Access from the University of Nottingham repository:

Copyright and reuse:

University of Nottingham

Title of Dissertation:

Chinese commercial banks' risk management performance before and after financial crisis: evidence from cost and profit efficiency

Author's Name:

Lian Liu

Name of MSc degree

MSc Risk Management

MSc Risk Management Author's Name Lian Liu Year 2012

Word count: 14981

Full Title of the Dissertation

Chinese commercial banks' risk management performance before and after financial crisis: evidence from cost and profit efficiency

By **Lian Liu**

Year of Publication

2012

Content

1. Introduction

From 2007, many investment banks have undergone bankruptcy and restructuring in the USA and some commercial banks in Europe and Britain have suffered heavy deficits and low liquidity. The subprime crisis which first happened in 2007 in America spread to Europe and finally erupted into a global financial crisis. The impacts of this crisis were not as apparent as those incurred in American, but Chinese stock market and real estate were still struck. The share prices dropped dramatically, the rate of unemployment rose and the buying power of customers decreased. Chinese economy fell into the downturn.

Previous studies investigated bank efficiency during financial crisis like the Asian financial crisis, transition period or economic reforms like accession WTO (e.g. Park and Weber, 2006; Thoraneenitiyan & Avkiran, 2009; Ataullah & Le, 2006). We use a more comprehensive and recent data to capture the last time financial crisis and to cover the typical commercial banks in China. In this paper, we explore the cost and profit efficiency using a non-parametric approach called Data Envelop Analysis (DEA) and Tobit regression. The sample data is an unbalanced panel data of 69 Chinese commercial banks which are divided into four groups over the period of 2003-2010.

Our objective is to test whether the financial crisis has adversely affected the Chinese banking system and whether efficiency has effectively materialized in this system. First, we analyze the trend of overall efficiency for each bank type pre- and post-crisis

and compare the different efficiency estimations and the efficiency scores of different bank ownership. Second, we give out several hypotheses regarding the potential determinants of Chinese banking efficiency and the possible relationship between bank efficiency and each determinant. The results are compared to the previous hypotheses and empirical researches. Some arguments are reasonably obtained to explain the results considering the existing circumstances of Chinese banking system.

This paper has some distinguishing features. First, our study takes both cost and profit efficiency into account using DEA approach instead of employing Stochastic Frontier Analysis (SFA) and unlike the prior literature which has a typically small number of banks in the sample. Second, it extends the studies of Maudos & Pastor (2003) and Ariff & Can (2008) which analyze cost and profit efficiency in Spanish and Chinese banking sectors respectively, but differs in the sample size, input and output variable selections, and regression dependent variable confirmation. Third, we only consider the domestic commercial banks and exclude foreign banks and other financial institutions like trust investment and cooperative companies. Hence, homogenization of specialization is achieved. Finally, this paper tests the effects of many factors, namely profitability, ownership, size, risk profile and environment changes, using Tobit regression in the second stage.

The paper is structured as follows. Section 2 provides the review of Chinese banking system and the reform during the recent decades. Section 3 describes the literature

review which focuses on the bank applications. Section 4 explains the methodology about the non-parametric approach, DEA models and the efficiency estimations. Section 5 is about the description of sample data, the selection of input and output variables, and the regression hypotheses. Section 6 displays the results and findings. The conclusions are presented in the last section.

2. Chinese Banking system

2.1. Banking reforms

The process of bank reforms in China has experienced several stages to transfer the state-owned ownership to the mixed ownership which were covered in many studies (e.g. Chen et al., 2005; Lin & Zhang, 2009; Yin et al., 2010). According to Tang (2005), we divide the reform into four stages.

In the first stage (1979-1984) which is called the initial institutional restructuring period, the People's Bank of China (PBC), which is also known as the central bank and its main objectives are maintaining price stability and executing supervisions on financial institutions, stripped its commercial banking off and established four state-owned commercial banks (SOCB). The four banks had distinct functions over different fields covering agriculture, construction, industry and commerce. The worked well as monopolistic institutions and had no incentives to compete with regional banking sectors. Additionally, the four state-owned banks operate for state government and their main business was to offer funds to state-owned enterprises.

That is to say, they had no right to make lending decisions based on commercial analysis and economic environment.

The second stage (1984-1994) is a deepening period for institutional restructuring. The primary mission of the reform is to transform the banking system to be market-oriented instead of a policy-driven one. In order to encourage competitions in banking system, the government relaxed limitations on the state-owned banks and permitted foreign banks and some new domestic banks to enter the financial market. Under this circumstance, the joint-stock commercial banks (JSCB), which operated for profit maximization, and the rural commercial banks (RCB), which aimed to finance small and medium-sized enterprises, were set up to diversify the banking system. As a result, the mono bank type was transformed into the system which was dominated by the state-owned banks with JSCBs and RCBs followed. Importantly, Wong & Wong (2001) pointed out that in this period the SOCBs were intervened by governments and extended loans blindly which may incur a large amount of non-performing loans.

The third stage (1994-2003) is called banking commercialization period. In this period the effort to reform banking and financial services accelerated especially when Asian financial crisis happened in 1998 and China joined WTO in 2001. In 1994 the newly established policy banks took the policy lending operation away from the SOCBs. Moreover, 112 city commercial banks (CCB) were also founded. Meanwhile, the central bank injected capital to offset the non-performing loans of the SOCBs. It is

undeniable that this stage was very important because the legislation and supervisory regime started to be developed, and financial restructuring and liberalization were also in progress. However, there were still many problems needed to be settled in the banking system. For instance, the asset quality was poor; liquidity and profitability were low; no systematical risk management was complemented. The reform was far from accomplishment.

The last stage started from year 2003 and went until now. The core objective of this period is partial privatization and modernization. Two strategies were employed to restructuring, the one is foreign investment strategy, and the other one is IPO strategy. During 2005 and early 2006, three state-owned banks proposed to accept partially privatize and take on minority foreign ownership. The project was completed in 2006. Moreover, foreign investors were encouraged to take equity in domestic banks and finally the foreign investment covered all types of domestic banks. For example, Newbridge Financial held 15% of Shenzhen Development Bank, Citicorp owned 5% of Pudong Development Bank, and Bank of America, Goldman Sachs, Temasek of Singapore and Royal Bank of Scotland all acquired stakes in the SOCBs. Apart from foreign investment, these banks went public to allow some shares to be traded. Obviously, the two strategies were intimately related because foreign investment promoted banks to go public and the benefits brought were increase in investor liquidity, improvement in transparency and accuracy of financial performances, and regularized market management. After adopting practical reform

measurements, the banking system became more comprehensive and multi-layered.

Generally, many achievements and improvements like strategic alliance with foreign financial investment, expansion of bank scale, establishment of internal risk management systems, increasing the autonomy of banks to make business decisions, encouraging competitions and diversifying the bank ownership structures, were completed during these reform stages. However, the ultimate success is subject to many factors. It is still uncertain whether the SOCBs can make effective operation decisions based on economic environment, whether the government intervention will make less power and can be reversed in the near future (Dobson & Kashyap, 2006), whether the SOCBs can efficiently implement risk management and credit rating analysis, and whether the problem of non-performing loans can be solved properly. We predict that the transformation in the SOCBs are more complicated and still take longer to enforce.

2.2. Banking regulatory

At present, the Chinese financial system is consisted of two regulatory institutions and other financial part. The People's Bank of China, or the central bank, plays a dominant and leading role in the system. The responsibilities of the central bank are same like that of the Federal Reserve Bank in America. To be more specific, the central bank is responsible for executing national monetary policy, supervising the credit market including the inter-bank loans, regulating and controlling the interest

rate for loans and deposits, managing foreign exchange market and gold reserves, and also monitoring and promoting the bond market. Decisions about the government intervention are transmitted down through the central bank and these decisions are made based on the national economic development and stability.

Another important regulatory institution is the China Banking Regulatory Commission (CBRC) which was established by the State Council in 2003. By the nature of the commission, the CBRC is the primary government organization which also works as a central pivot between the government mechanism and the commercial banks. Hence, the commission is responsible for the surveillance on the commercial banks' operations, approving and empowering the establishment, restructuring and dissolving of the commercial banks, and most importantly formulating principles and laws such as the Commercial Bank Law (launched in 1995) and Bank Operation Practices. After China joined the WTO, the rapid growth of the national economy acquired the establishment of the CBRC to protect the interest of investors and maintain market confidence. Therefore, the standardized regulatory makes sense to keep the banking system in order.

2.3. Banking types

Until now, the Chinese bank ownerships are various and different types of commercial banks are competing in the financial market. In 2010, the banking system was composed of more than 30,000 institutions including 5 state-owned commercial

banks (SOCBs), 12 joint-stock commercial banks (JSCBs), 120 city commercial banks (CCBs), 65 rural commercial banks (RCBs), 31 rural commercial and cooperative banks, 27 rural credit cooperatives, 86 three types new rural financial institutions, 75 foreign banks, 31 trust and investment companies, 45 finance companies, 8 financial leasing companies, 7 automobile financing companies, 3 monetary and financial companies, and 2 consumer financing companies. The two main groups are the SOCBs and JSCBs which took up about 70% of the total assets. As the PBC, the CBRC and the policy banks mainly serve special objectives, so we do not contain these banks into our categories.

State-owned commercial banks: There are currently five SOCBs, namely the Agriculture Bank of China, the Bank of China, the China Construction Bank, the Industrial and Commercial Bank of China, the Bank of Communications. The SOCBs make efforts to carry out the social welfare objectives. Their branches expand across the nation and overseas and the employees were more than 700,000 (Garcia-Herrero et al., 2006). As the reform deepened, The SOCBs were also forced to abandon their practice on job protection and to improve efficiency through consolidation. in terms of total assets, the SOCBs have lost market share over recent years, their shares on assets, loans and deposits dropped significantly. In 2005, the shares were 56.1%, 50.1% and 79.9% respectively (Yin et al., 2010). Moreover, the non-performing loans ratio, which was a big problem for the SOCBs, dropped down to about 6% in 2007 but still needs improvement. However, regardless of the decline, they have still dominated in

the deposit and loan market for almost two decades and this leading position remains unshakable. Such a dominant position comes from some political and historical reasons and the vast banking infrastructure as well.

Joint-stock commercial banks: The JSCBs are partially owned by foreign capital, local governments, national enterprises and the private sectors. By comparison, the JOCBs are much smaller than the SOCBs in the aspect of branch networks, assets and operation scales and their main services are set in medium-sized and large cities to offer retail and wholesale business. The twelve JSCBs are China Bohai Bank, China Minsheng Banking Corporation, China CITIC Bank, Shanghai Pudong Development Bank, China Merchants Bank, Guangdong Development Bank, Hua Xia Bank, Shenzhen Development Bank, Evergrowing Bank, Industrial Bank, China Everbright Bank, and China Zheshang Bank. Specially, the JSCBs diversified their businesses from retail banking services to providing foreign exchange and international transaction services. The JSCBs took years to expand activities and have captured the partial market shares of the SOCBs based on their open and market-oriented culture. However, because of the economic development imbalances, the operations of the JSCBs are still confined to their locality.

City commercial banks: Compared to the SOCBs and JSCBs, the CCBs are a small section of the Chinese banking system but also play an essential part. The assets of the CCBs accounted for 6% of the overall assets in 2006 (Sufian & Habibullah, 2012).

These banks are owned by local government and local enterprises. They offer commercial banking services like intermediary, settlements and money transfers. Their main customers are basically small and medium sized enterprises and residents, and the CCBs have the advantage of maintaining a strong relationship with local business alliances and resident customers. In turn, the advantage also acts as a disadvantage. As the CCBs cannot operate at the national level, they still have difficulties to attract the customers with large scales and are constrained to the locality.

Rural commercial banks: Their operation model is the same with that of the JSCBs but they locate in rural areas. The RCBs are owned by farmers, rural enterprises and other economic organizations of local financial institutions. The banks provide services to farmers and agriculture businesses.

2.4. Financial crisis

In all, the global financial crisis which derived from the 2007 subprime crisis to a certain degree affected the Chinese banking system in a short term but will impact significantly in the long term. In particular, the global financial crisis brought unfavorable effects on the Chinese banking system mainly through three ways.

First, under the financial crisis, the impacts on Chinese real economy reduced the profitability and worsened the performance of the enterprises. Meanwhile, the

buying powers of foreign customers declined and in turn affected export to decrease. Some industrial enterprises and export corporations had difficulties to obtain profits to repay the loans and interests. So this would cause higher ratios of bad assets and non-performing loans.

Second, the global economy went into the period of cutting interest rate and the Chinese commercial banks confronted with high exchange rate risk and interest risks. The sales of financial products as well as traditional deposit and loan business have been affected, and the profit margins shrunk considerably resulted from the business decline.

Third, some foreign countries like the US and European countries increased the demand for capital and funds but reduced the supply. This resulted in the reduction of foreign capital inflow to China. The negative impact on banking sectors could be proved by the evidence that foreign investors sold out the equity of Chinese banks.

In order to cope with the adverse effects, Chinese banking sectors should improve all around and concentrate on four aspects. First, in the subprime crisis, the financial and rating institutions violated the principles of integrity and failed to disclosure the true credit information about loan terms and interest rate risk which would mislead customers. Commercial banks should collect credit records of individuals or institutions and create more stringent credit evaluation system to reduce credit

liquidity risk.

