VSB – TECHNICAL UNIVERSITY OF OSTRAVA
FACULTY OF ECONOMICS

DEPARTMENT OF FINANCE

Analýza efektivnosti vybraných bank pomocí DEA modelů
Efficiency Analysis of Banks by Using DEA Model

Student: Bc. Wenmeng Hu
Supervisor of the diploma thesis: Doc. Ing. Tomáš Tichý, Ph.D.

Ostrava 2015

VŠB - Technical University of Ostrava
Faculty of Economics
Department of Finance

Diploma Thesis Assignment

Student:	**Bc. Wenmeng Hu**
Study Programme:	N6202 Economic Policy and Administration
Study Branch:	6202T010 Finance
Specialization:	01 Finance
Title:	Analýza efektivnosti vybraných bank pomocí DEA modelů Efficiency Analysis of Selected Banks Using DEA Models

Description:

1. Introduction
2. Foundations of Financial Analysis of Banks
3. Description of Data Envelopement Analysis Models
4. Application of DEA models and Efficiency Evaluation
5. Conclusion

Bibliography
List of Abbreviations
Declaration of Utilization of Results from the Diploma Thesis
List of Annexes
Annexes

References:

ADAM, Alexandre. *Handbook of Asset and Liability Management: From models to optimal return strategies.* New York: Wiley, 2007. 576 p. IBSN 978-0-470-03496-5.
COOPER, W. W., L. M. SEIFORD and K. TONE. *Data envelopment analysis: a comprehensive text with models, applications, references and DEA-solver software.* 2nd ed. New York: Springer, 2007. 489 p. ISBN 978-0-387-45281-4.
MISHKIN, Frederic S. and Stanley G. EAKINS. *Financial Markets and Institutions.* 8th ed. London: Prentice Hall, 2014. 704 p. IBSN 978-0133423624.

Extent and terms of a thesis are specified in directions for its elaboration that are opened to the public on the web sites of the faculty.

Supervisor: **doc. Ing. Tomáš Tichý, Ph.D.**

Date of issue: 21.11.2014
Date of submission: 25.04.2015

VYSOKÁ ŠKOLA BÁŇSKÁ-TECHNICKÁ UNIVERZITA Ekonomická fakulta 1 OSTRAVA

Ing. Iveta Ratmanová, Ph.D.
Head of Department

prof. Dr. Ing. Dana Dluhošová
Dean of Faculty

The declaration

"Herewith I declare that I elaborated the entire thesis, including all annexes, independently. "

Ostrava dated 23.04.2015

.....

WENMENG HU

Contents

1. Introduction

Profit maximization is one of the main goals of enterprises while the problem is how much inputs are required to gain the maximum extent of profits. In other words, how many profits can be earned by a certain extent of costs or how much costs are needed to gain an extent of profits that are concerns for managers. That refers to a conception of efficiency.

Efficiency is the extent to which time, effort, or cost is well-used for the intended task or function. It can measure a process if all factors take the full advantages. Furthermore, a high level of efficiency means that an enterprise can get an output by less cost, for instance. It is the pursuing of managers. When an enterprise makes its strategy of production or operation, it should know the conditions of itself. Is it efficient or not? If it is, how to keep its efficiency; if not, how to improve it and what is the expectation? DEA (Data Envelopment Analysis) model, which will be applied in our thesis, is the method to solve these problems.

DEA model is a set of popular approaches to measuring the efficiency of an organization's performance. It uses linear programming to assess the efficient situation of multiple decision-making units (DMUs) as long as the production process presents a structure of multiple inputs and outputs. It was proposed by Farrell in 1957 firstly and constantly developing to now. Compared to the optimal projection in production frontier, we can get the level of efficiency of the judged enterprise and a reference set that prompt the enterprise how to improve.

The objective of this thesis is to analyze the efficient situation of banks by DEA model. We will choose 21 banks in China and U.S.A. as the DMUs to study, which are the top banks in two countries ranked by their operating incomes in 2013. To achieve the aim of this thesis, the CCR (Charnes, Cooper and Rhodes (1978)) model, which is regarded as the basic DEA model, and SBM (Slacks-Based measure by Tone (1997, 2001)) model, which covered the shortage of the former, will be utilized to investigate the efficient analysis.

This thesis is divided into five chapters. The first and last chapters are introduction and conclusion. The introduction is a short outline of the thesis and conclusion is the summary of the whole thesis. Data and references in the appendix are the bases of the whole thesis.

In Chapter 2, we will talk about the financial statement of the banks firstly, which is the main source of the basic data of DEA model's application. The balance sheet and Income statement of banks will be detailed. After that, we will introduce the items of input and output which will be adopted in models' application. Secondly, the selected banks as DMUs will be presented. Because of the different nationalities of these banks, we will introduce the macro market environment of these two countries respectively and do the SWOT analysis for them. After that, financial ratio analysis will be offered, by which we can compute banks' situation about their profitability, assets quality and efficiency ratios.

The models that we will apply in the thesis will be introduced in Chapter 3. At first, we will have a general knowledge about DEA model including its principle, constraints and classifications. Secondly, we will have an expatiation of CCR model and SBM model, which are important models we will use to analyze the efficient situation of banks in our thesis. After that, we will compare the differences between them.

