Market power, stability and performance in the Chinese banking industry

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ABSTRACT

The recent financial crisis has led to a reduction in credit granted, a decreased volume of activity in international financial markets and an increase in risk-taking behaviour. Several rounds of banking reforms in China have aimed to improve the efficiency, enhance the financial stability and decrease the market power of Chinese banks. The aim of this study is to investigate whether an increase in the risk-taking behaviour of Chinese banks increases market power; we also examine whether efficiency improvement enhances Chinese banks' market power. Using data on 101 Chinese commercial banks over the period 2003-2011, our empirical results suggest that Chinese banks with higher volumes of non-traditional activities have lower market power, while the technical efficiency improvement of Chinese banks increases their market power. We find no significant evidence with regards to the impact of risk on market power. These results are highly recommended to bank managers and financial analysts.

1. INTRODUCTION

The banking industry plays an important role in the financial system and the economy as a whole. Due to the fact that China is the largest developing country in the world, the stability of the banking industry, which is the most important part of the financial system, plays a vital role in China's economic development and provides an environment of economic stability for other Asian countries. Several rounds of banking reforms in China have sought to establish a more competitive banking environment; the purpose of which is to decrease banks' market power and increase their efficiency. Furthermore, the stability of the banking sector is now of more concern to managers, regulatory authorities and government officials because of the financial crisis from 2007.

Bank's market power, an indicator of competition, describes the extent to which a bank can set its price above marginal cost. It is significantly affected by bank risk and bank efficiency (see Fernandez de Guevara and Maudos,

2007; Fernandez de Guevara *et al.*, 2005). In this paper, we examine the joint effects of technical efficiency and risk on the market power of Chinese banks. Specifically, our study focuses on the investigation of the following two research hypotheses:

1) Higher levels of risk undertaken by Chinese banks increase their market power.
2) Chinese banks with higher efficiency levels have higher market power.

Our paper follows the approach of Fernandez de Guevara *et al.* (2005) for Europe. In particular, we extend their study by the following ways: 1) we use Data Envelopment Analysis CCR and BCC models[2] to measure the technical, pure technical and scale efficiencies, and further analyse sources of inefficiency in the Chinese banking industry; 2) we use four different risk indicators to test the impact of risk on market power in the Chinese banking industry; 3) we examine not only the impact of efficiency on market power, but we use the Malmquist productivity index to check whether it explains successfully market power in the Chinese banking industry; 4) we control for comprehensive bank-specific, industry-specific and macroeconomic determinants of market power; and 5) using three different bank ownership types, we examine if market power is different among Chinese state-owned, joint-stock and city commercial banks over the examined period.

Our results suggest that efficiency affects positively the market power of Chinese banks, however there is no robust relationship between risk and banks' market power in China. In addition, the market power of Chinese banks is affected significantly and negatively by the volumes of non-traditional activities.

The rest of the paper is organised as follows: Section 2 gives a summary of the structure of the Chinese banking industry. Section 3 reviews the relevant literature on market power and its determinants in the banking industry. Section 4 introduces the estimation procedure for market power, bank productivity and the second-stage analysis. Section 5 describes the data. Section 6 presents the empirical results and Section 7 shows the robustness checks. Finally, Section 8 summarises and concludes the paper.

2. Review of the Chinese banking industry

Until 1978, the Chinese financial system followed the mono-bank model and was operated on socialist principles. The People's Bank of China (PBOC) played the dual role of central and commercial bank. A two tiered banking system, consisting of the PBOC and state-owned banks, was established during the first stage of financial reform, over the period 1979-1992. PBOC was free to serve as the Central Bank. In order to create a competitive environment and enhance supervision in the banking sector, the Chinese Banking Regulatory Commission (CBRC) and various ownership types of banks were established during the second stage of reform, from 1993 to the present.

Established by the State Council in 2003, the CBRC is the primary government agency and point of control for commercial banks. The CBRC is not only responsible for the supervision of commercial banking operations, but also formulates rules and regulations, authorises the establishment, changes, termination and business scope of banking institutions and conducts an onsite examination and offsite surveillance of their operations. The objective is to protect the interest of depositors and maintain market confidence through prudential and effective supervision.

The Chinese banking sector comprises five state-owned commercial banks[3] (SOCBs), 12 joint-stock commercial banks[4] (JSCBs), a big number of city commercial banks (CCBs), policy lending banks, credit cooperatives and foreign banks. The SOCBs are assigned sectoral policy objectives, previously in the hand of PBOC under the mono-bank system. However, with the creation of policy lending banks in 1994, their responsibilities have been restricted to commercial lending. Further, the stockholders of JSCBs are made up of local government and state-owned enterprises.

On the other hand, CCBs are local JSCBs established by local government, enterprises and residents. The establishment of Shenzhen city cooperative bank in July 1995 can be taken as the starting point when China's city commercial banking network begins its rapid, though arduous, development on the Chinese financial platform. Unlike their JSCBs counterparts, most of the CCBs are not allowed to operate at the national level, which is their major competitive disadvantage. Therefore, due to their lack of scale, the CCBs have to rely heavily on traditional lending activities, with interest income consists of approximately 95 per cent of their total revenues. In addition, the CCBs' competitive advantage stems from their strong relationship with local business fraternities and retail customers. By the end of 2011, there are 144 CCBs in China. Their assets totaled RMB 9984.5 billion, possessing a market share of 8.81 per cent among all depository banking institutions (CRBC annual report 2011).

3. Literature review

There are some previous studies examining the market power in banking industry. The Panzar-Rosse H statistic has been used by several studies for a number of countries and regions. For example, Bikker and Groeneveld (2000) evaluate bank competition in 15 EU countries over the period 1989-1996. They find that all countries are in a state of monopolistic competition except for Belgium and Greece, which are in a state of perfect competition. De Bandt and Davis (2000) analyse bank competition in France, Germany, Italy and United States for the period from 1992 to 1996. They conclude that large banks are in a state of monopolistic competition, while small banks are in a state of monopoly.

Bikker and Haaf (2002) assess the competition of the banking industries in 23 countries; they find that, in their sample, monopolistic competition

prevails. Claessens and Laeven (2004) examine bank competition in 50 countries and conclude that nearly all countries are in a state of monopolistic competition. Perera *et al.* (2006) examine competition in South Asia over the period 1995-2003. Their findings show that competition in the traditional interest-based product market is greater in Bangladesh and Pakistan, while the fee-based product market in India and Sri Lanka is more competitive.

There are a handful of studies investigating competition specifically in the Chinese banking sector. Yuan (2006) analyses the competitive condition of the Chinese banking industry over the period 1996-2000. The results suggest that China's banking sector was already near a state of perfect competition (that is, before foreign banks began to enter China's financial market). The competitive condition is assessed by Fu (2009) for a panel of 76 Chinese banks over the period 1997-2007. The results indicate monopolistic competition in the Chinese banking sector. She suggests that, after China's accession to the WTO, competition in the core market for bank lending increased, while the off-balance-sheet market became less competitive. The competitive condition of 16 Chinese banks for the period of 2004-2007 is evaluated by Masood and Sergi (2011). The results show that the Chinese banking sector is monopolistically competitive over the examined period.