Second, currently the main profit source of the domestic banking sectors is still the traditional business like loans and deposits. As the banks over dependent on the mono profit model, the trend to cut down profit is inevitable. Hence, it is important to make adjustments such as business integration, market segmentation, financial product innovation and technology development.

Third, agency problem and moral hazard are the cause of the outbreak of the subprime crisis. In order to protect the interests of customers, the bank managers should be appropriately motivated like wages, benefits or incentive stock options, and also be constrained by institutional, contracts or market constraints. Most important, risk management should play the key role to fight against the financial crisis.

Forth, market regulation cannot do everything, so government and relevant institutions should concern about the development of the financial markets to supervise the entire banking system and to avoid the risks of financial derivatives and market disorder.

3. Literature Review

As the commonly accepted view states, the bank's principal goal is to maximize the

shareholders' value. According to Fraser & Fraser (1990), two dimensions of bank performance underlying the principal are profitability, efficiency and risk, that is, all managerial decision would generate impacts on profitability, efficiency and risk. Therefore, Avikiran (2006) summarized the risk-return framework which highlighted the responsibility of management for striking well balance between risk and return. This suggested that the analysis of bank performance should include these profitability, efficiency and risk dimensions.

3.1. Applications of Data Envelop Analysis (DEA) in banking

According to Huang & Wang (2002), ''The most commonly use indicators of bank performance or efficiency are the accounting ratios and efficiency scores obtained from various frontier efficiency approaches''. Some of the earliest applications of data envelopment analysis (DEA), arguably the most widely used frontier efficiency technique first popularized by Charnes et al. (1978) are in the banking sector. As a result, DEA is a well-established relative efficiency analysis technique in banking.

There were massive of studies using DEA approaches over different countries. Miller & Noulas (1996) tested the overall efficiency and had the conclusion that the technical efficiency of overall American banks was about 97% (could be also showed as 0.97) which got very close to score 1 and represented a very high level of efficiency. About large American banks, Meanwhile, Seiford & Zhu (1999) took further steps and a two-stage DEA approach. Unlike the overall evaluation of US large banks conducted

by Miller & Noulas, they selected top 55 US banks and resulted that large banks had more probabilities to have higher profitability while small banks may have lower profitability but better marketability respectively and summarized that bank efficiency was positively related to bank size and profitability. Al-Shammari & Salimi (1998) examined Jordan banks and computed operation efficiency by employing a modified DEA. The results indicated that the large number of banks surveyed in the sample were fairly inefficient over the period of 1991 to 1994.

Some studies chose to exam the efficiency of bank branches. Al-Faraj et al. (1993) just concentrated one largest commercial bank in Saudi Arabia and used DEA to evaluate. Among 15 branches, 12 branches have scores around 1 which could be identified to be efficient. Moreover, Alirezaee et al (1998) also applied DEA numerical experiments and gathered large-sized sample data. They emphasized 1282 Canadian bank branches and concluded that most braches showed high efficient but some inefficiencies were due to location or market.

When incorporated comparison, several studies committed to find out whether there was improvement in bank efficiency after the special period like financial crisis. Zaim (1995) concluded that Turkish banks experienced improvement in efficiency in 1981 under a more liberalized banking environment after financial reforms and this improvement in cost efficiency mainly showed on technical and allocative efficiency components. Casu and Molyneux (2003) utilized a bootstrapping DEA technique to

conclude that the bank efficiency of European banking systems was investigated has revealed a slight improvement since the implementation of the EU's Single Market Program. Baer and Nazmi (2000) wanted to verify whether the implementation of newly modified bank structure has exerted positive influence to alleviate the negative impacts of the financial crises in Brazil caused by the constant inflation and the implications of the newly emerging bank structure. As a result, the test showed that after crisis banking industry was still inefficient.

Most important, various possible factors related to bank efficiency were taken into account in some studies. Recent development in the application of DEA demonstrates that the kind of analysis can not only determine bank efficiency scores over a certain periods, but also explore the impacts of contextual or environmental factors on the bank efficiency scores. As to Turkish commercial banks, Yildirim (2002) detected efficiency from 1988 to 1999 and Sakar (2006) focused on the period from 2002 to 2005. The result concluded from Sakar showed that the bank efficiency had significant relationships with branch numbers, staff numbers and market shares. The banks with less than 200 or with about 600 branches, with less than 5000 staff or around 9000 staff and with 3% market share of total assets or more than 11% market share had better scale efficiency, while around 9% market share around may show lower efficiency level. However, marketing competition and effective bank ownership could increase efficiency.

In addition, some scholars concentrated on the 1998 Asian financial crisis and dedicated to finding out the factors which might affect bank efficiency in crisis. Park & Weber (2006) studied Korean bank efficiency and productivity change. Under the circumstances of financial liberalization and the Asian financial crisis, they gave the conclusion that technical evolution and bank reforms were very significant determinants to improve bank efficiency and generate rapid growth. Apart from the DEA approach, Thoraneenitiyan & Avkiran (2009) utilized the slacks based measure (SBM). Their purpose was to identify the relationship between bank structure, country-specific conditions and bank efficiency in Asian countries after Asian financial crisis from 1997 to 2001. The important factor related to bank structure was the bank ownership. They found that banks acquisition and restructuring did not result in higher bank efficiency. As to the determinants to efficiency declination, they concluded that country-specific contexts like fluctuated interest rate and macroeconomic developments, which were same as the study of Park & Weber (2006), most attributed bank inefficiency.

According to Thoraneenitiyan & Avkiran (2009), there are several reasons for scholars to study bank efficiency and respective determinants post crisis. First is the district importance considering many financial factors, such as financial acquisition, the direction of capital flows to the financial markets, and macroeconomic reforms. Second, it is claimed that the banking crises are mainly caused by bank inefficiency in developing countries. After 1997 the East Asian crisis and 2007-2009 subprime crisis,

the bank regulation institutions of crisis-stroke countries like US, European countries and some Asian countries complemented banking system reforms and other practical methods to enhance bank efficiency and reduce failure risk and inefficiency by merge and acquisition. Finally, many studies contributed to investigate environmental factors which influenced bank efficiency estimation.

However, based on the previous researches the influence of environmental factors is limited to studies on European banking sectors. Under the examination of the cross-country bank efficiency, country-specific conditions played an important role to measure bank efficiency in developing countries. These investigations on bank efficiency of banking system show the trend that the focus of studies extended from the calculations on overall bank efficiency to estimations on more specific branch efficiency and identifications on factors which have the relationship with bank efficiency under a special economic environment.

3.2. Bank ownership and bank efficiency

In terms of the relationship between bank ownership type and bank efficiency, different types of bank ownership types may have different impacts on bank efficiency. A large number of studies examined these differences across or within countries.

Berger et al. (2009) compare the cost and profit efficiencies of different bank

ownership groups (the Big Four state-owned banks, non-Big Four state-owned banks, majority private domestic banks, majority foreign banks and no majority ownership banks), using a sample of 38 banks between 1994 and 2003. Berger et al. (2004) chose 28 developing nations to test bank efficiency, and Bonin et al. (2005) focused on Eastern European banks, while Delfino (2003) and Berger et al. (2005) investigated Argentine banks. All the studies above found that foreign banks are more efficient than domestic private banks, while these two types of banks are also more efficient than the state-owned banks.

In a study of Indian banks, Bhattacharya et al. (1997) found out that the state-owned banks were the most efficient banks compared to foreign and domestic private banks although the difference between state-owned banks and foreign banks was not much. When going into details, public banks have the highest average efficiency and the lowest variance on efficiency, while foreign-owned and domestic private banks had lower average efficiency. At the first stage of the study, the efficiency of foreign-owned banks remained ate the lowest level. At the last stage of study and during the last two years, foreign-owned banks efficiency grew up rapidly. Sensarma (2006) also found lower efficiency levels for foreign banks in India during the deregulation period. Moreover, in case of comparing Indian public banks and private domestic banks, Sathye (2003) showed that public banks are more efficient.

Cadet et al. (2008) supported the conclusions of Indian studies and reached a same

result in Haiti. However, Havrylchyk (2006) and Sturm & Williams (2004) used the DEA technique to explore the Polish and Australian banking industry respectively and the result was indicated different with the studies on India banks which mentioned above and showed that foreign banks are more efficient. Similarly, Bonin et al. (2005) and Staikouras et al. (2007) concluded that foreign banks are more efficient than domestic banks in transition countries and in South Eastern European region respectively. Both studies considered the specific economic environment and development.

Actually, there are mixed result to define whether foreign, public or domestic banks would be more efficient because the results are determined by a variety of factors. Garcia-Cestona & Surroca (2008) pointed out different goals for different bank types attributed different results. For instance, profit making purpose may not be the most important one for public banks because other businesses like regional development may considered in decision making process.

As to China, there are five main types of Chinese banks which are state-owned commercial banks (SOCBs), joint stock commercial banks (JSCBs), city commercial banks (CCBs), policy banks (PBs) and rural commercial banks (RCBs). Chen et al. (2005) gave the conclusion that the "big four" major SOCBs in China were cost efficient comparing to smaller JSCBs. However, Wei & Wang (2000) and Zhong et al. (2001) employed X-efficiency model to study Chinese banks. These researches concluded

that state-owned banks had a low level of bank efficiency. Meanwhile, Matthews et al. (2009) also indicated that JSCBs commonly display a better performance than SOCBs, and pointed out that the SOCBs show no productivity growth because the offset between technological progress and efficiency regression. Fu & Heffernan (2005) examined the cost X-efficiency of 14 Chinese banks during 1985–2002 and enhanced the conclusion of Wei et al that the SOCBs were less efficient than the JSCBs. Berger et al. (2006) applied SFA approach to evaluate cost and profit efficiency of Chinese commercial banks and also illustrated a lower efficiency level of the SOCBs than that of other bank types. Moreover, there was an increased trend for higher efficiency in foreign commercial banks.

In summary, among these studies the most common finding for developing countries is that in general the foreign banks are more efficient than or have the same level of efficiency with the domestic private banks. State-owned banks perform on average the lowest bank efficiency.

3.3. Risk factors and bank efficiency

Apart from studies on bank efficiency alone, more and more studies try to explore the relationship between bank profitability, risks and efficiency mostly using Tobit regression. Li et al. (2001) estimated profit equation by two-stage least square and measured profit which was represented by net income to assets using unexpected variation in market deposit, standard deviation of average capital income and

unexpected variation of loans.

On the other hand, the risk was measured by the standard deviation of net income to assets which may affected by market concentration and market power. Sinkey (2002) broke down bank performance into return, which was measured by ROE, and risk, which was presented by variability of ROE. In some banks report ROE was clearly computed but in other banks equity multiplier and ROA would be needed to come to ROE. In this study, capitalization was considered as potential risk exposure, and ROA, the profitability measurement, was determined by controllable factors and non-controllable factors. Sinkey further defined controllable factors to be turnover, loan quality, liquidity and capital management, while non-controllable factors were set as inflation, regulatory, market demand and district development. The underlying idea in the study was that this risk–return framework is consistent with the value-maximization framework.

Sufian (2009) investigated the efficiency of Malaysian banking sector through the Data Envelopment Analysis (DEA) approach around the Asian financial crisis 1997. After the efficiency estimation, the analysis further focused on the determinants which may have impacts on the bank efficiency. He adopted multivariate Tobit regression to test the relationship between Malaysian bank efficiency and the bank specific and macroeconomic and contained a set of explanatory variables like bank size, profitability, and ownership.

According to Ariff & Can (2006), in the first stage they combined cost efficiency and profit efficiency to analyze Chinese banking system implementing DEA the non-parametric techniques. In the second stage, they also used Tobit regression to examine whether ownership structure, bank size, credit risk, asset quality, capital risk, liquidity risk, profitability, operating costs and crisis the environmental factor.

Additionally, Ataullah & Le (2006) ran regression and implied that external factors were considered to be significant to bank efficiency. The external factors mainly included the competition intensity, growth in demand for financial services, and government regulations. Drake et al. (2006) applied non-parametric approach to assess the relative technical efficiency of Hong Kong banking sectors. The first stage was efficiency estimation, and the second stage is Tobit regression to analyze the impact of environmental variables such as macro economy and regulatory.

4.   Methodology

This paper uses data envelopment analysis (DEA), the non-parametric method, to analyze the bank efficiency in the first stage. Specifically, the bank efficiency is measured by both cost efficiency and profit efficiency. In the second stage, we use Tobit regression to assess whether some important variables including risk factors like credit risk, capital risk and liquidity risk commitments significantly affect bank efficiency.

There are several reasons for us to complete two-stage study. First, the underlying efficiency has two aspects. Cost efficiency aims to achieve the minimization of costs, while profit efficiency takes the goal of profit maximization into account. Our study combines these two aspects of bank efficiency to gain a more comprehensive result.

Second, many existing researches of China have adopted stochastic frontier approach (SFA), the parametric method, to assess bank efficiency. However, DEA does not make assumptions about functional forms and works well with a small sample size, and has advantages of accommodation a multiplicity of outputs and inputs. Therefore, this paper would examine whether the result is consistent with that of using parametric approach.