Chapter 4 is the core of this thesis. It is the application part. We divided it into three parts. The first one is a financial analysis of the selected 21 banks; the second part is to apply the CCR model and SBM model into practice; the third part is an extended application of SBM model. Considering the different financial environment of the two countries, we will change some elements and constraints in Part 3 to get the results that may be closer to the reality. For the procedure of computational aspect of models will be performed by software DEA-Solver-Learning Version (*DEA-Solver-LV*), we will put the emphasis on interpretation and analysis of results. Finally, we will have a comparison and conclusion of these practices and their results.

2. Foundations of Financial Analysis of Banks

To probe the efficiency of banks and compare them via DEA model, we should gather the relative financial information of the selected banks firstly. There are many sources of financial data. Financial statements of banks are the primary sources. These data can be usually got via banks' annual reports, which consist of the balance sheet, income statement and cash flow statement. The first part of this chapter is to introduce the balance sheet and income statement of banks, where the data are the basis of our DEA model's application.

To apply the DEA model to analyze banks' efficiency, we select the Top 21 banks in China and U.S.A. as DMUs. These banks are all ranked by their operating revenues in 2013. As to the second part of the chapter, we will have a brief of the situation of banking sectors respectively in these two countries firstly. Furthermore, the introduction of these banks in detail will proceed subsequently. The methodology of financial analysis about banks' profitability, assets quality and efficiency ratios will be introduced thirdly, by which we can get a glance of banks' financial situations.

2.1 Financial Statements of Banks

Because of the differences in businesses and operating structures between industrial corporations and commercial banks, the lists of the financial statement of them are different. Here we will introduce the balance sheet and income statement of commercial banks in this part.

2.1.1 Balance Sheet

Balance sheet, also called the statement of financial position, presents a snapshot view of a bank's all stock values of sources and usage of bank's funds at a special point in time, which is usually at the end of the financial year. It consists of three parts: assets, liabilities and ownership equity. Assets on the left side present the usage of a bank's fund; while liabilities and equity on the right side present sources of bank's funds. These three components satisfied:

$$Assets = Liabilities + Equity \tag{2.1}$$

In a bank, the assets are always of 4 major types: liquid assets, which include cash and balances with other financial institutions; short-term investment such as securities purchased in the open market; loans and leases, which is the main business

of traditional commercial banks and others such as fixed assets and goodwill. Liabilities are divided into two parts, which are deposits and non-deposit borrowings. Equity is the funds belonged to shareholders, which consist of perpetual preferred stock, common stock, surplus and undivided profits. Table 2.1 shows the classification of a bank's balance sheet.

Table 2.1 A classification of balance sheet[1]

BALANCE SHEET	
Assets	**Liabilities**
Cash and due from financial institutions	Deposits
Securities	Non-deposit borrowings
Loans and leases	**Equity**
Others	Preference shares
	Shared capitals
	Retained earnings

Cash and due from financial institutions can be divided into three parts, cash, balances with central banks and deposits in other financial institutions. Cash and due from banks is the most liquid asset of banks, which are designed to meet banks need for daily flows, such as deposit withdrawal and some unexpected or immediate cash need. Balances with central banks are always regarded as the deposit reserves. It is a minimum fraction of customer deposits and notes that each commercial bank must hold as reserves. Deposits in other financial institutions present the inter-bank lending. The corresponding item, inter-bank borrowing, is presented in the liabilities. Cash and due from financial institutions are the important component to calculate the liquidity ratio of banks.

Securities consist of two types, which are securities for liquidity and securities for investment. Federal funds sold and reverse repurchase agreements represent the former. They can be regarded as the secondary reserves. Securities for investment are the income generating portion of banks. They usually occur in the money market.

Loans and leases are the traditional business of banks. They always occur in the capital market and are the banks' most important sources of income. As to the loans and leases, we have the concepts of gross loans and leases and net loans and leases. The difference between them is the loan loss allowance. The loan loss

[1] Source from: MISHKIN, Frederic S. and Stanley G. EAKINS. *Financial Markets and Institutions*. 8th Edison; the same to Table 2.2.

allowance is formerly known as the reserve for bad debts, which involves credit risk of banks. On the one hand, the high level of loan loss allowance shows a bank's conservative attitude to credit risk; on the other hand, the high level of loan loss allowance might indicate large number of problem loans.

Others here include bank promises, fixed assets, intangibles and all other assets. Bank premises mean the agreement of providing loans to borrowers under the certain situation in a specific time, which is proposed by banks. For the agreement, borrowers should pay commitment fees. Fixed assets are banks' assets such as buildings, lands, machines, etc. in each branch. This kind of assets with stable value needs to be depreciated in every year. Intangibles are some value of banks like goodwill and brand. It is difficult to measure intangible assets' value, but it does exist and impacts banks' value.

Deposits in liabilities are the main source of bank's fund. In the three components, deposits from customers and corporations, deposits from financial institutions and deposits from government, individual deposits occupy a large proportion. Deposits are foundations of banks' money creation. Hence, it involves the problem of financial leverage. Nowadays, deleveraging becomes a requirement for banks. The deposits of banks should also be limited.

Non-deposit borrowings are another financing approach of banks. It can be inter-bank borrowings, federal funds purchased, repurchase agreement and issuing bonds.