The different competitive conditions found by these different studies is partly accounted for by the fact that different authors use different reduced revenue equations to measure competition. Further, the different results are closely linked with the banking sector reforms over the specific period investigated. For instance, three policy banks were established by the Chinese government in 1994, to take over the policy lending responsibilities undertaken previously by state-owned banks.

In addition, the commercial bank law was passed in 1995. SOCBs now have more freedom to engage in commercial lending activities, which substantially increases the competition between SOCBs and JSCBs. There is also stronger competition among the SOCBs. This explains the reason that during the period 1996-2000, the Chinese banking sector has been found to be perfectly competitive; while, after 1997, several banking reforms hindered competition. For example, the Chinese government injected capital worth of USD 33 billion to SOCBs in order to deal with lower capitalisation.

Furthermore, four Asset Management Companies were established by the Chinese government in 1999, to reduce the volume of non-performing loans in SOCBs. These types of reforms for SOCBs, regarding capital injections and non-performing loan write-offs by asset management companies, were initiated again by the government in 2003. These measures taken by the Chinese government decreased competition among SOCBs and between SOCBs and other types of commercial banks in China. These explain further the findings reported by Fu (2009) and Masood and Sergi (2011).

Several empirical studies also examine the determinants of market power in the banking industry. The Lerner index is used by Fungacova *et al.*

(2010) to evaluate the competitive condition in the Russian banking industry over the period 2001-2007. The results show that bank competition in Russian has improved slightly over the period studied. Furthermore, the findings suggest that bank size, risk and market concentration are significantly related to the market power of Russian banks. The competition of Russian banks is also examined by Anzoategui *et al.* (2012). Their findings suggest that larger and state-owned banks have greater market power than other banks. In addition, the results indicate that competition between Russian banks is negatively affected by bank concentration; but it is positively affected by financial and economic development.

The market power of the Spanish banking industry over the period 1986-2002 is investigated by Fernandez de Guevara and Maudos (2007). The results show an increase in market power from the mid-1990s. In addition, the findings suggest that bank size, efficiency and specification are significantly related to bank market power in Spain. The evolution of market power in the main banking sector of the European Union is analysed by Fernandez de Guevara *et al.* (2005). Their results show that there is no increase in the degree of competition within the EU, while bank size, risk, efficiency and economic cycle are significantly related to the market power of European banks.

4. Methodology

4.1 The estimation of bank market power

The methods to measure bank competition (market power) can be divided into two groups. The first group is based on the new industrial organisation literatures, which mainly includes: 1) the Lerner index (see Fernandez de Guevara *et al.*, 2007; Fernandez de Guevera and Maudos, 2004); 2) the Breshnahan mark-up test (see Shaffer, 1993; Suominen, 1994); and 3) the Panzar-Rosse H statistic (see Shaffer, 2004; Claessens and Laeven, 2004). The second group uses the concentration ratio as the measurement of competition (see Berger, 1995).

The Lerner index is used in this study mainly because: 1) it can be easily estimated for each bank, each year; and it matches its determinants, which are annual bank-level variables; 2) we can estimate the competitive condition (market power) for three different ownership types present in Chinese banks. 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 one to a minimum of zero, with a higher number indicating greater market power and hence less competition. The Lerner index represents the extent to which a particular bank has market power to set price above marginal cost.

The price is computed by estimating the average price of bank production (proxied by total assets) as the ratio of total revenue over total assets, follow-

ing Fernandez de Guevara *et al.*, (2005), Carbo-Valverde *et al.*, (2009a, 2009b) and others. The marginal cost is estimated on the basis of a translog cost function with one output (total assets) and three input prices (the prices of labour, capital and funds). Symmetry and linear homogeneity restrictions in input prices are imposed. The cost function is specified as:

$$LNTC = \alpha_0 + \alpha_1 LNY + \frac{1}{2}\alpha_2 (LNY)^2 + \sum_{j=1}^{3} \beta_j LNW_j + \sum_{j=1}^{3}\sum_{k=1}^{3} \beta_{jk} LNW_j LNW_k + \sum_{j=1}^{3} \gamma_j LNYLNW_j + \varepsilon \quad (1)$$

Where *TC* denotes total cost, and *Y* represents the total assets. There are three input prices used in our study which are represented by *W*: W_1 is the price of funds (the ratio of interest expenses to total funding), W_2 indicates the price of capital (the ratio of other non-interest expenses to fixed assets), W_3 stands for the price of labour (the ratio of personnel expenses to total assets). Also, *j* and *k* represent different inputs we use in this study. *LN* denotes natural logarithm. α_0 and ε are the constant and error terms, respectively. The estimated coefficients of the cost function are then used to compute the marginal cost (*MC*).

$$MC = \frac{TC}{Y}(\alpha_1 + \alpha_2 LNY + \sum_{j=1}^{3} \gamma_j LNW_j) \quad (2)$$

Once the marginal cost has been estimated and the price of output computed, we calculate the Lerner index for each bank and obtain a direct measure of bank competition. We use the same three input prices to calculate the marginal cost: price of funds, capital and labour.

4.2 Estimation of bank productivity

The output-oriented Malmquist method defined by Caves *et al.* (1982) is used to derive Total Factor Productivity (TFP) growth, and is estimated using DEA (Fare *et al.*, 2004).[5] This is the most popular non-parametric approach used to obtain TFP growth estimates. To introduce some notation, let us assume there are *n* observations using m inputs to produce *L* outputs. Each observation *n* uses a nonnegative vector of inputs denoted $X^n = (X_1^n, X_2^n .....X_m^n) \in R^m$ to produce a nonnegative vector of outputs, denoted $Y^n = (Y_1^n, Y_2^n .....Y_l^n) \in R^L$. The production technology can be written as: $F = \{(Y, X) : X\, can produce\, Y\}$ which describes the set of feasible input-output vectors. The input sets of production technology can be written as: $PT(Y) = \{X : (Y, X) \in F\}$, which describes the sets of input vectors that are feasible for each output vector. The output Malmquist TFP index can then be expressed as:

$$M_o(x^s, y^s, x^t, y^t) = \left[\frac{D_o^s(x^t, y^t)}{D_o^s(x^s, y^s)} \frac{D_o^t(x^t, y^t)}{D_o^t(x^s, y^s)}\right]^{\frac{1}{2}} \quad (3)$$

Where: M_0 measures the productivity change between period *s* and *t*; $D_o^s(x^t, y^t)$ represents the distance from period *t* observation to period *s* technology. $M_0 \rangle 1$ indicates positive TFP growth from period *s* to period *t*, while $M_0<1$ indicates a decline and M_0 indicates constant TFP growth.