Finally, besides testing the bank efficiency level, the determinants especially risk factors play roles to this efficiency level are also very important. Some authors have utilized censored Tobit regression (e.g. Casu & Molyneux, 2003; Maudos et al., 2002). It is obvious that Tobit regression integrates the censored nature of the dependent variable and generates consistent estimations. According to the scale score, we adopt Tobit regression with a left censored bound of zero and right censored bound of one to regress the bank efficiency and determine the factors of bank specific and economic environment variables.

4.1. Data Envelop Analysis (DEA)

4.1.1. Introduction to DEA

Schaffnit (1997) defined Data Envelopment Analysis (DEA) a theoretically sound framework for performance analysis that offers many advantages over traditional methods such as performance financial ratios and regression analysis. A set of entities, often called decision-making units (DMUs), mainly inquire the DEA and then receive inputs and produce multiple outputs. Samoilenko & Osei-Bryson (2008) pointed out the purpose of DEA is to establish the relative efficiency of each DMU within a sample and the most significant function of DEA is to evaluate the operating performance of a group of decision making units (DMUs) and the interaction performance efficiency.

It is obvious that the DEA can process multiple inputs and outputs simultaneously, Lin et al. (2009) also illustrate that the efficiency frontier obtained after interaction is the combination line of most favorable circumstances of evaluated units. Regarding the efficiency frontier, Farrell (1957) proposed to adopt this so-called efficiency frontier to measure production efficiency. ''Preset production function'' is commonly used, but he used ''non-preset production function'' instead and considered all decision-making units (DMUs) as one identical production function. Then a best practice group is established by using piece-wise to connect the best practice DMU points to form an enveloping curve or efficiency frontier. Other DMU points which are not on this efficiency frontier are identified to be inefficient. In other words, DEA

allows improvements and the magnitude of the inefficiencies for the inefficient units.

Basically, as Avkiran (2011) illustrated, in this linear programming each DMU uses linear program to scale the relative efficiency which estimated between 0 and 1. By comparing the final result, a DMU with 1 score represents an efficient performance in the sample, and with score less than 1 is considered to be inefficient performance.

Moreover, there are two quite different objectives in making assessments of efficiency. Avkiran (2011) clearly redefined this measurement as input-orientation and output-orientation. Under input-orientation, the objective is to estimate how much the inputs can be controlled while maintaining the existing number of outputs. Alternatively, under output-orientation, the objective is to expand the number of outputs for given levels of inputs. To sum up, "DEA is best described as an effective new way of visualizing and analyzing performance data." (Mansoury & Salehi, 2011).

DEA technique has some advantages over other methods. First, Avkiran (2011) pointed out that there is no preconceived structure and explicitly specify a mathematical form imposed on the data to create the production function. The idea underlying the assumption is that the bank efficiency can be measured based on the actual observed performance in the sample. As we mentioned above, DEA, the efficient frontier technique, identifies the inefficiency through comparing the particular DMU to the similar DMUs which are benchmarked to be efficient. This kind

of technique avoids getting some data like statistical average value of DMU performance which may be inapplicable.

Second, the result reported from DEA allows various potential improvements in input utilization and output generation. To be more specific, the technique takes different models like return to scale into account to calculate efficiency. This concept indicates that it is possible to increase or decrease efficiency under the given levels of size and production. Hence, from this aspect DEA plays an important role to work as a valuable benchmarking tool.

Finally, DEA has a strong capability of accommodating a multiplicity of inputs and outputs. That is to say, the interaction among multiple inputs and outputs can be captured in a scalar value. It is obvious that this ability of processing input and output variables is superior to traditional ratio analysis.

However, the limitation of DEA is also distinct. As the assumption of data fails to contain the measurement error, Berg (2009) suggested that the design of model, and inclusion or exclusion of variables can affect the results. Thus, compared with parametric techniques, DEA is more sensitive to the existence of measurement error. So in our study we will choose appropriate input and output variables with more considerations.

4.1.2. Efficiency estimations

The general concept of efficiency comes from the difference comparison between observed and benchmark, which can be also seen as optimal, combination values of inputs and outputs. As DEA is the frontier where the set of efficient observations on, this means that on this frontier there are no other linear combinations which can adopt less inputs without changing the outputs amount or can produce more outputs without increasing the quantities of input employed. According to different efficiency levels of input utilization and output generation, there are a number of efficiency concepts and measurements like X-efficiency, economic efficiency, cost efficiency and profit efficiency.

According to Wu et al. (2006), DEA basically allows us to focus on the input saving which can be also known as cost efficiency (CE) and on the output maximization which is profit efficiency (PE). Cost efficiency (CE) can be detailed into two components, the allocative efficiency (AE) and technical efficiency (TE). The AE, as Isik & Hassan (2002) defined, measures the proportional reduction in costs if the bank chooses the right mix of inputs given the prices (the point of tangency between the isoquant and budget line), and TE measures the proportional reduction in input usage that can be attained if the bank operates on the efficient frontier. Thus, if the banks are cost efficient, that means the banks are both allocatively and technically efficient. As to X-efficiency, the concepts of it were firstly introduced by Leibenstein (1966) and Kyj & Isik (2008) defined X-efficiency scores calculated by DEA are the

differences about input utilizations between the observed bank and the estimated

efficient frontier. As the input-orientation and output-orientation are two different

objectives of efficiency assessments, the non-frontier scale or scope efficiency is

output-orientation and concerns the choices of outputs, while X-efficiency features

on the input usages.

Under non-parametric methods, for instance, Maudos & Pastor (2003), Färe et al.

(2004), Chen et al. (2005), Ariff & Can (2008), Revanian et al. (2011) all chose to

examine cost efficiency and/or profit efficiency. To be more specific, there was a little

difference among these studies. Maudos & Pastor (2003) examined Spanish bank

efficiency during 1985 and 1996 by adopting alternative profit efficiency and

compared it with cost efficiency. On the other hand, Färe et al. (2004) set standard

profit efficiency as computing model to investigate US commercial banks from 1990

to 1994. While Chen et al. (2005) just focused on cost efficiency using the data

sample of 43 Chinese banks from 1993 to 2000. In our study, cost efficiency and

profit efficiency measurements will be well combined to obtain the bank efficiency

level. Data envelopment analysis (DEA) offers a range of models for the efficiency

assessment of decision making units (DMUs).

Regarding the nature of returns to scale of the production technology and the

problem based on whether correspondingly proportional change of all inputs and

outputs is reasonable, there are the constant returns-to-scale (CRS) model, proposed

by Charnes et al (1978), which is also known as the CCR model, and the variable returns-to-scale (VRS) model, introduced by Banker et al (1984), which also known as the BCC model. Specifically, the term returns to scale arises in the context of a firm's production function. It denotes changes like increase by a constant factor in all inputs are resulted in a proportional change in outputs. CRS model shows the simultaneously proportional in output and this is the standard to distinguish the VRS model. Charnes et al (1978) pointed out that the CRS model estimates the gross efficiency of a DMU. This efficiency comprises technical efficiency and scale efficiency. While VRS measures the pure technical efficiency. It is very important to choose an appropriate model specification. In our study, we choose CRS model to control the multiplicity of size in the sample under the assumption that the production function has constant returns over that range.

4.2. Stage 1: Efficiency estimations using non-parametric DEA methodology

4.2.1. Cost efficiency (CE)

Under the input orientation, cost efficiency weights how minimum the cost which is inputs number multiples the given inputs prices would generate the same amount of outputs at certain prices. Assume that there are N $(k = 1, \dots N)$ banks which have a vector of *n* inputs $x_k = (x_{k1}, \dots x_{kn})$ at price of $w_k = (w_{k1}, \dots w_{kn})$ and produce a vector of *m* outputs $y_k = (y_{k1}, \dots y_{kn})$ for given market prices $v_k = (v_{k1}, \dots v_{kn})$. For a bank i, the cost efficiency can be showed in a linear programming as follows:

$$\text{Min} \quad \sum_n x_{in} w_{in}$$

$$\text{s.t.} \quad \sum_k \lambda_k x_{kn} \leq x_{in}$$

$$\sum_k \lambda_k y_{km} \geq y_{im}$$

$$\sum_k \lambda_k = 1; \ \lambda_k \geq 0; k = 1, \dots. N$$

$$\forall n, \ \forall m, \quad x_k, \ w_k \ \in R_{n++}, \quad y_k, \ v_k \ \in R_{m++}$$

Where w_i is a vector of input prices, y_i is a vector of outputs produced by bank i, y_{km} is a matrix of observed outputs produced by all banks in the sample and x_{kn} is a matrix of observed inputs employed by all banks in the sample and λ_k is an intensity vector. $x_i^* = (x_{i1}^*, \dots., x_{in}^*)$ is obtained from a linear combination of banks which corresponds to the goal of input costs minimization at given inputs prices. The banks should generate at least as much outputs as bank i does utilizing the same numbers or less numbers of inputs. When coming to the cost efficiency, the potential minimum cost of the hypothetical bank has a cost $C_i^* = \sum_n x_{in}^* w_{in}$, and $C_i = \sum_n x_{in} w_{in}$ is the actual cost incurred by bank i. In theory, C_i^* should be less than or equal to C_i. So the cost efficiency of bank i is calculated as follows:

$$CE_i = \frac{C_i^*}{C_i} = \frac{\sum_n x_{in}^* w_{in}}{\sum_n x_{in} w_{in}}$$

Where CE_i is expressed by the ratio of the minimum costs to the observed costs. The interval of cost efficiency is arranged to be (0,1), and the best-performed bank has the cost efficiency equals to 1 in the sample. Cost efficiency is defined as an equation that the minimum cost incurred by a specific unit of output which is determined by the frontier (C*) is divided by the actual cost (C). Hence, the cost efficiency value CE=C*/C indicated a underlying note that if there is a cost saving at

(1-CE)*100 per cent in actual cost, it would be still possible to generate the same units of production.

4.2.2. Standard profit efficiency (SPE)

Unlike cost efficiency, profit efficiency corresponds to the objective of profit maximization. Moreover, according to Chen et al. (2005), profit efficiency shows a broader concept than cost efficiency for it considers both the costs and revenue of the production. With a specific amount and prices of inputs and outputs, profit efficiency measures the certain degree that the profit generated get close to the maximum profit level. In terms of the existence of market power in the pricing of outputs, as Berger and Mester (1997) illustrated, the profit efficiency can be distinguished into two categories: the standard profit efficiency (SPE) and the alternate profit efficiency (APE). The SPE set assumptions under the perfect competition market that no market power of output and input prices imposed to affect. Similar to the cost efficiency, in the case of bank i, we use the linear programming model proposed by Färe & Grosskopf (1997) to express. The model is showed as follows:

$$\text{Max} \quad \sum_m y_{im}\, v_{im} - \sum_n x_{in}\, w_{in}$$

$$\text{s.t} \quad \sum_k \lambda_k\, x_{kn} \leq x_{in}$$

$$\sum_k \lambda_k\, y_{km} \geq y_{im}$$

$$\sum_k \lambda_k = 1; \; \lambda_k \geq 0; k = 1, \dots . N$$

$$\forall n, \; \forall m, \quad x_k,\, w_k\, \in R_{n++}, \quad y_k,\, v_k\, \in R_{m++}$$

This solution to which corresponds to the vector of outputs $y_i^* = (y_{i1}^*, \ldots, y_{im}^*)$ and

the input demand vector $x_i^* = (x_{i1}^*, \ldots, x_{in}^*)$ which maximize the profits with the

given prices of outputs v and of inputs w. With the same amount or less amount of

inputs, the combination of banks that generate as much as or more than the outputs

of bank i would have a profit $P_i^* = \sum_m y_{im}^* v_{im} - \sum_n x_{in}^* w_{in}$. As the standard profit

efficiency is defined as the quotient between observed profit P_i and the maximum

profit P_i^* attainable as determined by the standard profit frontier given the specific

inputs and outputs prices, P_i^* would be higher than or equal to P_i. So the standard

profit efficiency (SPE) for bank i can be calculated as follows:

$$SPE_i = \frac{P_i}{SP_i^*} = \frac{\sum_m y_{im} v_{im} - \sum_n x_{in} w_{in}}{\sum_m y_{im}^* v_{im} - \sum_n x_{in}^* w_{in}}$$

Where the standard profit efficiency value SPE=P/SP* suggests that given the input

and output prices in the market, it would be possible if the firm wants to increase the

profits by (1-SPE)*100% per cent. However, in the concept of profit efficiency the

price of the output has some disadvantages because the market power in pricing is

not taken into account. The market power is the exogenous nature of the output

price.

4.2.3. Alternative profit efficiency (APE)

In order to solve the problem of taking no account of market power in pricing,

alternative profit efficiency is defined, in the case of bank i, in a linear programming

as follows:

    Max $R_i - \sum_n x_{in} w_{in}$

s.t. $\quad \sum_k \lambda_k R_k \geq R_i$

$\sum_k \lambda_k x_{kn} \leq x_{in}$

$\sum_k \lambda_k y_{km} \geq y_{im}$

$\sum_k \lambda_k = 1; \ \lambda_k \geq 0; k = 1, \dots . N$

$\forall n, \ \forall m, \quad x_k, \ w_k \ \in R_{n++}, \quad y_k, \ v_k \ \in R_{m++}$

The solution corresponds to the revenue R_i^* and the input demand vector $x_i^* = (x_{i1}^*, \dots, x_{in}^*)$ that maximize profits with the given prices of inputs w. This solution is obtained from a linear combination of firms that can utilize the same or less amount of inputs to produce at least as much outputs as bank i does, and can obtain at least as much revenues as bank i does. The APE for bank i then can be calculated as follows:

$$APE_i = \frac{P_i}{AP_i^*} = \frac{R_i - \sum_n x_{in} w_{in}}{\sum_m R_i^* - \sum_n x_{in}^* w_{in}}$$

Where the value of APE=P/AP* indicates that the firm is likely to increase its profits by (1-APE)*100% per cent facing the particular input and output prices. According to Berger & Mester (1997), alternative efficiency is closer to the reality and more precise when the existence of perfect competition is not uncertain. Under imperfect competition, there are differences in output quality among individuals of the sample, and there are some problems about information asymmetry when used to compute output prices.