Equity in banks is similar to it in corporate finance. *Preferred shares* and *share capitals* are invested by banks' owners. The difference is the holders with preferred shares can get the dividends preferentially than holders with common stocks; while holders with common stocks can participate in banks' decision-making. Retained earnings are undivided profits that will be reinvested in banks' operations.

2.1.2 Income Statement

The income statement presents the amount of revenues received and expenses incurred from a bank's business activities over a specific period, where it is always one year in annual reports. We can find the items of banks' income statement in Table 2.2. It exhibits a simple structure of banks' income statement.

The most differences in the income statement between banks and industrial corporations are the sources of incomes and provision for loans and leases losses.

Table 2.2 Main items of banks' income statement

INCOME STATEMENT
Interest income
Interest expense
Net interest income
Fee and commission income
Fee and commission expense
Net fee and commission income
Operating income
Operating expense
Provision for loans losses
Profit before tax
Tax expenses
Profit for the year

Interest income and *interest expense* reflect banks' traditional businesses, making loans, taking deposits. Hence, in a traditional bank, *net interest income* should be the central part of operating income.

Fees and commission income comes from the services such as settlement, clearing business and cash management. *Fees and commission expense* is also from these activities. In recent years, banks put more emphasis on their property of service, rather than saving institutions. *Net fee and commission income* are growing rapidly.

Operating income contains not only net interest income and net fees and commission income, but also dividend income, net trading income, income from fiduciary, net gains from financial instruments and others. Operating income can measure a bank's profitability.

Operating expense can measure a bank's inputs about its basic operation that have been used to keep the bank running smoothly. It consists of staff expenses, general expenses depreciation and amortization.

Provision for loans losses is the difference between the value of an investment and the book value of actual getting back. In a bank, it always points to the part of the bad debt that can't be paid off.

Let all incomes minus costs and impairment losses, we can get the *profit before tax*. And then less *taxation*, we can get the *net profit* of the bank during the particular time.

2.1.3 The Items of Input and Output

In Chapter 4, we will apply the DEA model into practice. As the components of foundations, we will introduce the items of input and output we will use which come from banks' financial statement.

In terms of inputs, what we regard as costs, should satisfy the rule of a) *interest related*; b) "*the less, the better*". *Interest related* means the change of the item will affect banks' profit. And "*the less, the better*" means the least possible of the item will maximize banks' profit. We will choose *number of employees*, *total assets,* and *operating expenses* as the input items in our application then.

Number of employees is the basic information of banks. It is always transformed into FTE (Full Time Equivalent) number, which doesn't present directly in financial statements. However, staff costs in operating are related to it. Similarly, number of branches, which reflects in fixed assets, is always considered in DEA analysis of banks' efficiency. We prefer number of employees rather than number of branches here because the latter in different areas and under the different banks' strategies have diversity in their scales. It will make a big difference in costs. However, number of employees, even in braches with difference scales, should be allocated in similar structure. It and its trends during years reflect a bank's scale and strategy directly.

As to *operating expense*, which present in the income statement, it can measure a bank's inputs about its basic operation that have been used to keep the bank running smoothly. It can measure a bank's procedure of production. If we use the interest expense instead of operating expenses, the total situation cannot be measured. Moreover, to a universal banks or investing bank whose traditional businesses are not the main incomes and expenditures, interest expense which can only measure banks' expenses of traditional business, taking deposits, cannot reflect the comparison fairly.

Total assets, which are all the funds a bank used by different forms, are chose here rather than total equity which presents the funds from shareholders, because ROE as an output item we will introduce later is calculated by net profit to equity. If

we used equity as input item, the evaluation might thus put emphasis on equity by squaring this value while other factors are evaluated in a linear manner.

Turning to output items, we choose *new deposits*, *new loans*, *operating income* and *ROE*. *New deposits* and *new loans* mean newly added deposits and newly added loans to customers in each year. In banks, deposits symbolize their credits and resource to create money. Newly added deposits are deposits in this year fewer deposits in last year. It can measure a bank's dynamic situation. Considering this, the item of new loans has been also chosen. Loan is banks' important investing tool. It seems an input item. However, given the third point of requirements of DMU's data (smaller input amounts are preferable and large output amounts are preferable), we consider it as an output item. *Operating profit*, which is operating incomes less operating expenses, and *ROE*, which is net profit to shareholder's investment, can measure a bank's profitability directly.

2.2 Methods of Financial Analysis

To apply the DEA model to analyze banks' efficiency into practice, we select 21 banks, which ranked by their operating revenues in 2013, as samples in two different markets, China and U.S.A. The reason of number of 21 banks we will explain in Chapter 3. And now, we will make an introduction for these banks. Firstly, we will talk about the background of the selected banks, such as the banking sectors in these two countries. Secondly, we will introduce some financial ratios of banks, by which we can get a glance of banks' financial situations through their profitability, assets quality and efficiency ratios.

2.2.1 Macro Financial Analysis

By 2013, the Asian-Pacific region, North America and West Europe are the main distribution areas of world top 1000 banks, where banks gathered 89.9% of the core capital of the world. China and U.S.A are the representations of the former two regions. Chinese banking sector had a great progress, which overtook U.S.A. and became the country with biggest size of core capital in the world first time. Meanwhile, the U.S. banks increased 27% of net profit before taxes. It is a great progress. Given the status of Chinese and U.S. banking sectors, we choose banks in these two markets.