4.3 Second stage analysis of the impacts of risk and performance on bank market power in China

In order to investigate the joint effects of efficiency/productivity and risk on market power in the Chinese banking industry, ordinary least square (OLS) estimation of the following form is considered, compared with the individual fixed effects employed by similar study of Fernandez de Guevara and Maudos (2007), to see whether we can obtain similar results, both of these methods do not assume endogeneity of explanatory variables:

$$R_{jt} = \beta_0 + \beta_1 efficiency_{it} + \beta_2 Risk_{it} + \beta_3 bank_{it} + \beta_4 industry_{it} + \beta_5 macro_{it} + \beta_6 ownership + \varepsilon_{it} \quad (4)$$

Where *R* denotes bank market power measured by the Lerner index, β_0 is a constant term, *efficiency* denotes the technical efficiency scores derived from the non-parametric DEA, and *Risk* is measured by the ratio of Loan loss provision over total loans (NPL). The risk indicator is cross-checked by three alternative measurements: volatility of ROA, volatility of ROE and Z-score. Further, the efficiency score is complemented by the Malmquist productivity index, to check the impact of productivity on market power in the Chinese banking industry. Bank, *industry* and *macro* represent bank-specific, industry specific and macroeconomic variables, respectively. Ownership represents three different types of banks namely SOCBs, JSCBs and CCBs. Further, *i* and *t* represent a specific bank in a specific year, while ε_{it} is the error term.

5. Data description

Our banking data is composed of annual data for 101 Chinese banks over the period 2003-2011. The banks used in this study are 5 SOCBs, 12 JSCBs and 84 CCBs. Table 1A and Table 1B present some key information regarding the structure of the Chinese banking system, i.e. the difference between SOCBs, JSCBs and CCBs in terms of their ownership, business scope and their assets (percentage to the total banking industry assets) over the period 2003-2011.

Since not all banks have information available for all years, we opt for an unbalanced panel, so as not to lose degrees of freedom. The bank-specific information is obtained primarily from the Bankscope database, maintained by Fitch/IBCA/Bureau Van Dijk, considered to be the most comprehensive database for research in banking. The industry specific and macroeconomic variables are retrieved from the China Banking Regulatory Commission (CBRC) (http://www.cbrc.gov.cn) and World Bank database (http://data.worldbank.org). The bank-specific variables used in the current study include: bank size,

risk, liquidity, taxation, capitalisation, non-traditional activity, labour productivity, and technical efficiency/total factor productivity growth. Bank concentration and stock market development are industry-specific variables; further, two macroeconomic variables are considered in this paper: inflation and GDP growth rates.

The definitions of the variables are given in Table 2. Table 3 presents the descriptive statistics for all variables used in the current study. It shows that liquidity and non-traditional activities across Chinese banks vary substantially over the examined period, while the differences in labour productivity and risk undertaken by Chinese banks are quite small.

Table 1A: Differences among state-owned, joint-stock and city commercial banks in China

Banks	*Ownership and business scope*
State-owned commercial banks	Fully central government owned (finance big state-owned enterprises)
Joint-stock commercial banks	Local government as well as private and state-owned enterprises (businesses mainly oriented to small and medium sized enterprises)
City commercial banks	Local government, enterprises and residents (most focus their business in the city where they were founded)

Table 1B: The assets of different ownerships of banks over the period 2003-2011 (RMB: Billion)

Years/Banks	*State-owned commercial banks (percentage of total banking industry assets)*	*Joint-stock commercial banks (percentage of total banking industry assets)*	*City commercial banks (percentage of total banking industry assets)*
2003	16051.17(58%)	2959.86(10.7%)	1462.17(5.3%)
2004	17981.67(57%)	3647.6(11.5%)	1705.63(5.4%)
2005	21005(56%)	4465.49(11.9%)	2036.69(5.4%)
2006	24236.35(55%)	5444.59(12.4%)	2593.79(5.9%)
2007	28007.09(53%)	7249.4(13.8%)	3340.48(6.4%)
2008	31835.8(51%)	8809.5(14.1%)	4131.97(6.6%)
2009	40089.02(50.9%)	11784.98(15%)	5680.01(7.2%)
2010	46894.3(49.2%)	14903.7(15.6%)	7852.6(8.2%)
2011	53633.6 (47.3%)	18379.4((16.22%)	9984.5 (8.81%)

Source: 2011 annual report from CBRC.

Table 2: Description of variables used in the study

Variables	*Acronym*	*Definition*
A. Bank-specific variables		
Lerner index	LERNER	Competition indicator
Bank size	LNTA	Natural logarithm of total assets
Risk	NPL	Ratio of loan loss provision to total loans
Volatility of ROA	VOA	Standard deviation of Return on Assets (ROA)
Volatility of ROE	VOE	Standard deviation of Return on Equity (ROE)
Z-score	Z-score	Ratio between a bank's return on assets plus equity capital /total assets and standard deviation of return on assets.
Liquidity	LOANTA	Ratio of loans to total assets
Taxation	TAX	Ratio of tax to pre-tax profit
Capitalisation	CAP	Book value of capital to total assets
Non-traditional activity	NTA	Ratio of non-interest income to gross revenue
Labour productivity	LP	Ratio of gross total revenue to number of employees
Efficiency	TE	Technical efficiency
Productivity	Malm	Malmquist productivity index
B. Industry-specific variables		
Concentration	C(3)	The ratio of largest three banks in terms of total assets, to total assets of the banking industry
Stock market development	SMD	Ratio of stock market capitalisation over GDP
C. Macroeconomic variables		
Inflation	IR	Annual inflation rate
GDP growth	GDPR	Annual GDP growth rate

The degree of correlation between the explanatory variables is tested through multivariate regression analysis. The matrix shows that, in general, the correlation between the independent variables is not strong, suggesting that any multicollinearity problems are insignificant.[6]

Table 3: Descriptive statistics of variables used in this study

Variables	*Obs*	*Mean*	*S.D*	*Min*	*Max*
Bank-specific variables					
Lerner index	416	0.22	0.18	0.003	0.92
Bank size	678	4.77	0.94	0.71	7.19
Credit risk	624	0.009	0.006	-0.002	0.042
liquidity	678	51.5	9.7	17.97	77.58
taxation	665	0.39	0.3	-4.56	3.18
capital	678	5.44	2. 7	-14	31
NTA	663	13.46	13.26	-34.22	79.4
Labour	386	0.0096	0.005	3.00e-06	0.03
efficiency	607	0.91	0.06	0.733	1
productivity	261	1.03	0.199	0.37	1.7
Industry specific variables					
concentration	898	15.35	2.3	10.19	18.56
Stock market	927	71.66	46.81	24.31	184.1
Macroeconomic variables					
inflation	928	2.9	2.12	-0.77	5.86
GDP growth	900	10.74	1.61	9.1	14.2

Bank size is expected to have a positive impact on market power, since large banks are likely to be in a better position to collude with other banks. Not only can they benefit from their more established reputations, but they are more successful in creating fully or partly new banking products and services than their smaller counterparts (Bikker et al., 2006). Taking into consideration that banks tend to compensate greater risk with higher margins, we expect a positive influence of risk on market power. The SOCBs are able to undertake higher risk compared with JSCBs and CCBs, as SOCBs' non-performing loans can be written off by the government through the four Asset Management Companies (AMCs).