We adopt DEA solver which is easy to operate to produce these three efficiency measurements.

4.3. Stage 2: Tobit regression model

The DEA efficiency scores obtained in the first stage will be employed as a dependent variable for regression in this stage. We will discover what determinants like bank specific and environmental factors may have impacts on the efficiency level. As the DEA efficiency score falls in the range of (0, 1), so the dependent variable is a limited dependent variable. With limited observations, the simple linear regression model is not an adequate empirical tool for capturing the relationship between the dependent variable and the independent variables. Although OLS regression is common and easy to control, it still fails to form a limited dependent variable model in many practical situations. Many studies chose alternative regression models like censored Tobit regression (for example, Casu & Molyneux, 2003; Drake et al, 2006; Sufian, 2009; Sturm & Williams, 2010). This model has two sorts of data and is usually used when the dependent variables have the censored nature. We follow Coelli et al. (1998) and use censored Tobit regression as well. The Tobit regression model designed for bank i efficiency determinants can be defined as follows:

$$EFF = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \varepsilon_i$$

Where random error $\varepsilon_i \sim N(0, \sigma^2)$, EFF is cost efficiency, standard profit and alternative profit efficiency scores, β_0 is constant factor and β_i is unknown parameter respectively, and X_i is represented by n dependent variables which are bank efficiency determinants. And STATA software is utilized.

5. Data and variables

Our data is unbalanced panel data and the major source of our sample data is BankScope which covers full information about different countries and offers homogenous category of Chinese banks. In the case of missing or questionable values, additional data and other supplementary information are acquired from sources like bank annual reports, China Banking Regulatory Commission and Yearly Statistics Book of China's Economics. The data covers overall 69 Chinese commercial banks over the period of 2003 to 2010 which seen the 2007-2008 subprime crisis. The worldwide financial crisis is expected to more or less exert some effects on Chinese banking system and this period is sufficiently long to cover the whole development process of the financial crisis and to assess the bank performance.

Among the 69 commercial banks, we classify these commercial banks into four groups: 5 state-owned commercial banks (SOCBS), 11 joint-stock commercial banks (JSCBS), 52 city commercial banks (CCBS) and 4 rural commercial banks (RCBS). We cover the all 5 state-owned banks which take up 71% of total deposits and 80% of total fixed asset in 2010 in the sample. There are 12 JSCB banks in China and our study contains 11 large banks. They occupy 20.7% deposits, 21.9% loan and 12.7% fixed assets in 2010. These banks are partially owned by governments and state but private sectors and foreign investment still have a portion. 4 RCBs are selected to represent this type of bank. Finally, we have 49 CCBs out of all 120 banks which hold over 7% of bank deposits and loans in 2010. These banks were established based on the urban credit cooperatives and have relatively small scale of assets which is

resulted from geographical restrictions. Policy banks, rural credit cooperatives and trust and investment companies are not taken into consideration because these banks are not pure commercial banks and the primary business is different from the commercial banks. Additionally, solely foreign-owned is neither included for the reason that there may some localization restrictions and their business strategies may be significantly affected by the parent banks.

In terms of the financial performance which is illustrated in Table 1, larger banks generally appear to hold higher ratio of net loans to total assets (NLTA). That is, the SOCBs take 51.27% and the JSCBs have 56.26%, while the RCBs and the CCBs hold 47.66% and 52.8% respectively. Turning to equity to assets (ETA), the situation is completely opposite. The CCBs own the highest average equity to assets ratio (5.6%) and followed by RCBs with 5%. The SOCBs have the mean ratio of 4.4% which is the lowest followed the JSCBs' 4.6%. In all, the profitability of the Chinese commercial banks is not strong enough. The SOCBs and the CCBs are the most profitable among these four groups with ROA 0.86% and 0.84% respectively. However, relatively high ROA of the SOCBs is associated with high cost-to-income. Interestingly, the CCBs have the lowest ratio of impaired loans to equity (ILE, 36.33%) whereas the SOCBs show highest one (122.37%). The reason may be that a large portion of income of the CCBs is non-interest income and this kind of income is less risky than interest income which may be affected by non-performing loans or impaired loans. Actually, the observable trend is also consistent with the calculated result of cost and profit

efficiency.

Table 1
Description of financial performance

Bank type	NLTA		ETA		ROA		ILE	
	Mean(%)	Sd.	Mean(%)	Sd.	Mean(%)	Sd.	Mean(%)	Sd.
SOCB	51.270	5.257	4.402	4.131	0.860	0.368	122.368	250.706
JSCB	56.261	6.914	4.590	3.891	0.619	0.422	58.624	133.097
RCB	47.656	6.381	5.008	2.021	0.728	0.530	55.099	75.266
CCB	52.802	9.714	5.609	2.326	0.840	0.581	36.328	43.643

5.1. Input and output selection

In order to select the most critical subjects in bank balance sheet, we will adopt intermediation approach to choose the input and output variables. The intermediation, which is also known as the asset approach, and production approaches are two commonly used approaches to model a commercial bank. In production approach a commercial bank allocates its resources to offer services to the customers (Berg et.al, 1991; Berg et.al. 1993; Tulkens & Eeckaut 1995; Shaffnit et.al, 1997). While in intermediate approach, commercial banks work as financial intermediaries to accumulate and purchase funds between depositors and borrowers. Subramanyam & Reddy (2008) clearly distinguished the two approaches that under production approach deposits are regarded as output, whereas in intermediate approach deposits are considered to have the nature of input.

Before ascertaining the input and output variables, we refers to many similar studies. Siems (1992) pointed out that a bank's success depended on management quality, which means evaluating management quality is an important start point to evaluate a bank's efficiency. He set some crucial input variables including the number of fixed asset, interest expense, other non-interest expense, full-time staff, salary expense

and number of loans, and output variables including asset, total deposit and interest revenue. His model gave us a good example.

Lin (2002) chose operating cost, total deposit, fixed asset, the number of staff, average salary and interest expenditure as input variables and only selected total loan as an output variable. The variable setting was to compare the cost efficiency of 43 merged and non-merged Taiwanese commercial banks. The result was about the operation efficiency considering acquisition.

Wang et al (2005) turned to study commercial banks in mainland China in 2004. Capital and asset are selected as input variables while net income, return on total assets (ROA), return on equity (ROE) are chosen as output variables respectively. His result showed that among 4 state-owned banks and 12 commercial banks in the sample, 2 banks had scale efficiency, 2 banks had constant returns to scale, 7 banks' returns to scale were increasing, and 7 banks suffered decreasing returns to scale. The result illustrated that when loan grew up, the bank efficiency decreased. So it was concluded that banks could not achieve efficiency by increasing total loans. Sakar (2006) combined the studies of Siems and Wang et al. and improved the input variables which were the number of branches, the average number of branch staff, total assets, total loans and total deposits. Whereas output items were the ratio of net interest revenue to asset, ratio of net interest revenue to operating revenue, ratio of non-interest revenue to asset, ROA, and ROE.

We can conclude from these studies that an efficient bank theoretically can spend fewer inputs like interest expense and capital and labor expense because lower interest expenses indicates a correspondingly less usage of intermediate funds, and produce more outputs like loans and investments. In sum, efficiency studies normally treat assets and costs as inputs while loans are typically considered as outputs.

As we set the purpose to measure bank efficiency including management quality and operation efficiency, we use three inputs: loanable funds (which includes deposits and short-term funding), fixed assets, number of employees. Their prices are average interest paid per unit of deposits, non-interest expense per unit fixed assets and personnel expenses per unit employee numbers respectively. The two outputs are total loans and equity. Their prices are average interest expense from loans and equity return per unit equity. In the models, the total cost is calculated by interest expense pluses non-interest expense, and the profit is particularly stood by operating profit. Table 2 demonstrates the input/output variables.

The variable setting follows three critical factors. First, the variables are selected due to related literature discussion. Second, input and output variables must match the items to evaluate and must be necessary in the analysis method. Finally, we should guarantee each variable can be quantified.

Table 2
Variables of cost and profit efficiency.Means and standard deviation for 2003,2007 and 2010

Symbol	Definition	2003		2007		2010	
		69 observations		69 observations		69 observations	
		Mean	Sd.	Mean	Sd.	Mean	Sd.
x1	Loanable funds=deposits and short-term funding	216645.388	669015.789	514548.339	1467563.413	915117.460	2416136.762
x2	Number of employees	22202.014	81211.402	24151.507	81515.774	27079.090	84710.343
x3	Physical capital=book value of fixed assets	5421.041	17486.103	5831.433	17728.482	8476.080	25436.327
y1	Loans	176796.846	543191.465	272432.910	747629.871	509713.030	1334295.980
y2	Equity	1576.586	5497.916	6602.909	19494.997	12025.560	33867.053
w1	Price of loanable funds=interest expense/x1	0.024	0.025	0.022	0.011	0.020	0.009
w2	Price of labour=personnel expense/x2	0.107	0.120	0.209	0.141	0.300	0.208
w3	Price of physical capital=non-interest expense/x3	0.842	0.570	1.266	0.790	1.670	1.264
v1	Price of loans=interest from loans/y1	0.039	0.013	0.066	0.018	0.060	0.026
v2	Price of equity=return on equity	0.116	0.092	0.204	0.160	0.200	0.101
C	Total cost=interest expense and non-interest expense	10483.982	23734.654	15468.692	42630.377	24000.234	60095.288
P	Operating profit	4161.615	11513.273	7836.677	26867.801	17086.026	46185.612

5.2. Determinants and hypothesis

We classify the potential determinants of bank efficiency into three categories: bank-specific variables, risk profile and crisis characteristic. The bank-specific variables group contains profitability which is substituted by the ratio of return on assets (ROA), ownership type and bank size. Ownership type is accounted by two dummy variables SOCB for state-owned banks and JSCB for foreign capital holding banks. As to bank size, the natural logarithm of total assets (LTA) is the proxy. The second group risk profile consists of credit risk, capital risk, liquidity risk and asset quality. Loan-loss-reserves to gross loans (LG), equity to assets (ETA), net loans to total assets (NLTA) and impaired loans to equity (ILE) are descripted for these risks respectively. Finally, the crisis characteristic is concluded to be represented by GDP level which can show the economic conditions pre and post financial crisis. The summary of variables descriptions and definitions are listed in Table 3.

Table 3
Description and definition of Tobit model variables

Variable name	Symbol	Description	Expected sign
Profitability	ROA	Return on assets(ROA)	(+)
Size	LTA	The natural logarithm of total assets	(+)
	SOCB	A dummy, 1 for SOCB	
Ownership	JSCB	A dummy, 2 for JSCB	(+)
	RCB	A dummy, 3 for RCB	
	CCB	A dummy, 4 for CCB	
Credit risk	LG	Loan-loss-reservation/gross loans(%)	(-)
Capital risk	ETA	Equity to assets(%)	(+)
Liquidity risk	NLTA	Net loans to total assets(%)	(+)
Asset quality	ILE	Impaired loans to equity(%)	(+)
Economic development	GDP	Logarithm of per capita GDP	(+)

With respect to the bank-specific variables, there is a common finding that the more profitable banks, which presents as a high ROA or ROE, the more efficient they appear to be. Most empirical literature (e.g. Mester, 1996; Carbo et al., 2002, Ataullah et al., 2004; Casu & Girardone, 2004; Chang & Chiu, 2006) concluded this positive relationship between profitability and efficiency. Undoubtedly, we use ROA to present the probability and follow these studies to set the hypothesis as follows:

H_1: there is a positive relationship between bank efficiency and profitability.

While coming to the bank size and efficiency, there are mixed results and the relationship is not clearly defined in the literature. Several studies (for instance, Berger et al., 1993; Miller & Noulas, 1996; Ataullah et al., 2004; Chen et al., 2005) reported that bank size has significantly and significantly negative relationship, while Isik & Hassan (2002) and Girardone et al. (2004) concluded the same result as well. Although economic scales and economic scopes are positively related to bank size, Carbo et al. (2002) found no significant relationship between size and bank efficiency

(Pi & Timme, 1993; Berger & Mester, 1997) got the same conclusion as well).