There is an interesting phenomenon in these two countries, China and U.S.A., where both of them have 4 big banks leading the banking sectors. In China, they are Industrial and Commercial Bank of China (ICBC) with operating revenue of RMB 578,901 million, China Construction Bank (CBC) with operating revenue of RMB 511,140 million, Agricultural Bank of China (ABC) with operating revenue of RMB 465,771 million and Bank of China (BC) with operating revenue of RMB 407,509 million; In U.S.A., they are J.P. Morgan (JPM) with operating revenue of USD 96,606 million, Bank of America (BAC) with operating revenue of USD 88,942 million, Wells Fargo (WFC) with operating revenue of USD 83,780 million and Citigroup (CITI) with operating revenue of USD 76,366 million.

Symmetrically, we select following banks in each country on behalf of smaller banks. However, the operating revenues of the fifth and subsequent banks are as half or less half as the fourth bank in each country. Hence, we divide these banks into four parts by country and scale of operating revenues which is presented in Table 2.3. The reason of the number of smaller banks of 13 is to fit the application of DEA model that we will explain in Chapter 3.

Table 2.3 The selected banks in China and U.S.A.

Nationality		**China**	**U.S.A.**
Banking System		**Two-stage System**	
Ownership		**Joint-stock System**	
Separate/Mixed Operation		**Strictly Separate Operation**	**Mixed Operation**
Types		**Traditional Banks**	**Universal banks**
Operating Incomes	**≥USD 50,000 million**	Industrial&Comercial Bank of China Ltd. (ICBC)	J.P. Morgan Chase&Co. (JPM)
		China Construction Bank Corp. (CBC)	Bank of America Corp. (BAC)
		Agricultural Bank of China Ltd. (ABC)	Wells Fargo&Co. (WFC)
		Bank of China Ltd. (BC)	Citigroup Inc. (CITI)
	≤USD 50,000 million	Bank of Communication Co., Ltd. (BOCM)	Goldman Sachs Group, Inc. (GS)
		China Merchants Bank Co., Ltd. (CMBC)	Morgan Stanly (MS)
		China Minsheng Bank Corp., Ltd. (CMSB)	Capital One Financial Group (COF)
		China Industrial Bank Co.,Ltd. (CIB)	U.S. Bancorp (USB)
		China Citic Bank Corp., Ltd. (CNCB)	PNC Financial Services Group (PNC)
		Shanghai Pudong Development Bank Co.,Ltd. (SPD)	The Bank of New York Mellon Corp. (BNY)
		China Everbright Bank Co.,Ltd. (CEB)	

Table 2.3 exhibits the selected banks in China and U.S.A., which is divided by operating income of USD 50,000 million. The header lines show the properties of banking sectors in two countries, which are banking system, the system of ownership, operation institution and types of banks.

Banking system indicates the relationship between the central bank and commercial banks and relationship among banks. There are two kind systems, which are One-stage Banking System and Two-stage Banking System. One-stage Banking System means all banks to be engaged in all banking operations. In other words, there is no central bank. All banks take the charge of government's unified management. Or we can say that all banks are central banks. It is typical for centrally planned economies in 20th century. Turing to two-stage Banking System, it is the most frequent banking model in nowadays. The first stage of it is the central bank and the second is formed by commercial banks. Banks in the second stage operate independently while central bank supervises them.

The system of ownership indicates the property of banks. Although most of the big banks are joint-stock corporations nowadays, the major holders of banks have the right to influence banks' decision-making or administrative model.

Operation institution refers to the business structure of banks. There are two types of it, which is separate operation and mixed operation. Separate operation means banking companies cannot perform securities business. On the contrary, mixed operation means a bank can be a combination of the banking company, securities company and insurance company. After 1999, U.S.A. produced the *Gramm-Leach-Bliley Act*. It repealed part of the *Glass–Steagall Act* of 1933 and removed barriers in the market among banking companies, securities companies and insurance companies. The Act permits one institution acting as any combination of an investment bank, a commercial bank, and an insurance company. Nowadays, banks in almost every country have implemented mixed operation regime.

Types of banks are decided by their business or target customers. We distinguish banks by their business here, and banks are divided into traditional banks, investment banks, and universal banks. Taking deposits and making loans are main businesses of traditional banks, of which the main incomes are net interest margin and service fees; Investment banks provide services such as financing, securities

underwriting, assets restructuring etc., and the main income is commission; Universal banks combine traditional banking and investment banking, even more including insurance services. The separate operation institution in last paragraph always refers to the isolation of investment banks from traditional banks; while mixed operation institution is represented by universal banks.

Banking Sector in China

After 1984, Chinese banks started implementing Two-stage Banking System while commercial banks still operated under the order of the central bank. The central bank is a subordinate institution of government and serviced for it. The commercial banks had a higher while still low level of independence since 1995. In 1998, on-line banking went into Chinese people's sight, but even now the banking on-line system has not been valued by people. People prefer the Zhifubao system proposed by an e-business company. On the other hand, a large proportion of the rural population can't get the services from banks. Lacking investment philosophy and few banking outlets in small towns are two main reasons for the limitation of the rural market. These two factors make Chinese domestic demand of market to be inefficient. Insufficient domestic demand of market leads banks to pursue the oversea market. The first attempt was in 2006, and it achieved great success indeed. By the way, because of the late start of expanding oversea market and conservative risk attitude, Chinese banks were shocked slighter than U.S.A. by the financial crisis starting in U.S.A. and the subprime crisis in Europe.