The level of bank capitalisation is expected to have a positive influence on market power; banks which have higher capital levels normally face lower bankruptcy and funding costs, which leads to higher relative margins (Lerner index). The Chinese government injects capital to the SOCBs, which enhances their market power. The efficient structure hypothesis argues that more efficient banks are expected to gain market share and larger banking margins;

thus, efficiency is expected to be positively related to market power. Increasing competition in traditional bank activity (loan-deposit services) obliges banks to engage in non-traditional activities. We anticipate there to be a positive influence of non-traditional activity on bank market power.

Higher productivity, in terms of labour or the banks as a whole, increases the volume of businesses engaged by banks, from which economies of scale can be gained and higher banking margins achieved. Thus a positive impact of (labour) productivity is expected. The taxation burden is expected to have a negative impact on market power. There is no a priori expectation regarding the impact of liquidity on market power. On the one hand, lower liquidity indicates that banks are engaged in higher volumes of loan business which will enlarge the banking margins; whereas on the other hand, a lack of liquidity in banks increases the risk and bankruptcy cost and decreases the bank margins. Thus the impact of this variable on market power is not clear.

With the industry-specific variables, concentration is expected to be positively correlated with banks' market power. Consistent with the Structure-Conduct-Performance (SCP) paradigm, in a highly concentrated market banks are more likely to collude with each other to obtain market power and super-normal profits. Stock market development is expected to be positively related to bank market power. As argued by Maudos and Nagore (2005), in a well developed stock market, banks can specialise in non-interest income activities, which allow them to enjoy higher levels of market power. A negative impact of inflation on bank market power is expected, while it is expected that there will be a positive effect of GDP growth on market power (see Maudos and Fernandez de Guevara, 2010).

Figure 1: Productivity, efficiency and the Lerner index for Chinese banks over the period 2003-2011

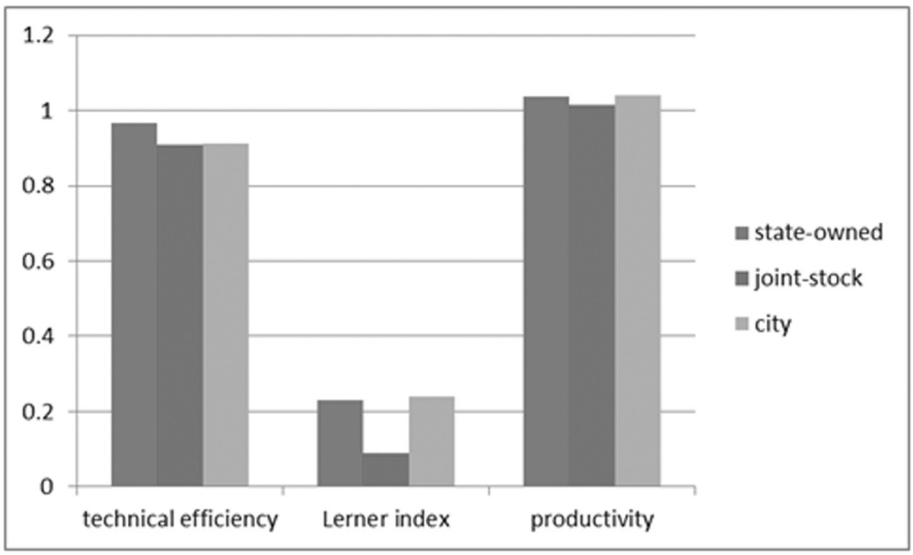
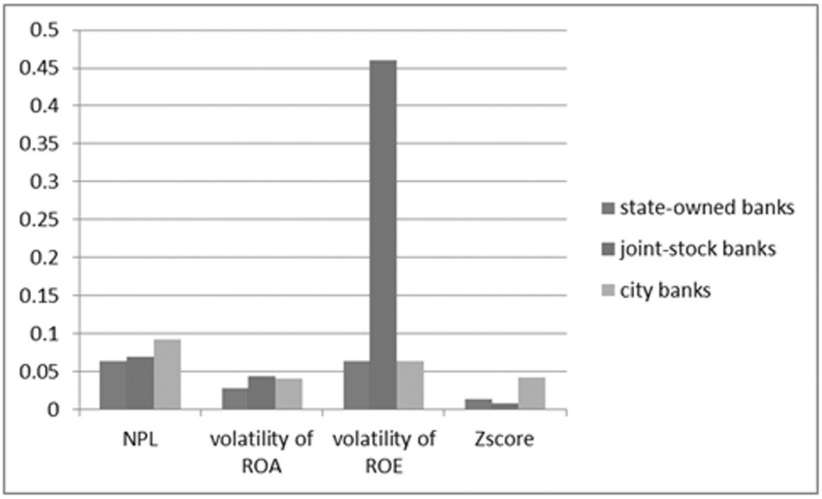


Figure 1 shows the productivity, Lerner index and technical efficiency of SOCBs, JSCBs and CCBs over 2003-2011. The SOCBs and CCBs have higher efficiency and productivity than JSCBs over the period examined. Our results are not in line with Chen *et al.*, (2005), Yao and Jiang (2010) and Berger *et al.*, (2009) who argue that SOCBs are the least efficient, compared to JSCBs and CCBs. This is because we examine a more recent period (our sample considers data after 2008).

To be more specific, one of the five SOCBs, the Agricultural Bank of China successfully listed on Shanghai and Hong Kong stock exchanges on July 2010. The listing not only improves the corporate governance of the bank but, more importantly, increases the efficiency of the bank and leads to the further efficiency improvement of SOCBs as a whole. The Lerner index shows that competition among CCBs in China is the lowest over the examined period, followed by the SOCBs, while the competition among JSCBs is the highest.

Figure 2 shows the risk conditions of SOCBs, JSCBs and CCBs in China over the period 2003-2011. The results from the NPL in Figure 2 show that the risk of CCBs in China is the highest, followed by JSCBs, then SOCBs. These results are in line with Das and Ghosh (2007) for Indian state-owned banks; they argue that bigger banks normally have lower risks. This can be explained by the fact that the businesses of CCBs are limited to within the city; their profits are mainly from traditional loan-deposit services. They make loans to small enterprises within the city, while the probability of default on loans is much higher than the country-wide companies, which leads to a higher credit risk and higher volatility of return on assets.

Figure 2: Risk undertaken by different ownerships of Chinese banks, assessed using NPL, volatility of ROA, volatility of ROE and Z-score



Notes: SOCBs (State-Owned Commercial Banks), JSCBs (Joint-Stock Commercial Banks), CCBs (City Commercial Banks)

Furthermore, comparing to JSCBs and CCBs in China, CCBs have a shorter history and less experience in risk management. However, when risk is measured by the volatility of ROE, the JSCBs are found to have the highest risk, while for SOCBs and CCBs the risk is similar. This result reflects the fact that JSCBs are volatile in generating profits using shareholders' money over the examined period. The results of volatility of ROA and Z-score are in line with volatility of ROE, which show that JSCBs have higher risk than SOCBs and CCBs over the period examined.