However, we can theoretically reckon that the larger banks are more cost efficient than the smaller banks because the large banks have more opportunities to establish efficient structures to operate and manage. On the other hand, larger banks have a large number of branches, departments and employees. This may attribute cost inefficiency. In our study, we follow the majority studies and make the hypothesis bellows:

H_2: *there is a positive relationship between bank efficiency and bank size.*

As to the ownership, we narrow our review of the recent literature to the studies about the Chinese banks and there are some controversial arguments. The results of the many studies indicated that state-owned and foreign banks are the most cost efficient (e.g. Bhattacharya et al., 1997; Havrylchyk, 2006), while other showed the opposite conclusions (Fu & Heffernan, 2005; Berger et al., 2006 Ariff & Can, 2008). Undeniable, there are still some uncertain factors to make the relationship uncertain and mixed. Accordingly, we still believe that ownership is an essential factor so our hypotheses are showed below:

H_3: *there is a positive relationship between bank efficiency and ownership.*

The second group of variables includes all financial ratios which can illustrate risk

elements. Banks which provide more loans are expected to induce higher credit risk which can be explained by the ratio of loan loss reservation to gross loans and the ratio of gross loans to total assets. Carvallo & Kasman (2005) and Casu & Girardone (2004) indicated that higher ratio of loan loss provisions or reserves to total loans proves that the banks are more likely to have higher risk-taking level. These banks may be less efficient. On the contrary, there are still some researches (for example, Brewer & Lee, 1986; Mansur et al., 1993; Hassan, 2003) showed that credit risk is positively related to the bank efficiency, which means that high credit risk can also attribute to high level of efficiency. Generally, credit risk is expected to incur an inverse relationship with efficiency (e.g. Brewer & Lee, 1986; Mansur et al., 1993; Hassan, 2005). Hence, we follow the majority of the studies to hypothesize that:

H_4: there is a negative relationship between bank efficiency and credit risk.

Nevertheless, the studies of capital risk did not provide clear evidence. In our study, the ratio of equity to assets is selected as a proxy for capital risk. Berger & Mester (1997) pointed out that the negative relationship between capital risk and efficiency is expected as issuing shares to raise money and increase equity may incurs more transaction costs than gaining deposits. Although equity is a more expensive funding source compared to deposits, Berger & Mester (1997) suggested that the implications on cost efficiency are not straightforward. Similarly, Altunbas et al. (2004) and Freixas & Rochet (1997) showed the same result that the relationship of

efficiency and capital levels was negative. However, Carvallo & Kasman (2005) proposed that the banks with higher efficiency will indicate higher profitability so that results in more earnings and equity. Moreover, Chang & Chiu (2006) suggested the positive relationship between bank efficiency and capital risk. According to these results, we consider the equity to be an important way to reflect the bank funding method and retained earnings which do have a positively impact on the bank efficiency.

H_5: *there is a positive relationship between bank efficiency and capital risk.*

We follow Williams & Nguyen (2005) to set the ratio of net loans to total assets as a proxy for liquidity risk. More loans might help banks to diversify the credit risk and provide evidence of high effectiveness of funding, while more loans gave out may attribute higher impaired and non-performing loan ratio and then cause high liquidity risk. Jahankhani & Lynge (1980) and Mansur et al. (1993) set the ratio of liquid assets to total assets to present liquidity risk, and they concluded that there is a negative relationship between liquidity risk and bank efficiency. Similarly, Ariff & Can (2008) also came to the same conclusion that liquidity risk is significantly and negatively associated to the efficiency, though the liquidity proxy is loans to deposits. Meanwhile, they changed the variable to the customer and short-term funds and found liquidity risk is positively related to the efficiency. However, in essence, these studies suggested that liquidity risk may positively or negatively relate to bank

efficiency, we try first to hypothesize the positive relationship between high net loans to total assets and efficiency.

$H_6: there\ is\ a\ positive\ relationship\ between\ bank\ efficiency\ and\ liquidity\ risk.$

In general, the asset quality is always represented by non-performing loans or impaired loans. It is argued that non-performing provisions and impaired loans may have detrimental effects on banks because banks are more likely to pay more managerial efforts and additional expenditures to deal with the problem. Specifically, the expenditures are spent in several ways. Karim et al. (2010) pointed out that the banks need to monitor the careless borrowers, maintain and analyze the workout arrangements, and dispose and manage collaterals. In recent years, a number of researchers took the asset quality, specifically non-performing loans and impaired loans, into account. Wheelock & Wilson (1995) and Berger & Humphrey (1992) summarized that failing banks with a large amount of non-performing loans perform far from the best-practice banks. That is to say, banks with high ratio of problem loans have lower cost efficiency. In addition, a number of other studies also fund negative relationships between bank efficiency and impaired loans (Kwan & Eisenbeis, 1995; DeYoung, 1997; Altunbas et al., 2000; Fan and Shaffer, 2004; Girardone et al., 2004). A negative relationship between problem loans and bank efficiency suggests the positive relationship between asset quality and efficiency. It is true and obvious that massive non-performing loans may signal banks utilize fewer resources for credit

evaluation and loan monitoring process than the benchmarked banks and this largely

results in bank inefficiency. So we hypothesize like that:

H_7: *there is a positive relationship between bank efficiency and asset quality.*

Finally, we add the macroeconomic development variable to the regression model.

Per capita GDP is demonstrated in logarithm form and serves as a proxy measure for

the overall level of development, including the quality of state institutions and the

level of skills. This variable can capture the effect of economic recession and booming.

As other variables are correlated with GDP, bank performance will dependent on

business cycle and economic environment, and bank business will grow according to

the growth of the GDP level. In booming, financial infrastructures like stock market

and other financial institutions and enterprises will increase their demand on

financing like loans and deposits. Additionally, costs may decrease due to the overall

economy development and corresponding improvements of business quality. This

will directly increase the bank efficiency. In downturn, the situation is vice versa.

Hence, several studies showed the positive relationship between bank efficiency and

GDP and the measure is statistically significant (Kedah, 2002; Grigorian & Manole,

2002; Yildirim & Philippatos, 2002). However, Anayiotos et al. (2010) and Fries & Taci

(2005) found no significant link of bank efficiency with GDP growth. According to

Rezvanian et al. (2011), we hypothesize that the GDP level is positively related to

bank efficiency.

H_8: *there is a positive relationship between bank efficiency and economic development.*

6. Empirical results and findings

6.1. Cost and profit efficiency

Some notes should be made from the scores displayed in Table 4. To summarize, the overall cost efficiency score is 0.6271 which indicates that the Chinese commercial banks in our sample incur, or rather waste, around 40% of their costs to produce no economic profit comparing to the benchmark bank. What is worse, the mean value of profit efficiency is 0.1633 which suggests that under the same condition the sample banks only obtain the profit nearly one sixth of the profits earned by the best-performance bank. Furthermore, there is a fact concluded that the profit efficiency scores are considerably lower than the scores of cost efficiency and basically the alternative standard efficiency scores are below the level of the standard profit efficiency. It is obvious to note that the joint stock commercial banks appear to be the most cost efficienct and profit efficienct while the state-owned banks show the lowest level. Rural and city commercial banks are just in the middle.

Table 4
The scores of cost and profit efficiency

	Cost efficiency					Standard profit efficiency					Alternative profit efficiency				
	SOCB	JSCB	RCB	CCB	ALL	SOCB	JSCB	RCB	CCB	ALL	SOCB	JSCB	RCB	CCB	ALL
2003	0.5097	0.5916	0.6205	0.3729	0.4320	0.0039	0.2337	0.1484	0.0540	0.0845	0.0039	0.2142	0.1484	0.0540	0.0845
2004	0.5783	0.7484	0.6903	0.6034	0.6298	0.0480	0.2659	0.1318	0.0808	0.1109	0.1177	0.1451	0.2500	0.1352	0.1422
2005	0.5250	0.7547	0.5523	0.6015	0.6175	0.0068	0.3154	0.0065	0.1210	0.1371	0.0213	0.0570	0.0166	0.2234	0.1702
2006	0.5591	0.8025	0.6415	0.6441	0.6630	0.0000	0.2184	0.0597	0.1438	0.1404	0.0000	0.1580	0.0799	0.2094	0.1785
2007	0.5855	0.8374	0.6719	0.7021	0.7134	0.1001	0.3892	0.0454	0.2719	0.2650	0.2078	0.0591	0.0446	0.1980	0.1677
2008	0.5535	0.7740	0.6642	0.6797	0.6847	0.0217	0.0666	0.2780	0.2037	0.1730	0.0189	0.0182	0.2491	0.1958	0.1578
2009	0.6259	0.7716	0.6375	0.6704	0.6814	0.0007	0.1025	0.1700	0.2581	0.2096	0.0001	0.0919	0.2708	0.0594	0.0725
2010	0.5626	0.6903	0.5548	0.5951	0.5951	0.0549	0.1136	0.1745	0.2164	0.1859	0.0328	0.0301	0.2178	0.1969	0.1596
Mean	0.5625	0.7463	0.6291	0.6087	0.6271	0.0295	0.2132	0.1268	0.1687	0.1633	0.0503	0.0967	0.1597	0.1590	0.1416
Sd.	0.0337	0.0707	0.0481	0.0966	0.0823	0.0334	0.1051	0.0815	0.0758	0.0539	0.0696	0.0647	0.0949	0.0638	0.0379

Turning to cost efficiency which is showed in Figure 1, the four types of banks display the distinct performances. It is very clear that the JSCBs lead in every year from 2003 to 2010 and appear to be the most efficient on average (0.7463). Interestingly, the SOCBs oppositely show the lowest average level of cost efficiency (0.5625) and the most inefficiency in every year. The RCBs and the CCBs lie in the middle. Among the eight years, the average level of cost efficiency do not change that much and the standard deviation of it is 0.0823. Considering the recent global financial crisis, the year 2007 is very crucial to divide the pre-crisis period and post-crisis period. About the JSCBs and the CCBs, there is an explicit trend that from 2003 to 2007 that their levels of cost efficiency go up to the peak with the rising rate of around 40% and 80% respectively. Although in 2004 the RCBs and the SOCBs show the relatively small decline, afterwards their efficiency scores keep rising to the highest point. Beyond the year 2007, all banks of the four types except the SOCBs suffer the 17% or so decrease in the cost efficiency. In this case, we have reason to believe that the financial crisis to a certain degree cause unfavorable effects on cost efficiency. Overall, taking all the banks together, the cost efficiency score ascends to the highest in 2007 (0.7134) prior to going down to 0.5951 after the financial crisis.

Figure 1, 2 and 3 illustrate the cost efficiency, standard profit efficiency and alternative profit efficiency respectively. They provide a comparison among these four types of banks and show a clear trend about efficiency level during the period.

On standard profit efficiency, the profit level of every bank type fluctuates substantially along with the years and keeps under the 0.4 (0.1633) which is considerably lower than the cost efficiency level (0.6271). Separately, the JSCBs are the most profit efficient which have the mean score of 0.2132 while the standard deviation is also the highest (0.1051) which is higher than the second one 0.2 points. The CCBs follow the first place and enjoy the relatively good performance with average level of 0.1687. The efficiency levels of the SOCBs and the RCBs are far below the average level (0.0295 and 0.1268 respectively) and the SOCBs represent the lowest score of profit efficiency in every single year and finally maintain it at a very low level with a minor standard deviation (0.0334). All the banks experience the ups and downs before and after the financial crisis. The year 2007 sees the highest score of each category except the RCBs which undergo the trend of drop and postpone their peak to the year 2008. After 2007, the score of the CCBs falls slightly but still remains between the interval of 0.2 to 0.25 and the RCBs keeps their efficiency level around 0.2 as well. However, the JSCBs and the SOCBs suffer the sharp slump by 32% and 90% respectively. The JSBCs lose the leading place and end with the score around 0.1 while the level of the SOCBs still maintains below 0.1. It is apparent that the SOCBs are the most profit inefficient and the financial crisis does affect the efficiency level to fluctuate and decrease. The JSCBs appear to be the most vulnerable to the crisis.