As to the 11 banks in China, which is presented in Table 2.1, all of them are traditional banks. With the regulation of strictly separate operation in Chinese banks, securities companies in China are small and confined.

Although the selected banks are all joint-stock companies in terms of ownership, divided by their majority stockholders, there are two types of State-owned Commercial Banks and Private Commercial Banks. The former 5 banks, ICBC, CBC, ABC, BC and BOCM, are state-owned. Chinese government invests them directly as equities and, of course, takes charge of them. The latter 6 banks, CMBC, CMSB, CIB, CNCB, SPD and CEB are not invested by government directly, while their major stockholders of CMBC, CIB, CNCB, SPD and CEB are state-owner corporations. They are similar to the former 5 banks. It means under the government's charge, bank

managers needn't worry about banks profitability and risk, in other words, these banks have low independence and autonomy and efficiency. CMSB is the only private enterprise among the 11 banks, for which it is hard to expand its scale.

SWOT Analysis of Chinese Banking Sector

SWOT analysis is a structured planning method used to evaluate the strengths, weaknesses, opportunities and threats involved in a project or in a business venture. Here we will introduce Chinese banking sector from these four parts. We will divide the situation into domestic and abroad.

Strengths

In the mainland of China, the government supporting policies are main strengths of Chinese banks. Government provides funds and credit guarantee to nationalized banks. If banks suffered risks or got into trouble, government would get involved and offer a fiscal favor or monetary help via Central Bank. Banks take advantages over domestic market shares not only for supporting policies, but also for customers' investing preference and the same culture connotation. Chinese people trust local banks more.

As to the international market, Chinese banks have been performing well and have a good record to global customers. Recent years, Chinese banks who emphasize foreign market and international cooperation, has made remarkable achievements.

Weaknesses

In the domestic market, most old people who are risk averters, lack investment philosophy. Their favorite financial product is T-bills. Young people prefer electronic consumption and rarely to invest. It is bad for banks' financial innovation. And insufficient domestic demand impedes banks improvement. People went to banks are accustomed to seeking manual services rather than self-services; however, the poor manual services of big banks is disclosed many times.

In the international market, Chinese banks lack creativeness. There also exist problems about banks' management and their structures.

Opportunities

Insufficient domestic demand is not because of the capacity of market. The potential market in the rural district is worth exploiting. With the deepening of the

financial internationalization, it should be beneficial to promote international cooperation and competitiveness, widen the international market and optimize the investing environment for banks.

Threats

The financial reports of Chinese banks are the most beautiful in the world; while their authenticities cause controversy. Chinese banks are over dependent on the guidance of the government and the Central Bank, lacking the sense of competition. Monopolization in banking sector makes small banks survival difficultly. The strictly separate operation institution makes financial market faulty.

With the entrance of foreign banks, the loss of talents becomes a big problem of Chinese banking sectors. Meanwhile, Chinese bankers should expand their oversea market, promote their management and increase their competitiveness. Transforming operational ideas and cultivate enterprise culture are essential steps.

Banking Sector in U.S.A

Dual-chartering system is the prominent characteristics of U.S. banking sector. Dual-chartering system means U.S. banks may have charters issued at two different levels of government, national and state. And banks should be under the supervision of the local banking authority. The national banks in U.S.A. must be the member banks of Federal Reserve simultaneously, and under the regulatory of the Controller of the Currency and Federal Deposit Insurance Corporation. All of the 10 selected U.S. banks, which are presented in Table 2.1, are national banks in U.S.A. As to the types of the 10 selected banks in U.S.A., before the production of U.S. *Gramm-Leach-Bliley Act* in 1999, U.S. banks have already implemented mixed operation regime. Hence, all of the 10 banks are universal banks. Among these banks, the main businesses of MS, GS and BNY are providing securities services such as financing, securities underwriting, assets restructuring etc., so we regard them as investment banks.

Recent years, U.S.A. has been out of the mire of the financial crisis and maintained a good momentum of development, which should thank to the recovery of the real estate market and fiscal policies and measures took by the government.

For commitment to liberalization, the U.S. banking market is competitive and efficient. While lacking macro adjustment, the great low-ebb of the business cycle might be too heavy to suffer by people. And after the financial crisis, the U.S. regulatory authorities noticed the importance of banking supervision. Basel III made a higher requirement of banking asset quality. On the other hand, many banks suffered the instabilities from sharply scale expansion before. They had to consider scale down and increasing capital strength. In this regard, deleveraging, anti-monopoly and enhancing supervision become the main targets of U.S. banks.

SWOT Analysis of U.S. Banking Sector

Strengths

The Wall Stress groups the top financial talents, and U.S.A. is regarded as the most developed country of the financial industry. The environment of competition makes the U.S. banking competitive and efficient.

U.S. banks emphasize their brand effects. Excellent service and product innovation are their greatest strength. With the mixed operation institution, the financial market formed a good relationship of collaboration. Banks have good relationships with most of the U.S. big companies and infiltrate their financial services into various sectors.

Weaknesses

Although the U.S.A. has been recovered through the financial analysis, it is not easy to build customers' faith in a short time. The existing banking structure encourages the behaviors of speculation.