6. Empirical results

First, the overall technical efficiency scores of SOCBs, JSCBs and CCBs are estimated using the CCR model, then the pure technical and scale efficiency scores are derived from the BCC model. Table 4 presents the mean values of technical, pure technical and scale efficiencies of the three different bank ownership types over the period 2003-2011.

Table 4: Mean values of Technical efficiency, Pure technical efficiency and Scale efficiency of all Chinese commercial banks: 2003-2011

Banks/efficiency scores	*Technical efficiency*	*Pure technical efficiency*	*Scale efficiency*
State-owned commercial banks	0.966	0.971	0.995
Joint-stock commercial banks	0.908	0.92	0.979
City commercial banks	0.911	0.922	0.973

We find that SOCBs have the highest overall technical efficiency over the examined period, followed by CCBs, then JSCBs. However, the difference of efficiency scores between CCBs and JSCBs is smaller than between SOCBs and JSCBs. The overall technical efficiency scores of SOCBs, JSCBs and CCBs in China are 0.966, 0.908 and 0.911, respectively. These figures indicate that, on average, SOCBs can reduce their factors of production by 3.4 per cent whilst maintaining output. JSCBs and CCBs can reduce their factors of production by 9.2 per cent and 8.9 per cent, respectively.

Based on the decomposition of technical efficiency into pure technical efficiency and scale efficiency, the results show that SOCBs have the highest pure technical efficiency score, followed by CCBs, then JSCBs. Compared with pure technical efficiency, the scale efficiency of Chinese commercial banks is higher: scale efficiency contributes more than pure technical efficiency to the overall efficiency of Chinese banks. In other words, the inefficiency of Chinese commercial banks is attributed to pure technical inefficiency rather than scale inefficiency. The results also suggest that Chinese commercial banks embody pure technical inefficiency and face a misallocation of inputs and outputs in their banking operation.

Table 5 shows the Malmquist productivity index of SOCBs, JSCBs and CCBs over the examined period. Because 2003 is the reference year, the Malmquist productivity index takes an (initial) score of 1.000 for that year. Hence, any score greater than 1.000 in subsequent years indicates an improvement, while any score lower than 1.000 shows a decline.

As observed in Table 5, the SOCBs have exhibited productivity progress, of 0.3 per cent in 2004 relative to 2003, increasing to a record of 11 per cent in 2005, but declining to a low of 0.4 per cent in 2006; however, productivity declined further to a record of 4.6 per cent in 2007 and 3.2 per cent in 2008, before exhibiting 6.5 per cent productivity progress in 2009. Although SOCBs' productivity decreased by 14 per cent in 2010, productivity progressed to a record of 49 per cent in 2011, due mainly to the successful listing of the Agricultural Bank of China.

Relative to the base year (2003), the empirical results also suggest that the JSCBs experienced a productivity decline in 2004 (of 1 per cent), 2006 (2.7 per cent), 2007 (0.1 per cent) and 2008 (2.1 per cent); this compares with 1.5 per cent (2004), 3 per cent (2006) and 6.1 per cent (2008) for the CCBs. Both of these bank ownership types saw productivity rise in 2005, 2009 and 2010, by 3.3 per cent (2005), 4.8 per cent (2009) and 2.3 per cent (2010) for JSCBs; and 3.8 per cent (2005), 5.8 per cent (2009) and 26 per cent (2010) for CCBs. However, the JSCBs had a 0.1 per cent productivity decline in 2007 compared to a 3.1 per cent productivity improvement for the CCBs. In addition, the JSCBs saw a productivity rise of 6.6 per cent, compared to a productivity decline of CCBs by 10.4 per cent in 2011.

Table 5: The Malmquist productivity index of Chinese state-owned, joint-stock and city commercial banks: 2003-2011

Year/banks	*State-owned*	*Joint-stock*	*City*
2003	1.000	1.000	1.000
2004	1.00275	0.9897	0.9846
2005	1.1095	1.0334	1.0379
2006	0.9958	0.973	0.9705
2007	0.9545	0.9989	1.0312
2008	0.9682	0.9789	0.9386
2009	1.0648	1.0476	1.0583
2010	0.862	1.023	1.256
2011	1.493	1.066	0.896

All three bank ownership types in China saw productivity rise in 2005. This can be explained by: 1) economic growth in China; 2) the establishment of the CBRC, improving the operation and supervision of the Chinese banking indus-

try; and 3) significant technology improvements; while the productivity decline in 2008 for all banks is attributed to the financial crisis from 2007. The hosting of the 2008 Olympic Games attracted more international companies and financial institutions to invest their funds or launch projects in China; this not only improved Chinese banks' operations and management, but also led to an improvement in productivity in 2009.

Table 6 shows the empirical findings for the impact of efficiency on market power in the Chinese banking industry, using NPL, volatility of ROA, volatility of ROE and Z-score as risk indicators. The results suggest that the ratio of loans over assets (liquidity) is significantly and positively related to the market power of Chinese banks, indicating that larger volumes of loans made by Chinese banks increase bank margins. The risk of bankruptcy because of illiquidity in China is impossible because all of the banks investigated are supported by either central government, city government, or large state-owned enterprises.

The positive and significant impact of capitalisation on market power is in line with our expectation. We find that there is a significant and negative impact of non-traditional activity on the Lerner index for Chinese banks: those with higher volumes of non-traditional activities normally have lower market power (higher bank competition). This finding can be explained by the fact that Chinese banks still lack the ability and experience to engage in non-traditional activities, which leads to a decrease in bank margins (Lerner index).

The results show that there is a positive influence of efficiency on the Lerner index, indicating that banks with higher efficiency normally have greater market power (lower bank competition). This is in line with the efficient structure hypothesis. Finally, we report that inflation has a significant and positive impact on the market power of Chinese banks. This indicates that Chinese banks have the ability to anticipate inflation and adjust the interest rate accordingly; hence a larger increase in revenue over costs leads to higher bank margins.

Besides the investigation of the impact of efficiency on market power, we use the Malmquist productivity index to examine whether productivity has had an influence on the market power of Chinese banks; we use four risk indicators to double check the robustness of the results. The results appear in Tables 7. The findings show that there is a negative impact of concentration on the Lerner index, meaning that in a more concentrated banking market, banks have lower market power. This is not in line with the study of Claessens and Laeven (2004), analysing the banking sectors of 50 developed and developing countries; nor do the results conform with the SCP paradigm. This finding can be explained by the fact that the Chinese government still intervenes strongly in the operation of the banking market. Although SOCBs are very large in terms of total assets, the Chinese government deliberately decreases their market power (by increasing competition) in order to induce bank managers to improve efficiency.