In terms of the alternative profit efficiency, there are some differences comparing to standard profit efficiency. The overall mean level of alternative profit efficiency is 13.25% lower than that of the standard profit efficiency. On average, the RCBs, instead of the JSCBs, prove to be the most efficient (0.1597), followed by the CCBs (0.1590) with a slight gap. Unsurprisingly, the SOCBs perform the worst (0.0503), while the average score of the JSCBs (0.0967) is just a bit higher than that of the SOBCs. The alternative profit efficiency level of the JSCBs fluctuates and descends by about 50% over the whole period. While the efficiency levels of the SOBCs, the JSCBs and the RCBs have decreased by almost 80%, 60% and 90% respectively, that of the CCBs has significantly increased by about three times over the period of 2003 to 2005. In 2007, the SOCBs take the highest score (0.2078) among these banks and the score reaches the peak before going down sharply. Interestingly, the level of the RCBs suffers the second lowest in 2007 and then rises drastically to the highest point (0.2708). From 2008 to 2010, the RCBs keep their efficiency level around 0.25 which is much higher than that of any other banks. Over the period of 2005 to 2008, the efficiency level of the CCBs nearly keeps even and no large fluctuations showed prior to the dramatic decrease after 2008.
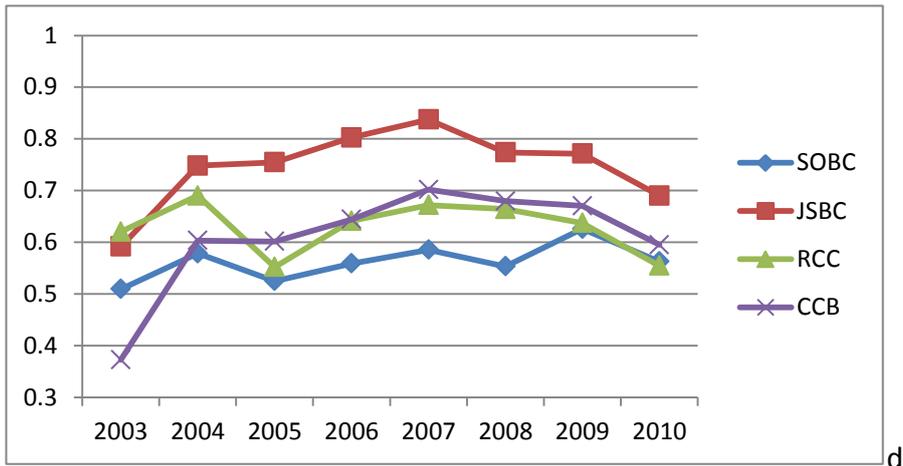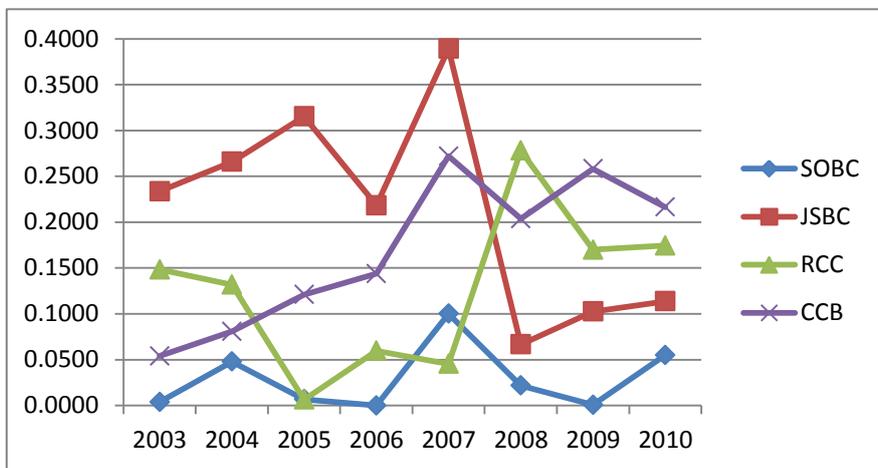
Figure 1.   Cost efficiency (CE)

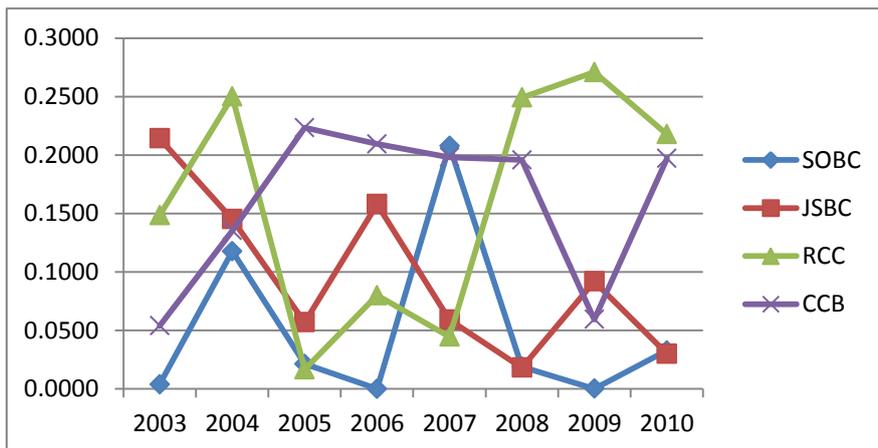Figure 2.   Standard profit efficiency

Figure 3.   Alternative profit efficiency

Generally speaking, cost efficiency, standard profit efficiency and alternative profit

efficiency represent the similar trend over the whole period that the mean scores improve before 2007 but drop after 2007. The reason for this could be due in part to the potential risks and economy recession caused by the financial crisis. Because of this crisis, it is feasible to believe that the elements related to the political and economic instability in China may diminish the capability of the banks to efficiently manage operating costs and dampen profits. Under this circumstance, banks prefer to reduce their activities, which may reduce the profit efficiency.

Moreover, some previous studies (e.g. Barry, 1998; Bos & Schmiedel, 2003) summarized a principle that profit efficient banks appear to be also cost efficient, but the inverse is not necessarily practicable. In contrast in our study, the banks which are the most cost efficient are still the most profit efficient in China. Bos & Schmiedel (2003) state that the banks which are profit efficient are also cost efficient in a perfect competitive market. While Tabak et al. (2011) point out in an imperfect competitive market profit efficient banks may be cost inefficient. Hence, in our study we can conclude that Chinese bank market is a relatively perfect and fair competitive market.

Our study shows an interesting finding that the profit efficiency level is far below the cost efficiency level. This finding is consistent with most previous studies (e.g. Berger & Mester, 1997; Maudos et al., 2002; Yildirim & Philippatos, 2007). The profit efficiency scores are so small for two reasons. First, the primary objective of these

banks is not always profit maximization or better capitalization especially the SOCBs. The social objective like promote economic development is more important. Second, all the banks are included in the banking system controlled by the central bank and regulatory commission. Meanwhile, the CCBs are also under the supervisions of local governments. Banking behaviors including aggressive and speculative activities are strictly confined. So focusing on the value enhancement of the banks instead of carrying amount of profit makes more sense.

In addition, the overall alternative profit efficiency score is 13% lower than that of standard profit efficiency. This explains the existence of market power in pricing bank products in China. The finding supports the result of Ariff & Can (2008) and Tabak et al. (2011) but contradicts that of Maudos & Pastor (2003).

Chen et al. (2005) demonstrates that the SOCBs and CCBs are the most cost efficient compared to the JSCBs. However, our result is that the JSCBs are the most cost and profit efficient while the SOCBs are the most inefficient. The result confirms the conclusions drawn by Wei & Wang (2000), Zhong et al. (2001), Matthews et al. (2009) and Fu & Heffernan (2005). On account of the features of the JSCB establishment, on the one hand, joint stock banks can reduce the operation costs and solve management and technical difficulties given the superiority of sharing management experience, capital and technology. On the other hand, multi parties bear the operation risks to guarantee the efficiency and effectiveness of business. Additionally,

the JSCBs can require incentives in China like favorable taxation policy, additional investment policy and deficit cover policy. Therefore, based on the benefits mentioned above, the JSCBs take advantages over other banks to be the most cost and profit efficient.

Compared to the JSCBs, the SOCB are the most inefficient. It is not surprising to achieve this result. There are several drawbacks gave rise to the inefficiency. From the perspective of internal organization system, the labor division was unclear and too many administrational departments exist. If banks overemphasized the administration and hierarchy, the strength of business units would be weakened. Furthermore, redundancy and functional overlap of department were the major problems which would lead to excessive expenditures on employees and operation inefficiency as well. From the perspective of external banking system, the market-oriented reforms of the banking sector in China lagged behind the structural change in the real economy. Although the shares separating reform was put into practice, the result after reform was still uncertain. The credit structure and capital allocation displayed serious imbalances. There is a fact that the state-owned banks expanded credit business and accumulated massive non-performing assets but they are "too big to fail" due to the capital supplement from the central bank. Because of the social objectives of the SOCBs to stabilize the national economy and excessive impaired loans and non-performing assets, it is not likely for the SOCBs to optimize their profits. As a result, the unreasonable organization and inequitable financial

regime combined together to bring about the inefficiency of the SOCBs.

As all the efficiency scores show an apparent turning point in 2007, we can conclude that Chinese banking system is inextricably linked to the global economy, because the subprime crisis first happened in America in 2007 and then expanded to other countries' economies. It is possible that Chinese banking system has antedating or immediately response to the changes but there is no sufficient evidence to support this notion.

6.2. Potential determinants of efficiency

Considering the regression independent variables including bank-specific variables, risk profile and crisis environment, we show the Tobit regression equation in details:

$$EFF = \beta_0 + \beta_1 ROA + \beta_3 LTA + \beta_4 SOCB + \beta_5 JSCB + \beta_6 RCB + \beta_7 CCB + \beta_8 LG$$
$$+ \beta_9 ETA + \beta_{10} NLTA + \beta_{11} ILE + \beta_{12} GDP + \varepsilon_i$$

We run three regressions about cost efficiency, standard profit efficiency and alternative profit efficiency respectively. The number of observations is 368 and the Prob > Chi^2 is 0 which means that at least one of the regression coefficients in the model is not equal to zero. Meanwhile, LR Chi^2 explains the similar thing. All the three models are fitted models and have high explanatory power.

Table 5
Results of Tobit regressions

Variable	Cost efficiency		Standard profit efficiency		Alternative profit efficiency	
	Coef.	P>|t|	Coef.	P>|t|	Coef.	P>|t|
Constant	-0.0845844	0.305	-0.8503519	0.000	-0.0187044	0.913
ROA	0.0927084	0.000	0.2574299	0.000	0.1422784	0.000
LTA	0.0764967	0.000	0.1085563	0.000	0.0082333	0.738
SOCB	-0.2371091	0.000	-0.4564556	0.000	-0.1970403	0.013
JSCB	0.0223066	0.410	-0.0356185	0.552	-0.0390698	0.492
RCB	-0.104778	0.794	-0.1319692	0.136	-0.0492388	0.557
LG	-0.0196718	0.003	0.0292425	0.044	0.0284254	0.038
ETA	0.0022822	0.490	0.0132852	0.067	0.0176079	0.012
NLTA	0.0090937	0.000	0.0099736	0.000	0.0029749	0.139
ILE	-0.0002307	0.014	-0.0000499	0.808	-0.0000719	0.713
GDP	-0.00000000445	0.000	-0.000000011	0.000	-0.0000000102	0.000

Table 5 indicates the determinants of the bank efficiency. The dummy variable CCB is omitted. Taking profitability first, it is apparent that all coefficients on ROA are positive and very significant at 0.000. This is consistent with what we expected previously and suggests that the more profitable banks appear to be more cost and profit efficient. Specifically, in our study one unit increase in profitability may result in 9.3%, 25.7% and 14.3% growth in cost, profit and alternative profit efficiency respectively. High profitability has a very crucially positive influence on bank efficiency. The reason can be that high probability make banks' businesses grow rapidly and appropriate resource allocation can promote the banke efficiency. Our result is consistent with the studies conducted by Mester (1996), Carbo et al. (2002), Ataullah et al. (2004) etc.

Turning to the impact of size (LTA) on efficiency, the reported coefficient is positive and very significant except on alternative profit efficiency. This means that the large-sized banks are the most cost and profit efficient and then the medium-sized banks followed by the small banks with the lowest efficiency scores. Interestingly, the largest banks, which are also known as the SOCBs, show the lowest efficiency scores adversely. In theory, large bank size implies economy of scales and scale efficiency

and is probably to attribute to high level of cost and profit efficiency. However, the performance of the SOCBs indicates the opposite. The reason can be explained that to a certain degree large scale and size do generate high operating efficiency because of complete established structure but could also lead to relatively high operating costs like high labor commissions because of massive employees. Carbo et al. (2002), Pi & Timme (1993) and Berger & Mester (1997) sited this reason, but our finding supports that of Isik & Hassan (2002), Girardone et al. (2004) and Chen et al. (2005).

In terms of ownership, the coefficients on SOCB are negative in all three efficiency estimations and very significant (0.000) for cost efficiency and standard profit efficiency and significant at 1.3% for alternative profit efficiency. On the other hand, the coefficients on RCB and JSCB are all negative except JSCB's coefficient of cost efficiency. However, they are not significant. Hence, as we expected, the lowest efficiency level of the SOCBs is partially affected by its ownership type. While there are no obvious relationships between ownership and bank efficiency of other banks especially JSCB. That is to say, the high efficiency level of JSCB is determined by other factors. The result reverses the previous hypothesis and supports the conclusions of Fu & Heffernan (2005), Berger et al. (2006) and Ariff & Can (2008), but still overturned that of Bhattacharya et al. (1997) and Havrylchyk (2006).

On the relationship between credit risk and efficiency, as expected, banks with higher ratio of loan loss reserves to gross loans (LG) tend to have lower cost efficiency. This

negative but very significant (at 0.3%) relationship suggests that higher loan loss reserves will incur higher credit risk. On the contrary, the coefficients on profit estimations are positive and also significant at about 4%. There is an explanation underlying that the more loans banks lend out, the more reserves set aside to cover the estimated loss loan in loan portfolio. The result about cost efficiency is the same as the previous hypothesis which is supported by Carvallo & Kasman (2005) and Casu & Girardone (2004). In terms of profit efficiency, the result shows consistent with that of Brewer & Lee (1986), Mansur et al. (1993) and Hassan (2003).

In Chinese commercial banks, the loan loss reserves are generally categorized into two types: one is general reserve which is calculated as 1% of the loan balance; the other one is special reserve which is set differently based on the repayment ability and risk of borrowers. If the amount of loan loss reserves increases, there may be two main reasons. The one is that the amount of loans lent increases as well; the other one is that too many loans cannot be paid off due to aggressive lending behavior and insufficiency of strict risk rating to the borrowers. When coming to the details, the lending business is a major and vitally important business to the SOCBs. Given that the main function of SOCB is to provide sufficient and appropriate funds to support social constructions and business operation, the scale of the loans they lend is large. After 2007, the recession emerged in China and hence this downturn lowered the borrowers' ability to repay the loans and finally banks had to set aside more loan loss reserves. The high risks on loan lending brought down the profit

efficiency but increased the cost inefficiency. Instead, since 2006, the JSCBs and the CCBs diversified their banking businesses and expanded innovations into emerging markets like short-term financing bonds, corporate annuity fund and trade finance. These banks had more channels to get profits and successfully diversified business risks. Therefore, their performance about cost and profit efficiency is much better, especially the JSCBs, than the SOCBs.