Opportunities

U.S. banks position their target market as global market. With the deepening of the internationalization, U.S. banks' expansion in other countries should be faster. Developing international business, absorbing foreign capitals, attracting the person with abilities are necessary steps to exploit the global market.

Threats

Changes in government regulations and financial crisis like recessions are main threats to most U.S. bank now. Decrease in demand for home loans and investments will also have a significant effect on the U.S. banks. With the recovery of

the economy, competitions from other banks are intensified. At the same time, *Wikileaks* exposures banks' internal financial information and analyzes their financial situation. It is both with pros and cons.

2.2.2 Financial Ratios

To judge the statement of the selected banks we mentioned above, we will introduce the financial analysis about banks' profitability, assets quality and efficiency ratios from 2009 to 2013. For convenient to compare them, we use the weighted average value of results. The weights we set of 2009 to 2013 are 0.05, 0.075, 0.125, 0.25 and 0.5 respectively.

Profitability Ratios

To probe a financial performance of a bank, the first indicator should be profitability that reflects the market's evaluation of the bank. Thus, we will show the Return on Equity (ROE), Return on Assets (ROA), Net Interest Margin (NIM) and Net Profit Margin (NPM).

Return on Equity (ROE) approximates the net profit to stockholders' investing capital in the bank. It can measure the return earned by a bank on its equity. Return on Assets (ROA) is another measure of the rate of profitability, which calculated by net profit to total assets of the bank. It indicates how capable management has been in converting assets into net earnings. The higher of ROE and ROA ratios, the more income is generated by a given level of inputs. The formulae of ROE and ROA are presented as following:

$$Return\ on\ Equity = \frac{Net\ Profit}{Equity}; \tag{2.1}$$

$$Return\ to\ Assets = \frac{Net\ Profit}{Assets}. \tag{2.2}$$

Net Interest Margin (NIM) is net interest income to total assets. It can measure how large a spread between interest earnings and interest costs management were achieved by a close control over earning assets and pursuit of the cheapest source of funding. In traditional banks, taking deposits, making loans and getting the differences of their interests is the major incomes. Net interest income plus non-interest income is operating income, to which by net profit can be used to measure the

effectiveness of expense management and service pricing policies. That is Net Profit Margin (NPM). The formulae of them are presented in (2.3) and (2.4).

$$Net\ Interest\ Margin = \frac{Net\ Interest\ Income}{Total\ Assets}; \tag{2.3}$$

$$Net\ Profit\ Margin = \frac{Net\ profit}{Operating\ Income}. \tag{2.4}$$

Risk Ratios

As to risk ratios, we divide them into 3 parts, which is liquidity ratio, credit ratio, and capital adequacy ratio.

Liquidity measures the ability of a bank whether having sufficient cash and borrowing capacity to meet customer withdrawals, loan demand, and other cash needs. Here we compute the most liquid assets, which consist of cash and due from banks. It is the money to meet customers' withdrawing, petty loan requirement and some unexpected or immediate cash need. We use cash and due from banks to total assets as liquidity ratio (LR) to analyze banks' liquidity risk here, and the formula is:

$$LR = \frac{Cash\ and\ Due\ from\ Banks}{Total\ Assets}. \tag{2.5}$$

Credit risk, just as its name implies, is probability that some of a financial institution's assets, especially its loans, which will decline in value and perhaps become worthless. We use Allowance to total loans ratio (ATTL), which calculated by dividing allowance for loan losses (ALL) by total loans and lease, and Loan to deposit ratio (LTD) where we use total loans to total deposits to measure the banks' credit risk. The formulae of them are presented as following:

$$ATTL = \frac{Allowance\ for\ Loan\ Losses}{Gross\ Loans}; \tag{2.6}$$

$$LTD = \frac{Gross\ Loans}{Gross\ Deposits}. \tag{2.7}$$

Capital adequacy ratio (CAR) is an important tool to measure a bank's assets' quality. It is calculated by the capital required to risk-weighted assets. We use the Tier 1 capital adequacy ratio (CCAR) here, where capital required defined as actual contributed equity plus retained earnings. It is the core measure of a bank's financial strength from a regulator's point of view. In Basel III, Tier 1 capital ratio was required to be more than 6%. And we can calculate the ratio by (2.8).

$$CCAR = \frac{Tier\ 1\ Capital}{Risk\ Weighted\ Assets}. \quad (2.8)$$

Efficient Ratios

In an effort to get maximize profitability and to realize the value of the shareholders' investment, bankers recognize the need for greater efficiency in their operations. That usually means reducing operating expenses and increasing the productivity of their employees through the use of automated equipment and improved employee training. We can use two indicators to measure the efficiency of a bank, which are Operating efficiency ratio (OER) and Employee productivity ratio (EPR).

Operating efficiency ratio (OER) expresses total operating expenses in relation to total operating revenues. It is a very basic idea to measures a firm's efficiency. A high ratio indicates a low level of efficiency. Employee productivity ratio (EPR) relates to the efficiency of employees, which calculated by operating revenues to number of employees. It measures how many contributions of every employee to operating income. The higher of the ratio, the more efficient a bank will be. For compare two countries' EPR fairly, we transform the results of Chinese bank of CHY into USD as the exchange rate of 6 USD/CHY. The formulae of OER and EPR are:

$$OER = \frac{Total\ Operating\ Expenses}{Total\ Operating\ Revenues}; \quad (2.9)$$

$$EPR = \frac{Net\ Operating\ Income}{Nimber\ of\ FTE\ Employees}. \quad (2.10)$$

2.3 Summary

In this chapter, we introduced the foundations of our thesis. At first we talked about the sources of our data. The financial statements of banks, which mainly refer to the balance sheet and income statement, were introduced simply. And some items which we will use as inputs, such as number of employees, operating expenses and assets; and outputs such as new deposits, new loans, operating profit and ROE, of the DEA application in Chapter 4 were detailed. Also, we explained the reason we chose them.