Table 6: Empirical results for the impact of efficiency on market power

	NPL		*Volatility of ROA*		*Volatility of ROE*		*Z-score*	
Bank-specific	*coefficient*	*T-stat*	*coefficient*	*T-stat*	*coefficient*	*T-stat*	*Coefficient*	*T-stat*
Bank size	0.012	0.48	0.007	0.31	0.001	0.04	0.012	0.48
Risk	1.78	1.10	1.65	0.70	0.0006	0.04	1.49E-06	0.86
Liquidity	0.004*	2.61	0.004***	3.06	0.004***	2.96	0.004***	3.11
Taxation	-0.099	-1.14	-0.09	-1.03	-0.107	-1.24	-0.093	-1.09
Capitalisation	0.0065*	1.80	0.007*	1.88	0.007*	1.88	0.007*	1.84
NTA	-0.003**	-2.41	-0.002*	2.35	-0.003**	-2.53	-0.003**	-2.51
Labour productivity	-2.88	-1.03	-3.22	-1.15	-3.7	-1.05	-2.88	-1.33
Technical efficiency	1.15***	4.55	1.15***	4.66	1.14***	4.60	1.16***	4.69
Industry-specific								
Concentration	-0.018	-0.88	-0.02	-0.93	-0.02	-0.89	-0.02	-0.96
Stock market development	0.0004	1.34	0.0003	1.08	0.0003	0.94	0.0003	0.99
Macroeconomics								
Inflation	0.018*	1.86	0.019**	1.98	0.02*	1.92	0.02**	1.99
GDP growth	0.004	0.45	0.005	0.48	0.006	0.58	0.006	0.62
Constant	-0.83***	-2.88	-0.82***	-3.01	-0.85***	-2.73	-0.85***	-3.13
Dummy 1(SOCBs)	-0.096	-1.54	-0.09	-1.48			-0.094	-1.56
Dummy2 (JSCBs)	-0.13***	-2.32	-0.13***	-3.49	-0.05	-1.11	-0.13***	-3.45
Dummy3(CCBs)					0.08	1.20		
observations	246		252		251		253	
F-test	7.04***		7.39***		7.20***		7.42***	

• *,**,*** represents significance level of 10%, 5% and 1% respectively.

Table 7: Empirical results for the impact of productivity on market power

	NPL		*Volatility of ROA*		*Volatility of ROE*		*Z-score*	
Bank-specific	*coefficient*	*T-stat*	*coefficient*	*T-stat*	*coefficient*	*T-stat*	*Coefficient*	*T-stat*
Bank size	0.016	0.38	0.03	1.01	0.05	0.38	0.04	0.83
Risk	-1.5	-0.64	4.82***	2.77	-0.02	-1.25	-0.005**	-2.65
Liquidity	0.003	1.22	0.005	1.53	0.003	0.59	0.003	1.11
Taxation	-0.21	-1.61	-0.15	-1.33	-013	-1.48	-0.28**	-2.44
Capitalisation	0.005	1.38	0.007	1.60	0.006	1.42	0.007	1.55
NTA	0.003	1.65	0.005*	2.10	0.003	1.58	0.005*	2.12
Labour productivity	-0.06	0.03	-3.1	0.62	-0.49	0.33	1.92	0.39
productivity	0.08	0.54	0.09	0.7	0.05	0.42	0.03	0.2
Industry-specific								
Concentration	-0.06**	2.88	-0.04**	-2.08	-0.03**	-2.33	-0.07***	-3.11
Stock market development	-0.002**	-2.52	-0.003*	-1.95	-0.005**	-2.42	-0.005***	-2.93
Macroeconomics								
Inflation	0.005***	3.33	0.05**	2.58	0.05***	2.95	0.04***	3.35
GDP growth	0.06***	2.95	0.07**	2.52	0.07***	2.93	0.07***	3.53
Constant	-0.09	-0.18	-0.35	-0.73	0.01	0.01	-0.15	-0.29
Dummy1(SOCBs)	-0.038	-0.55	-0.007	-0.18			-0.22	-0.38
Dummy2 (JSCBs)	-0.075	-0.48	-0.15	-1.38	-0.05	-0.65	0.25	0.28
Dummy3(CCBs)					0.07	0.88		
observations	140		140		140		140	
F-test	3.18***		3.93***		3.33***		3.97***	

• *,**,*** represents significance level of 10%, 5% and 1% respectively.

We find that the coefficient of stock market development is negative and significant, indicating a negative influence of stock market development on banks' market power in China. This result can possibly be explained by the fact that a highly developed stock market provides firms with more opportunities to obtain funds through issuing shares than taking loans from banks. As banks' role of channeling funds between borrowers and lenders declines, they have incentives to compete more heavily to retain customers in both traditional and non-traditional products.

In terms of the macroeconomic determinants of bank competition, the results show that the coefficient of inflation is positive and significant, indicating a positive relationship between inflation and bank market power in China. This is in line with Delis (2012) for 84 banking systems studied worldwide. The positive and significant impact of GDP growth rate on bank market power is in accordance with the finding by Maudos and Fernandez de Guevara (2010) for a sample of banks from European, Canada, the United States and Japan.

7. Robustness check

In order to check the robustness of our results, we conduct a number of alternative tests. First, instead of using the three-bank ratio to measure concentration, we use the five-bank ratio. Table 8 presents the results. Our findings show that Chinese banks with higher volumes of non-traditional activities have lower market power, whilst higher technical efficiency leads to higher bank market power. These findings are in accordance with the results reported in Table 6.

Second, we re-estimate equation 4 using the individual fixed effects estimator suggested by Fernandez de Guevara and Maudos (2007). Besides the significant impacts of non-traditional activity and technical efficiency on bank market power, we find that Chinese banks with high levels of total assets have lower market power. This finding is in contrast with our expectation, but can be explained by the fact that smaller banks, such as CCBs, operate within cities, where competition is weaker, while larger banks (such as SOCBs) operate on national and international markets, where competition is stronger. In this case, smaller banks have greater market power than their larger counterparts. We further find that stock market development is significantly and positively related to market power, which is in line with our expectation.

Finally, the results show that Chinese banks have lower market power during periods of economic boom, as reflected by the significant and negative coefficient of GDP growth. This finding can be explained by the fact that economic growth lowers bank entry requirements, the resulting increase in competition reduces the market power of incumbent banks. Compared to Table 7, we have opposite results with regards to stock market development and GDP growth rate; mainly due to the different econometric method applied.