On the other hand, the coefficients on equity to assets (ETA) are all positive but the P values show no significant relationships. It is assumed that the increase or decrease in equity would have no obvious effects on bank efficiency. Given the unobvious implication, our result supports that of Berger & Mester (1997). Theoretically, the higher participation of shareholders, the more efficient the banks show because banks may feel more obliged to operate efficiently and effectively. Therefore, it may conclude that the shareholders have less power to affect and promote the operation of Chinese commercial banks. Although the joint stock reform made some progresses in banking system, the control of local government and central bank still take over the motivations of shareholders.

The coefficients on net loans to total assets (NLTA) are significantly positive on cost efficiency and standard profit efficiency but not significant on alternative profit efficiency. This indicates that banks attempt to capitalize on the assets which tend to be rational utilized. This banking behavior in turn could increase the efficiency level.

Although NLTA is an important determinant to the efficiency, the coefficients are relatively too small for this variable to make a great impact on efficiency scores since the one unit change in NLTA ratio only will make about 0.9% change in efficiency scores. Hence, it is not surprising to interpret that the SOCBs which have monopolized the market share of deposit and loans still obtained lowest cost and profit efficiency scores, because the strength of the effects caused by the loans is slight and not so much obvious. Our study obtains the same result as that of Jahankhani & Lynge (1980) and Mansur et al. (1993).

A similar result is found regarding the relationship between asset quality and efficiency. The coefficients on impaired loans to equity (ILE) are all negative and only significant to cost efficiency. It is obvious that too many impaired loans may occupy much time and many labors to manage and collect. In this case, the costs on it will increase and in turn cause cost inefficient. Particularly, after 2007 financial crisis, more impaired loans incurred and share prices fell to make equity shrink heavily, so this seriously affected the cost efficiency level to go down in and after financial crisis. The asset quality mainly affects the cost efficiency while the profit efficiency is not significantly influenced because Chinese government injected a large amount of money to cover the impaired loans of commercial banks. The result verifies the previous hypothesis and supports that of the most studies (e.g. Kwan & Eisenbeis, 1995; DeYoung, 1997; Altunbas et al., 2000, etc).

Considering the macroeconomic factor, the relationship between economic development (GDP) and efficiency is negatively significant. Before the financial crisis, the market appeared to be active and dynamic, the SOCBs were able to attract the majority of deposits of the public with less interest expenses, while the JSCBs, CCBs and RCBs had more opportunities to focus on their featured business and innovate in their services in emerging market. Hence, the efficiency scores increased before the crisis. When the crisis struck the stock market, investor confidence was suffered and the growth of Chinese economy slowed down. Under the continued restrictive financial environment, banks experienced the recession had difficulties to get adequate funds to make loans with low interest expenses and the expansion of other emerging businesses encountered troubles as well. Therefore, banks underwent an upward pressure on their cost and profit efficiency. Our study indicates the same result with that of Kedah (2002), Grigorian & Manole (2002) and Yildirim & Philippatos (2002).

7. Conclusion

For the past twenty years, the Chinese banking system has experienced instructional restructuring, partial privatization and modernization to increase the core competitiveness of commercial banks. Foreign investment strategy and IPO strategy are the two main methods for partial privatization and modernization. Moreover, many other efforts were made to improve asset quality, reduce non-performing loans, enhance the process of credit assessment and monitoring, apply proper skills and

techniques of risk management, and finally promote the overall bank performance. After joining WTO, Chinese banks drove the reform forward and cultivated some positive motivations to accept the fully-opened market and competitiveness. However, the global financial crisis may have adverse effects in the short term or long term. Under this circumstance, it is a real challenge for the state-owned banks to maintain their traditional businesses and for the joint-stock banks and other regional banks to expand their operations beyond the limitations of locality. So in this way, it is undoubted that Chinese commercial banks should pay more attention to achieve a high level of cost and profit efficiency.

Our study aims to examine the bank efficiency and to test whether the financial crisis have impacts on the efficiency. The research has some differences from previous empirical studies in many ways. First, we employ the DEA approach and take into account three efficiency estimations: cost efficiency, standard profit efficiency and alternative profit efficiency. Second, we select 69 commercial banks to form a sample whose size is sufficient enough. The sample covers four types of banks: state-owned commercial bank, joint-stock commercial bank, city commercial banks and rural commercial banks. The study compares the efficiency among these bank groups. Third, we conduct the second stage analysis to identify potential determinants of the efficiency of Chinese banks. Forth, the financial crisis is considered to analyze the trend and fluctuation of the efficiency scores.

The findings of our study provide the evidence that, over the period, the joint-stock banks are the most efficient than other three types of banks, followed by the city commercial banks and rural commercial banks, while the state-owned commercial banks have the lowest level of all efficiency estimations. Furthermore, profit efficiency score is smaller than cost efficiency score and alternative profit efficiency is lower than standard profit efficiency. In addition, every type of banks undergoes a rise in cost and profit efficiency before the 2007-2008 financial crisis but experiences decrease after the financial crisis. Despite the effects of the financial crisis during this period, the state-owned commercial banks display no improvement in their performance and their efficiency remains at a very low level.

In the second stage we use Tobit regression to investigate the potential determinants of bank efficiency. Our study makes several hypotheses and compares the results with that of the previous empirical findings. In essential, the results confirm the estimation of the first stage study that the joint-stock commercial banks are more efficient than the state-owned commercial banks, and that medium-sized banks have higher bank efficiency than large-sized and small-sized banks. Moreover, the banks with high profitability, low credit risks and high liquidity are both cost and profit efficient. However, high asset quality can attribute to high level of cost profitability while there is no significant link between asset quality and profit efficiency. Additionally, we find no statistically significant relationship between capital risk and bank efficiency. Finally, the economic development and environment are positively

associated with cost and profit efficiency.

In the light of the above results, we can draw some implications and suggestions. First, the benefits of partial privatization and modernization are showed because of the high cost and profit efficiency of the joint-stock commercial banks. Hence, the strategy to promote different equity stakes, especially those of foreign investment and local enterprises, is in the right direction. This allows enterprises and foreign investment to access the domestic retail banking market and the joint-stock commercial banks in turn are beneficial from risk management skills, technology information and mutual communication of operational management. In particular, the banks adopt risk management skills to control impaired loans and monitor the credit process. Moreover, under this circumstance, regulatory commission and other institutions make very attempt to provide better protection to depositors and borrowers which will also improve bank efficiency. In addition, the majority of the joint-stock commercial banks in China are medium-sized which are less likely constrained by the extensive non-performing loans of large-sized banks and less resources of businesses of small-sized banks.

Second, in the network, the overall deposit and loan shares, and asset size of the state-owned commercial banks are still in a monopoly position. That is to say, the state-owned commercial banks take great advantages in the traditional banking products and services, and the joint-stock banks may have difficulties in capturing

shares of these traditional banking businesses. However, taking on a look in the future, the profitability of single business of deposits and loans will inevitably reduce due to the development of the banking reform. On the contrary, the emerging market for financial innovations and products about money management will show higher operating return and achieve more developments. It indicates that the state-owned banks can not only focus on their traditional business, but also diversify and extend their business in order to reverse the low level of cost and profit efficiency.

Third, the exploration of the determinants of cost and profit efficiency implies that profitability and efficiency are closely related. During this period, banks should not simply take aggressive behaviors to obtain high income or earnings, but should also make profits efficiently considering the cost-to-income ratio or other standards. However, higher profitability is still a very important driving force for the banks to improve bank efficiency and meet the demand of growing economy and modernization reform.

Apart from profitability, banks need more complete process to assess their credit risk, asset quality and liquidity risk. The three elements play a vital role for operations. A large volume of non-performing loans was carried in many Chinese commercial banks, especially in the state-owned banks. Actually, this problem is still leaved to be resolved by using massive funds to cover. But in long run, the assessment and

evaluation system must be established to control and monitor banks' credit and capital structure.

Forth, it is obvious that economy environment have great impacts on the bank performance. Despite the banking reform for decades, the financial crisis makes the bank efficiency fluctuate pre and post-crisis. This suggests that an internal mechanism through management level and business strategy units should be set to serve the functions of enterprise wide risk management. To be specific, banks ought to cultivate the awareness of risk and establish various reporting lines. Moreover, agency problem should be dealt with to avoid risk-taking behaviors at the expense of shareholders' interests. The combination of assessment or evaluation system and risk management mechanism is needed to cope with financial crisis and to stabilize the bank efficiency even in the recessions.

Word count: 14981

References

- Al-Faraj, T., Alidi, A., & Bu-Bshait, K. (1993). Evaluation of bank branches by means of data envelopment analysis. International Journal of Operations & Production Management. 13, 45–52.

- Ali Mansoury, Mahdi Salehi. (2011). Efficiency analysis and classification of bank by using Data Envelopment Analysis (DEA) Model: Evidence of Iranian Bank. International Journal of the Physical Sciences. 13 (6), 3205–3217.

- Alirezaee, M., Howland, M., & van de Panne, C. (1998). Sampling size and efficiency bias in data envelopment analysis. Journal of Applied Mathematics and Decision Sciences, 2, 51–64.

- Al-Shammari, M., & Salimi, A. (1998). Modeling the operating efficiency of banks: A nonparametric methodology. Logistics Information Management. 11, 5–12.

- Altunbas, Y., Evans, L., & Molyneux, P. (2001). Bank ownership and efficiency. Journal of Money, Credit and Banking. 33(4), 926–954.

- Altunbas, Y., Liu, M. H., Molyneux, P., Seth, R. (2000). Effi ciency and Risk in Japanese Banking. Journal of Banking and Finance. 24, 1605-1628.

- Ariff, M., Can, L. (2008). Cost and profit efficiency of Chinese banks: a non-parametric analysis. China Economic Review. 19 (2), 260–273.

- Ataullah, A., & Le, H. (2006). Economic reforms and bank efficiency in developing countries: The case of the Indian banking industry. Applied Financial Economics. 16, 653–663.

- Ataullah, A., Cockerill, T., & Le, H. (2004). Financial liberalization and bank

efficiency: A comparative analysis of India and Pakistan. Applied Economics. 36(17), 1915–1924.

- Avkiran NK. (2006). Developing foreign bank efficiency models for DEA grounded in finance theory. Socio-Economic Planning Sciences. 40, 275–96.

- Baer, W., Nazmi, N. (2000). Privatization and restructuring of banks in Brazil. Quarterly Review of Economics and Finance. 40, 3–24.

- Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science, 30(9). 1078–1092.

- Berg, S. A., Førsund, F. R. and Jansen, E. S. (1991). Technical efficiency of Norwegian banks: The non-parametric approach to efficiency measurement. The Journal of Productivity Analysis. 2 (2), 127-142.

- Berger, A. N. and Humphrey, D. B. (1992). Measurement and efficiency issues in commercial banking. Output Measurement in the Service Sectors. Chicago: University of Chicago Press.

- Berger, A. N., & Mester, L. J. (1997). Inside the black box: What explains differences in the efficiencies of financial institutions? Journal of Banking & Finance. 21(7), 895–947.

- Berger, A. N., Clarke, G. R. G., Cull, R., Klapper, L., & Udell, G. F. (2005). Corporate governance and bank performance: A joint analysis of the static, selection, and dynamic effects of domestic, foreign, and state ownership. Journal of Banking and Finance. 29(8–9), 2179–2221.

- Berger, A. N., Demirgüç-Kunt, A., & Levine, R. (2004). Bank concentration and competition: An evolution in the making. Journal of Money, Credit and Banking. 36, 433–451.

- 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, 113–30.

- Berger, A., Hunter, W., & Timme, S. (1993). The efficiency of financial institutions: A review and preview of research past, present and future. Journal of Banking and Finance. 17, 221–249.

- Berger, A.N., Hasan, I., Zhou, M. (2006). Bank ownership and efficiency in China: What will happen in the world's largest nation? Federal Reserve Board, Mimeo.

- Bhattacharya, A., Lovell, C. A. K., & Sahay, P. (1997). The impact of liberalization on the productive efficiency of Indian commercial banks. European Journal of Operational Research. 98, 332–345.

- Bonin, J. P., Hasan, I., &Wachtel, P. (2005). Bank performance, efficiency and ownership in transition countries. Journal of Banking & Finance. 29(1), 31–53.

- Bos, J. W. B., & Schmiedel, H. (2003). Comparing Efficiency in European Banking: A Meta Frontier Approach. De Nederlandsche Bank Research Papers. 57.

- Brewer Jr., E., Lee, C.F. (1986). How the market judges bank risk. Economic Perspectives. Federal Reserve Bank of Chicago, 25-31.

- Carvallo, O., & Kasman, A. (2005). Cost efficiency in the Latin American and Caribbean banking systems. International Financial Markets, Institutions and

Money. 15, 55–72.