Secondly, we put the emphasis on financial analysis of the selected banks. We chose 21 banks in China and U.S.A., which ranked by their operating incomes in 2013.

We introduced the background and sector situation of these two countries. Furthermore, we did the SWOT analysis of them. After that, the financial ratio method of financial analysis which we will do in Chapter 4 was introduced, through what we can get a glance of the selected banks' financial situations through their profitability, assets quality and efficiency ratios.

3. Description of Data Envelopment Analysis Models

This chapter deals with two basic DEA models we will utilize to analyze the efficiency of selected banks, the CCR (Charnes, Cooper and Rhodes (1978)) model and the SBM (Slacks-Based Measure by Tone (1997, 2001)) model. Firstly we will introduce the general principle of Data Envelop Analysis; then the two basic models will be described in detail.

3.1 Data Envelopment Analysis

Data Envelopment Analysis, which is abbreviated as DEA hereinafter, is a popular method set to evaluate the efficiency of organizations. In DEA, there are some factors, which are inputs, outputs and DMUs (Decision making Units). As its principle described, a DMU in DEA is regarded as the entity responsible for converting inputs into outputs and whose performances are to be evaluated. In short, DEA reflects DMUs' efficiency to convert inputs into outputs. If we build coordinate points of inputs and outputs in pairs in geometric portrayal, we can get an efficient frontier which structured by DEA to "envelop" all points. And that is the reason of DEA's name.

This thesis is concerned with the efficiency of banks in China and U.S.A.; hence the selected banks are DMUs here. As the research objects, there are several requirements to DMUs: a) each DMU should have a certain degree of managerial independence for the purpose of securing relative comparisons; b) numerical data are available for each input and output, noting that the units of the different inputs and outputs needn't be congruent; c) the items (inputs, outputs and choice of DMUs) should reflect an analyst's or an manager's interest. The efficiency scores should reflect that smaller input amounts are preferable and large output amounts are preferable.

To make the results of DEA more reliable, it is required that the number of DMUs (n) should exceed the combined number of inputs and outputs ($m + s$). The formula is:

$$n = \max\{m \cdot s, 3 \cdot (m + s)\}^2. \tag{3.1}$$

[2] WILLIAM, W. C, Lawrence M. S, Kaoru T. *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software. Page 116.*

In the applied chapter subsequently, we choose *number of employees*, *operating expenses* and *total assets* as inputs; *new deposits*, *new loans*, *operating profit* and *ROE* as outputs to study the selected banks' efficiency. That is why we need 13 smaller banks followed by 8 biggest banks in two countries we said in Section 2.2.1. The number of 21 banks as DMUs is appropriate to 3 inputs and 4 outputs.

In terms of DEA's computational aspects of input and output data, we can classify all DEA models into two types: Radial and Non-Radial.

Radial measure means that a proportionate change of input/output values. For instance, if there existed inputs x_1 and x_2 in the concerned problem, where x_1 and x_2 are in radial, then activity (x_1, x_2) should be subject to change proportionally as (tx_1, tx_2) with a positive t. The CCR model of DEA we will introduce in the succeeding section is the representation of radial approach. The efficient score is its main concern; while it does not take account of non-zero slacks (the existence of input exceeds and output shortfalls). Non-Radial means the relevant variables need not stick to a proportionate change. Correspondingly, it neglects the radial characteristics of variables. The Non-Radial approach is represented by SBM, which reflects not only the efficiency value but also the slacks as well. We will introduce it in Section 3.3.

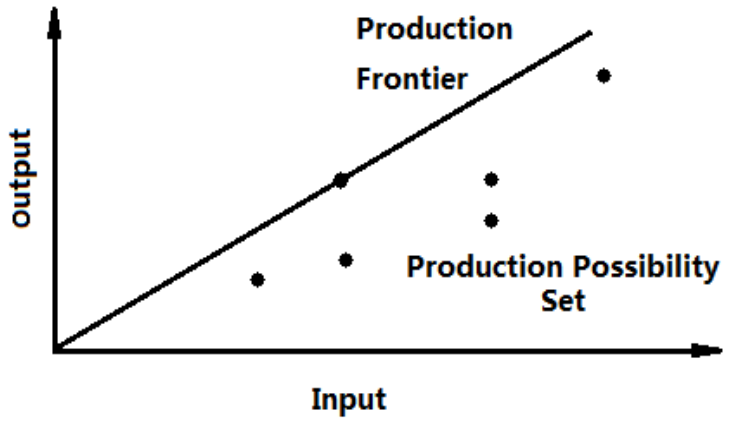
Oriented indicates the input or output orientation in evaluating efficiency. Input-oriented models aim to investigate the efficiency by input level while keep the output satisfying at least the present levels. On the contrary, output-oriented models assess the efficiency by output levels under the situation of without requiring any more of the observed input values. For the analogous idea of input-oriented and output-orient, we both adopt the former in each model's application in our thesis.

