		Dependent variable=scale efficiency	
Independent variables	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
Risk variables						
Credit risk	0.01	1.59	0.02*	1.92	-0.02	-1.43
Liquidity risk	0.99**	2.26	1.13***	2.73	0.45	0.71
Capital risk	-0.008	-0.87	-0.01	-1.03	-0.03	-0.84
Insolvency risk	-0.17	-1.16	-0.19	-1.14	0.11	0.28
Other bank-specific variables						
Bank size	-0.13**	-2.03	-0.09	-1.44	-0.08	-0.37
Bank diversification	0.01***	5.42	0.01***	4.39	0.05**	2.27
Bank profitability	-4.45	-0.93	-5.55	-1.10	-2.56	-0.32
Industry-specific variables						
Lerner index	6.04***	9.33	6.19***	9.71	7.2**	2.43
Banking sector development	3.29***	10.36	3.93***	11.06	1.07*	1.80
Stock market development	-0.006***	-6.21	-0.007***	-6.99	-0.004	-0.97
Macroeconomic variables						
Inflation	0.1***	6.93	0.11***	7.44	0.17**	2.45
GDP growth rate	0.22***	8.37	0.26***	9.24	0.2*	1.76
Dummy 1 (JSCBs)	-0.97***	-4.78	-0.95***	-4.12	-0.84**	-2.50
Dummy 2 (CCBs)	-1.29***	-5.86	-1.27***	-5.15	-0.83	-1.53
Constant	-11.11***	-11.07	-12.97***	-12.05	-5.76	-1.11
No. of observations	444		445		445	
Log likelihood	-86.58		-77.88		-26.8	

Notes:*, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 8 Results of bootstrapped truncated regression on the impacts of risk and competition on bank efficiency (efficiency-adjusted Lerner index as competition indicator)

	Dependent variable=technical efficiency		Dependent variable=pure technical efficiency		Dependent variable=scale efficiency	
Independent variables	Coefficient	T-stat	Coefficient	T-stat	Coefficient	T-stat
Risk variables						
Credit risk	0.001	0.82	0.0002	0.17	-0.0001	-0.13
Liquidity risk	-0.02	-0.45	-0.04	-0.97	0.005	0.10
Capital risk	0.0002	028	-0.0001	-0.17	0.001	0.74
Insolvency risk	-0.03	-1.55	-0.03**	-2.23	-0.003	-0.11
Other bank-specific variables						
Bank size	-0.005	-0.83	0.005	1.05	-0.012	-1.17
Bank diversification	0.001***	4.77	0.001***	-3.68	0.003***	4.44
Bank profitability	-1.58**	-1.99	-1.63*	-1.89	0.61	0.57
Industry-specific variables						
Efficiency-adjusted Lerner index	0.3***	6.46	0.3***	4.55	0.06	0.95
Banking sector development	0.19***	8.33	0.17***	8.35	-0.02	-0.62
Stock market development	-0.001***	-7.11	-0.001***	-9.51	0.0001	0.69
Macroeconomic variables						
Inflation	0.003**	2.54	0.002	1.43	0.001	0.68
GDP growth rate	0.02***	8.59	0.02***	9.81	0.001	0.40
Joint-stock banks	-0.08***	-5.68	-0.06***	-4.13	-0.08**	-2.19
City banks	-0.11***	-5.98	-0.08***	-4.74	-0.08**	-2.18
Constant	0.28***	4.10	0.27***	4.06	1.1***	11.48
No. of observations	386		365		363	
Log likelihood	749.77		760.23		1183.52	
Wald test	346.15***		363.87***		35.53***	

Notes:*, ** and *** denote significance at 10%, 5% and 1% levels, respectively