- Casu, B., & Girardone, C. (2004). Financial conglomeration: Efficiency, productivity and strategic drive. Applied Financial Economics. 14(10), 687–696.

- Casu, B., & Molyneux, P. (2003). A comparative study of efficiency in European banking. Applied Economics. 35, 1865–1876.

- Chang, T. -C., & Chiu, Y. -H. (2006). Affecting factors on risk-adjusted efficiency in Taiwan's banking industry. Contemporary Economic Policy. 24 (4), 634–648.

- Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. European Journal of Operational Research. 2(6), 429–444.

- Chen, X., Skuly, M., & Brown, K. (2005). Banking efficiency in China: Application of DEA to pre-and post-deregulation eras: 1993–2000. China Economic Review. 16, 229–245.

- Claire Schaffnit, Dan Rosen, Joseph C. Paradi. (1997). Best practice analysis of bank branches: An application of DEA in a large Canadian bank. European Journal of Operational Research. 98 (2), 269-289.

- Coelli, T., Rao, D. S. and Battese, G. E. (1998) An Introduction to Efficiency and Productivity Analysis, Kluwer, Norwell, MA.

- Delfino, M. E. (2003). Bank ownership, privatization and efficiency: Empirical evidence from Argentina. Working paper, University of Warwick.

- DeYoung R. (1997). Bank mergers, X-efficiency, and the market for corporate control. Managerial Finance. 23:32–49.

- DeYoung, R. (1997). X-Efficiency and Management Quality in National Banks.

Journal of Financial Services Research. 15 (2).

- Dobson, W., & Kashyap, A. K. (2006). The contradiction in China's gradualist banking reforms. Working paper, Graduate School of Business, University of Chicago.

- Drake L, HallMJ B. Simper R. (2006). The impact of macroeconomic and regulatory factors on bank efficiency: a non-parametric analysis of Hong Kong's banking system. Journal of Banking & Finance. 30, 1443–66.

- Fadzlan Sufian, Muzafar Shah Habibullah. (2012). Navigating the Impact of Globalization on Bank Efficiency in China. China & World Economy. 19 (5), 85-101.

- Fan, L., Shaffer, S. (2004). Efficiency versus Risk in Large Domestic US Banks. Managerial Finance. 30, 1-19.

- Färe, R., & Grosskopf, S. (1997). Profit efficiency, Farrell decomposition and the Mahler inequality. Economic Letters, 57, 283–287.

- Färe, R., Grosskopf, S., &Weber,W. L. (2004). The effect of risk-based capital requirements on profit efficiency in banking. Applied Economics. 36 (15), 1731–1743.

- Farrell, M. J. (1957) The measurement of productive efficiency, Journal of Royal Statistical Society. 120, 253–81.

- Fraser DR, Fraser LM. (1990). Evaluating commercial bank performance: a guide to financial analysis. Rolling Meadows, IL: Bankers Publishing Co.

- Freixas, X., & Rochet, J. (1997). Microeconomics of Banking. Cambridge: MIT

Press.

- Fries, S., 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, X., & Heffernan, S. (2005). Cost X-efficiency in China's banking sector. Cass business school working papers WP-FF-14-2005.

- Garcia-Cestona, M., Surroca, J. (2008). Multiple goals and ownership structure: effects on the performance of Spanish savings banks. European Journal of Operational Research. 187, 582–599.

- García-Herrero, A., S. Gavilá and D. Santabárbara (2006), China's banking reform: an assessment of its evolution and possible impact. CESifo Economic Studies, Ox-ford University Press. 52 (1), 304-363.

- George Anayiotos, Hovhannes Toroyan, Athanasios Vamvakidis. (2010). The efficiency of emerging Europe's banking sector before and after the recent economic crisis. Financial Theory and Practice. 34 (3), 247-267.

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

- Grigorian, D. and V. Manole. (2002). Determinants of Commercial Bank Performance in Transition: An Application of Data Envelopment Analysis. IMF Working Paper. 2, 146.

- Harvey Leibenstein. (1966). Allocative Efficiency vs. "X-Efficiency". The American

Economic Review. 56 (3), 392-415.

- Hassan, M. K., A. Samad and M. M. Islam (2003), The Performance Evaluation of the Bahraini Banking System. University of New Orleans Working Paper.

- Hassan, M.K. (2005) The Cost, Profit and X-Efficiency of Islamic Banks, Paper Presented at the 12th ERF Annual Conference, 19th-21st December, Egypt.

- Havrylchyk O. (2006). Efficiency of the Polish banking industry: foreign versus domestic banks. Journal of Banking & Finance. 30, 1975–1996.

- Huang, T. -H., & Wang, W. -H. (2002). Comparison of economic efficiency estimation methods: Parametric and non-parametric techniques. The Manchester School. 70, 682–709.

- Isik, I., & Hassan, M. K. (2002). Cost and profit efficiency of the Turkish banking industry: An empirical investigation. The Financial Review. 37(2), 257–279.

- Janhankhami, A. and Lynge, M. J., Jr. (1980). Commercial Bank Financial Policies and their impact on market. Journal of Bank Research. 169-178.

- Kwan, S.H., Eisenbeis, R. (1995). An analysis of inefficiencies in banking. J. Bank. Finan. 19 (3–4), 733–734.

- Kyj, L., Isik, I. (2008). Bank X-efficiency in Ukraine: an analysis of service characteristics and ownership. J. Econ. Business. 60, 369–393.

- Li, S., Liu, F., Liu, S., Whitmore, G.A. (2001). Comparative performance of Chinese commercial Banks: Analysis, findings and policy implications. Review of Quantitative Finance and Accounting. 16, 149–170.

- Lin, P. W. (2002). Cost efficiency analysis of commercial bank mergers in Taiwan.

International Journal of Management. 19(3), 408–414.

- Lin, X., & Zhang, Y. (2009). Bank ownership reform and bank performance in China. Journal of Banking and Finance. 33, 20–29.

- Mansur, I, Zangeneh, H. and Zitz, Mark, S. (1993). The association between banks' performance ratios and market. Applied Economics. 1993. 25 (1), 1503-1510.

- Matthews, K., Zhang, X., Guo, J. (2009). Nonperforming Loans and Productivity in Chinese Banks, 1997-2006. Chinese Economy 42, 30-47.

- Maudos, J., & Pastor, J. M. (2003). Cost and profit efficiency in the Spanish banking sector (1985–1996): A non-parametric approach. Applied Financial Economics. 13(1), 1–12.

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

- Mester, L. J. (1996). A study of bank efficiency taking into account risk-preferences. Journal of Banking & Finance. 20(6), 1025–1045.

- Miller, S. M., & Noulas, A. G. (1996). The technical efficiency of large bank production. Journal of Banking & Finance. 20(3), 495–509.

- Mohd Zaini Abd Karim, Sok-Gee Chan, Sallahudin Hassan. (2010). Bank efficiency and on-performing loans: evidence from Malaysia and Singapore. Prague Economic Papers. 34 (2), 118-132.

- Nakhun Thoraneenitiyan, Necmi K. Avkiran. (2009). Measuring the impact of restructuring and country-specific factorson the efficiency of post-crisis East

Asian banking systems: Integrating DEA with SFA. Socio-Economic Planning Sciences. 43 (2), 240–252.

- Necmi K. Avkiran. (2011). Association of DEA super-efficiency estimates with financial ratios: Investigating the case for Chinese banks. Omega. 39 (3), 323–334.

- Park, K., Weber, W., 2006. A note on efficiency and productivity growth in the Korean Banking Industry 1992–2002. Journal of Banking and Finance 30, 2371–2386.

- Pi, L., & Timme, S. G. (1993). Corporate control and bank efficiency. Journal of Banking & Finance, 17, 515–530.

- Rasoul Rezvanian; Rima Turk Ariss; Seyed M. Mehdian. (2011). Cost efficiency, technological progress and productivity growth of Chinese banking pre- and post-WTO accession. Applied Financial Economics. 37 (1), 1-18.

- Raulin Lincifort Cadet. (2008). Cost and Profit Efficiency of Banks in Haiti: Do Domestic Banks Perform Better than Foreign Banks. Universit´e de Rennes 1, France.

- Rogers, K. E. (1998). Nontraditional activities and the efficiency of US commercial banks. Journal of Banking & Finance. 22, 467–482.

- S. Carbo, E.P.M. Gardener, and J. Williams. (2002). Efficiency in Banking: Empirical Evidence from the Savings Banks Sector. International Economic Review. 21 (2), 149-170.

- Sakar, B. (2006). A study on efficiency and productivity of Turkish banks in

Istanbul stock exchange using malmquist DEA. Journal of American Academy of Business, Cambridge. 8(2), 145–155.

- Samoilenko, S., & Osei-Bryson, K. M. (2008). Increasing the discriminatory power of DEA in the presence of the sample heterogeneity with cluster analysis and decision trees. Expert Systems with Applications. 34(2), 1568–1581.

- Sathye, M. (2003). Efficiency of banks in a developing economy: the case of India. European Journal of Operational Research. 148, 662–671.

- Seiford, L., & Zhu, J. (1999). Profitability and marketability of the top 55 US commercial banks. Management Science. 45, 1270–1288.

- Sensarma, R. (2006). Are foreign banks always the best? Comparison of state-owned, private and foreign banks in India. Economic Modelling. 23, 717–735.

- Siems, T. F. (1992). Quantifying management's role in bank survival. Federal Reserve Bank of Dallas Economic Review(January), 29–41.

- Sinkey Jr JF. (2002). Commercial bank financial management in the financial-services industry, 6th ed. Englewood Cliffs, NJ: Prentice-Hall.

- Sintok, Kedah. (2011). The Determinants Efficiency and Profitability of World Islamic Banks. 2010 International Conference on E-business, Management and Economics. 3 (1), 13-26.

- Staikouras, C., Mamatzakis, E. and Koutsomanoli-Filippaki, A. (2007). Cost efficiency of the banking industry in the south eastern European region, International Financial Markets, Institutions and Money In press.

- Sturm JE, Williams B. (2004). Foreign bank entry, deregulation and bank efficiency: lessons from the Australian experience. Journal of Banking & Finance. 28, 1775–99.

- Sufian, F. and Habibullah, M.S. (2009) 'Bank specific and macroeconomic determinants of bank profitability: empiricalevidence from the China banking sector', Frontiers of Economics in China. 4 (2), 274–291.

- Sufian, F. and Noor, M.A.N.M. (2009) The Determinants of Islamic Bank's Efficiency Changes: Empirical Evidence from the MENA and Asian Countries Islamic Banking Sectors. International Journal of Islamic and Middle Eastern Finance and Management. 2 (2), 120-138.

- T. Subramanyam, C. S. Reddy. (2008). Measuring the risk efficiency in Indian commercial banking: a DEA approach. Journal of Economics and Business. 6 (1), 76-105.

- Tang, S. (2005). Review and outlook of China's banking reforms, Speech at the Caijing Magazine leadership forum: world and China 2005.

- Tulkens H, Eeckaut PV. (1995). Non-parametric efficiency, progress and regress measures for panel data: methodological aspects. European Journal of Operational Research. 80, 474–99.

- Wang, W. K., Huang, H. C., & Lai, M. C. (2005). Measuring the relative efficiency of commercial banks: A comparative study on different ownership modes in China. Journal of American Academy of Business, Cambridge, 7(2), 219–223.

- Wei, S. -J., & Wang, L. (2000). The non-parametric approach to the measurement

of efficiency: The case of China commercial banks. Journal of Financial Research. 3, 88–96.

- Wheelock, D.C., Wilson, P.W. (1995). Explaining bank failures: deposit insurance, regulation and efficiency. Rev. Econ. Stat. 77 (4), 689–700.

- Williams, Barry. (1998). Factors affecting the performance of foreign-owned banks in Australia: A cross-sectional study. Journal of Banking and Finance. 22, 197–219.

- Williams, J., & Nguyen, N. (2005). Financial liberalization, crisis, and restructuring: A comparative study of bank performance and bank governance in South East Asia. Journal of Banking & Finance. 29(8/9), 2119–2154.

- Wong, Y. C. R., & Wong, M. L. S. (2001). Competition in China's domestic banking industry. Cato Journal. 21(1), 19–41.

- Wu, D., Yang, Z., & Liang, L. (2006). Using DEA-neural network approach to evaluate branch efficiency of a large Canadian bank. Expert Systems with Applications. 31(1), 108–115.

- Ya Ping Yin, Jianlu Shang and Mick Broadbent. (2010). Efficiency measurement and decomposition for the Chinese state-owned commercial banks at the provincial level. Journal of Chinese Economic and Business Studies. 8 (1), 45-65.

- Yildirim, C. (2002). Evolution of banking efficiency within an unstable macroeconomic environment: The case of Turkish commercial banks. Applied Economics, 34, 2289–2301.

- Yildirim, S. and G. Philippatos. (2002). Efficiency of Banks: Recent Evidence from

the Transition Economies of Europe, 1993–2000. Knoxville: University of Tennessee. Mimeo.

- Zaim, O. (1995). The effect of financial liberalization on the efficiency of Turkish commercial banks. Applied Financial Economics. 5, 257–264.

- Zhao, X., Zhong, J. M, & Jiang, Z. S. (2001). An analysis of the efficiency of state-owned banks with examples. South China Financial Research. 16, 25–27.