Table 8: Empirical results for the impact of technical efficiency on market power (concentration measured by the 5-bank concentration ratio)

	NPL		*Volatility of ROA*		*Volatility of ROE*		*Z-score*	
Bank-specific	*coefficient*	*T-stat*	*coefficient*	*T-stat*	*coefficient*	*T-stat*	*Coefficient*	*T-stat*
Bank size	-0.006	-0.21	-0.004	-0.14	-0.009	-0.35	-0.002	-0.09
Risk	1.37	0.93	2.71	1.22	-0.011	-0.78	6.76e-07	0.40
Liquidity	0.0003	0.23	0.001	0.81	0.001	0.65	0.001	0.79
Taxation	-0.1	-1.38	-0.098	-1.38	-0.102	-1.43	-0.1	-1.41
Capitalisation	0.005	1.63	0.005	1.55	0.005	1.60	0.005	1.61
NTA	-0.004***	-3.48	-0.004***	-3.54	-0.004***	-3.68	-0.004***	-3.63
Labour productivity	-3.67	-1.05	-4.1	-1.19	-3.74	-1.09	-3.68	-1.07
Technical efficiency	1.02***	3.91	1.05***	4.09	1.04***	4.01	1.02***	3.96
Industry-specific								
Concentration	0.007	0.41	0.014	0.82	0.013	0.77	0.009	0.54
Stock market development	0.0007	0.98	0.001	1.35	0.001	1.29	0.001	1.03
Macroeconomics								
Inflation	-0.001	-0.10	-0.005	-0.38	-0.004	-0.34	-0.002	-0.13
GDP growth	-0.013	-0.52	-0.024	-0.99	-0.023	-0.92	-0.02	-0.65
Constant	-0.64**	-1.99	-0.83**	-2.35	-0.76**	-2.16	-0.69**	-2.20
Dummy1 (SOCBs)	-0.08	-1.24					-0.09	-1.39
Dummy2(JSCBs)	-0.11	-2.96	-0.03	-0.67	-0.03	-0.64	-0.12***	-3.34
Dummy3(CCBs)			0.89	1.39	-0.08	1.27		
observations	246		252		251		253	
F-test	4.80***		4.97***		4.88***		4.76***	

• *,**,*** represents significance level of 10%, 5% and 1% respectively.

Table 9: Empirical results for the impact of technical efficiency on market power (fixed effects estimator)

	NPL		*Volatility of ROA*		*Volatility of ROE*		*Z-score*	
Bank-specific	*coefficient*	*T-stat*	*coefficient*	*T-stat*	*coefficient*	*T-stat*	*Coefficient*	*T-stat*
Bank size	-0.18***	-3.22	-0.2***	-3.55	-0.195***	-3.47	-0.198***	-3.52
Risk	4.07**	2.15					8.23e-06	1.53
Liquidity	0.003	1.25	0.003	1.34	0.003	1.35	0.002	1.22
Taxation	-0.13	-1.61	-0.103	-1.30	-0.11	-1.42	-0.103	-1.30
Capitalisation	0.003	0.94	0.005	1.27	0.005	1.32	0.002	0.48
NTA	-0.003**	-2.26	-0.003**	-2.20	-0.003**	-2.25	-0.003**	-2.25
Labour productivity	2.66	0.67	3.84	1.00	3.72	0.98	2.76	0.71
technical efficiency	0.97***	3.14	0.91***	2.98	0.88***	2.89	0.9***	2.97
Industry-specific								
Concentration	0.006	0.60	0.003	0.35	0.003	0.32	0.006	0.56
Stock market development	0.001***	3.67	0.0001***	3.31	0.001***	3.15	0.001***	3.47
Macroeconomics								
Inflation	-0.003	-0.33	-0.0005	-0.06	-0.0004	-0.05	-0.002	-0.21
GDP growth	-0.03**	-2.46	-0.023**	-2.27	-0.022**	-2.12	-0.024**	-2.30
Constant	0.24	0.58	0.4	0.99	0.39	0.99	0.36	0.90
Observations	246		252		251		253	
F-test	3.73***		3.79***		3.58***		3.70***	

• *,**,** represents significance level of 10%, 5% and 1% respectively.

• dummy variables are dropped from the estimation

8. Summary and conclusions

The risk management of the Chinese banking industry is not only important for the stability of the financial system and economic growth in China, but it has a huge impact on the economic stability of Asian countries. Several rounds of banking reforms have sought to establish a more competitive environment, reduce risk-taking behaviour and increase bank efficiency. There is, however, uncertainty over whether lower risk undertaken by Chinese banks decreases market power; whilst the empirical literature has not documented if increased bank efficiency increases market power in the Chinese banking industry.

This paper investigates the relationship between (i) risk and market power, and (ii) efficiency/productivity and market power, using 5 SOCBs, 12 JSCBs and 84 CCBs from China over the period 2003-2011. Using different concentration indicators and different econometric estimation methods, the results show that higher efficiency leads to higher market power for Chinese banks. Furthermore, we find that Chinese banks with higher volumes of non-traditional activities normally have lower market power.

In order to increase bank efficiency and create a more competitive environment, the current paper has relevant policy implications: 1) the Chinese government or the banking regulatory authority should encourage Chinese banks to engage in more non-traditional activities; 2) Chinese banks should allocate inputs and outputs more appropriately in their banking operations; 3) relevant policy should be made carefully to counterbalance the increase in efficiency and decrease in competition.

Accepted for publication:

Appendix

Estimation of Bank Technical Efficiency

There are two main methods to measure bank efficiency, one parametric, the other non-parametric. The typical parametric estimation can be represented by the stochastic frontier approach (SFA), whilst Data Envelopment Analysis (DEA) is a widely used non-parametric method to investigate bank efficiency.

SFA, as developed by Aigner *et al.*, (1997), is applied to banks by Ferrier and Lovell (1990). It specifies the particular form of the cost function, usually a translog form, and allows for random errors. SFA assumes that the errors consist of inefficiencies which follow an asymmetric distribution, usually a truncated or half-normal distribution, and random errors that follow a symmetric distribution, usually the standard normal distribution. It is criticised for its pre-specified functional form and distributional assumption (Fries and Taci, 2005). Furthermore, it is likely that regulations and other market imperfections distort prices in the Chinese banking sector, complicating the application of SFA to price and quantity data. This makes SFA unsuitable for the estimation of technical efficiency in the Chinese banking sector.

Instead, the efficiency estimates in this study have been obtained using DEA. This originated with Charnes, Cooper and Rhodes, 1978 (noted also as the CCR model) and is a linear programming technique. The CCR model measures the efficiency of each Decision Making Unit (DMU) and is obtained as the maximum of a ratio of weighted outputs to weighted inputs. This denotes that the less input is invested in producing a given output, the more efficient is the production.

DEA has the following advantages: 1) it is able to handle multiple inputs and outputs stated in different measurement units; 2) it does not require any assumptions to be made about the distribution of inefficiency (see Charnes et al., 1995); and 3) it works particularly well with small samples (see Maudos, et al., 2002). 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 appropriate when all DMUs are operating at an optimal scale.

Banker e*t al.* (1984) extended the CCR model by relaxing the CRS assumption. The resulting "BCC" model is used to assess the efficiency of DMUs characterised by variable returns to scale (VRS). The VRS assumption provides the measurement of pure technical efficiency (PTE); that is, the measurement of technical efficiency devoid of the scale efficiency effect. The CCR model can be expressed as:

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ &\text{subject to} \\ &-y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0, \\ &\lambda \geq 0 \end{aligned} \tag{5}$$

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 easily be modified to account for VRS by adding the convexity constraint, N1'λ=1, to provide:

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ &\text{subject to} \\ &-y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0, \\ &N1'\lambda = 1 \\ &\lambda \geq 0 \end{aligned} \tag{6}$$

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 CRS model and 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 score and the CRS technical efficiency score. The relationship between CRS and VRS

is given below:

$$TE_{CRS} = TE_{VRS} \times SE \tag{7}$$

ENDNOTES

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2. See appendix for the estimation of technical efficiency and rationale on the choice of models.

3. These are: Bank of China (BOC), Industrial and Commercial Bank of China (ICBC), Agricultural Bank of China (ABC), China Construction Bank (CCB), and Bank of Communication.

4. These are: China Minsheng Banking Corporation, China Citic Bank, Shanghai Pudong Development Bank, China Merchant Bank, Gungfa Bank, Hua Xia Bank, Ping An Bank, Evergrowing Bank, Industrial Bank, China Everbright Bank, China Zheshang Bank and China Bohai Bank.

5. Since regulators are more concerned with bank outputs than inputs, we consider the output-oriented Malmquist index. Furthermore, some of the inputs (those relating to physical capital) are sticky downwards in the short run, with banks more likely to expand outputs than reduce inputs in order to increase productivity (Delis *et al.* 2011).

6. Kennedy (2008) argues that multicollinearity is a problem when the correlation is equal to or greater than 0.8, below 0.8 indicates that the estimation does not suffer from multicollinearity. The results are not reported here, however, they are available from the authors on request.

REFERENCES

Aigner D, Lovell C A K and Schmidt P (1997) 'Formulation and estimation of stochastic frontier production models', *Journal of Econometrics*, 6, 21-37.

Anzoategui D, Peria M S M and Melecky M (2012) 'Bank competition in Russia: an examination at different levels of aggregation', *Emerging Markets Review*, 13, 42-57.

Banker R D, Charnes A and Cooper W W (1984) 'Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis', *Management Science*, 30, 1078-1092.

Berger A N (1995) 'The profit-structure relationship in banking—Test of Market-Power and Efficiency-Structure Hypotheses', *Journal of Money, Credit and Banking*, 27, 404-431.

Berger A N, Hasan I and 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.

Bikker J A and Groeneveld J M (2000) 'Competition and concentration in the EU banking industry', *Kredit und Kapital*, 33, 62–98.

Bikker J A and Haaf K (2002) 'Competition, concentration and their relationship: an empirical analysis of the banking industry', *Journal of Banking and Finance,* 26, 2191–2214.

Bikker J, Spierdijk L and Finnie P (2006) 'The impact of bank risk on market power', De Nederlandsche Bank, Working Paper no. 120.

Carbo-Valverde S, Humphrey D, Mandos D and Molyneux P (2009a) 'Cross-country comparisons of competition and pricing power in European Banking', *Journal of International Money and Finance*, 28, 115-134.

Carbo-Valverde S, Rodriguez-Fernandez F and Udell G (2009b) 'Bank market power and SME financing constraints', *Review of Finance*, 13, 309-340.

Caves D W, Christensen L R and Diewert W E (1982) 'The economic theory of index numbers and the measurement of input, output and productivity', *Econometrica*, 50, 1393-1414.

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

Charnes A, Cooper W W, Lewin A Y and Seiford L M (1995) *Data envelopment analysis: theory methodology and applications*, Boston: Kluwer Academic Publishers.

Chen X, Skully M and Brown K (2005) 'Bank efficiency in China: application of DEA to pre- and post-deregulation eras: 1993-2000', *China Economic Review*, 16, 229-245.

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

Das A and Ghosh S (2007) 'Determinants of credit risk in Indian state-owned banks: An Empirical Investigation', *Economic Issues*, 12, 27-46.

De Bandt O and Davis E P (2000) 'Competition, contestability and market structure in European banking sectors on the eve of EMU', *Journal of Banking and Finance*, 24, 1045-2066.

Delis M D (2012) 'Bank competition, financial reform and institutions: the importance of being developed', *Journal of Development Economics*, 97, 450-465.

Delis M D, Molyneux P and Pasiouras F (2011) 'Regulation and Production Growth in Banking: Evidence from Transitional Economies', *Journal of Money, Credit and Banking*, 43, 735-764.

Fare R, Grosskopf S and Weber W L (2004) 'The effect of risk-based capital requirements on profits efficiency in banking', *Applied Economics*, 36, 1731-1743.

Fernandez de Guevara J and Maudos J (2007) 'Explanatory factors of market power in the banking system', *The Manchester School*, 75, 275-296.

Fernandez de Guevara J, Maudos J and Perez F (2007) 'Integration and competition in the European financial markets', *Journal of International Money and Finance,* 26, 26-35.

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

Fernandez de Guevara J and Maudos J (2004) 'Measuring welfare loss of market power: an application to European banks', *Applied Economics Letters*, 11, 833-836.

Ferrier G D and Lovell C A K (1990) 'Measuring cost efficiency in banking: econometric and linear programming evidence', *Journal of Econometrics*, 46, 229-245.

Fries S and Taci A (2005) 'Cost efficiency of banks in transition: evidence from 289 banks in 15 post-communist countries', *Journal of Banking and Finance*, 29, 55-81.

Fu M (2009) 'Competition in Chinese commercial banking', *Banking and Finance Review*, 1, 1-16.

Fungacova Z, Solanko L and Weill L (2010) 'Market Power in the Russian Banking Industry', Universite de Strasbourg, Working Paper no. 09.

Kennedy P (2008) *A Guide to Econometrics*, Malden: Blackwell Publishing.

Masood O and Sergi B S (2011) 'China's banking system, market structure and competitive conditions', *Frontiers of Economics in China*, 6, 22-35.

Maudos J, Pastor J M, Perez F and Quesada J (2002) 'Cost and profit efficiency in European banks', *Journal of International Financial Markets, Institutions and Money*, 12, 33-58.

Maudos J and Nagore A (2005) 'Explaining market power differences in banking: a cross-country study', European Commission, working paper no. 10.

Maudos J and Fernandez de Guevara J (2010) Bank size, market power and financial stability, Paper presented at the conference European Association of University Teachers of Banking and Finance, Bangor.

Perera S, Skully M and Wichramanayake J (2006) 'Competition and structure of South Asian banking: a revenue behavior approach', *Applied Financial Economics*, 16, 789-801.

Shaffer S (1993) 'A test of competition in Canadian banking', *Journal of Money Credit and Banking*, 25, 49-61.

Shaffer S (2004) 'Patterns of competition in banking', *Journal of Economics and Business*, 56, 287-313.

Suominen M (1994) 'Measuring competition in banking: a two product model', *Scandinavian Journal of Economics*, 96, 95-110.

Yao S and Jiang C (2010) 'Banking reform and efficiency in China: 1995-2008', University of Nottingham, research paper no.11.

Yuan Y (2006) 'The state of competition of Chinese banking industry', *Journal of Asian Economics,* 17, 519–534.