As to the efficiency, there are 3 situations. (1) Full efficiency which is to be attained if and only if the DMU satisfies: (a) the efficient ratio under the optimal situation equals 1 and (b) there exist no input exceeds nor output shortfalls; (2) weak efficiency, or technical efficient, which is to be obtained if the DMU achieves the condition (a) of full efficiency, while slacks are not limited; (3) otherwise, we can say the DMU are inefficient.

3.2 CCR Model

The CCR model, as the most basic DEA models, is the origin and base of other models. It is initially proposed by Charnes, Cooper and Rhodes in 1978. CCR model is the representation of radial measure with the assumption of constant returns-to-scale of activities, where constant returns-to-scale here means that if all inputs increased 100%, the new values for output would increase the same proportion to point on Production Frontier.

Figure 3.1 Production Frontier of the CCR Model[3]



To solve the efficient problem in mathematical method, we transform all concerned factors into the form of algebra. For n DMUs with m input items and s output items, the input data (x) for DMU_j are expressed by:

$$\boldsymbol{x}_j = (x_{1j}, x_{2j}, \ldots, x_{mj}); (\boldsymbol{x}_j \geq \boldsymbol{0}; \exists\ x_j \neq 0; j = 1, 2, \ldots, n) \tag{3.2}$$

the output data (y) for DMU_j are expressed by:

$$\boldsymbol{y}_j = (y_{1j}, y_{2j}, \ldots, y_{sj}).\ (\boldsymbol{y}_j \geq \boldsymbol{0}; \exists\ y_j \neq 0; j = 1, 2, \ldots, n) \tag{3.3}$$

All the scalar ($\boldsymbol{x}$, $\boldsymbol{y}$) belongs to R^n. $X = \boldsymbol{x}_{mn}$ indicates all inputs of DMUs; $Y = \boldsymbol{y}_{sn}$ indicates all outputs of DMUs. n is the number of DMUs.

The set of feasible activities that consists of notation ($\boldsymbol{x}$, $\boldsymbol{y}$) is called the production possibility set, where the ($\boldsymbol{x}$, $\boldsymbol{y}$) satisfies $\boldsymbol{x} \geq X\boldsymbol{\lambda}$ and $\boldsymbol{y} \leq X\boldsymbol{\lambda}$ ($\boldsymbol{\lambda}$ is a semi-positive vector in R^n; $\boldsymbol{\lambda} \geq \boldsymbol{0}$), and it's donated by P. The component of each such vector pair can be regarded as a semi-positive orthant point in (m+ s) dimensional

[3] Source from WILLIAM, W. C, Lawrence M. S, Kaoru T. *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software. Page 88.*

linear vector space in which the superscript m and s specify the number of dimensions required to express inputs and outputs. The shape of production frontier in the single input-single output case of CCR model shows in Figure 3.1, where it shows the situation of $m = 1$, and $s = 1$.

For each DMU, we formed the virtual input and output by (yet unknown) weights ($\boldsymbol{v}_i$) ($i = 1, 2, \ldots, m$) and ($\boldsymbol{u}_r$) ($r = 1, 2, \ldots, s$), where $\boldsymbol{v} \geq \mathbf{0}$; $\boldsymbol{u} \geq \mathbf{0}$.

The efficiency of a selected DMU_o, where o ranges over 1, 2, …, n, can be measured by following formula:

$$\theta_o = \frac{\boldsymbol{u}\boldsymbol{y}_o}{\boldsymbol{v}\boldsymbol{x}_o}. \tag{3.4}$$

3.2.1 CCR Efficiency

From the constraints and efficient formula in (3.4), it is readily to get the fractional program:

$$(FP_o) \qquad \max_{\boldsymbol{v},\boldsymbol{u}} \theta = \frac{\boldsymbol{u}\boldsymbol{y}_o}{\boldsymbol{v}\boldsymbol{x}_o} \tag{3.5}$$

$$\text{subject to} \qquad \frac{\boldsymbol{u}\boldsymbol{y}_j}{\boldsymbol{v}\boldsymbol{x}_j} \leq 1 \quad (j = 1, 2, \ldots, n) \tag{3.6}$$

$$\boldsymbol{v} \geq \mathbf{0}; \boldsymbol{u} \geq \mathbf{0}. \tag{3.7}$$

θ here means the efficient score of DMU_o. It is a constant. $\boldsymbol{v}$ and $\boldsymbol{u}$ denote the weight vectors of inputs and outputs. $\boldsymbol{u}\boldsymbol{y}_o$ is virtual outputs; $\boldsymbol{v}\boldsymbol{x}_o$ is virtual inputs. Constraint (3.6) restricts θ in the range of $0 \leq \theta \leq 1$.

The linear program (LP_o) of fractional program (FP_o) can be replaced as:

$$(LP_o) \qquad \max_{\boldsymbol{v},\boldsymbol{u}} \theta = \boldsymbol{u}\boldsymbol{y}_o \tag{3.8}$$

$$\text{subject to} \qquad \boldsymbol{v}\boldsymbol{x}_o = 1 \tag{3.9}$$

$$\frac{\boldsymbol{u}\boldsymbol{y}_j}{\boldsymbol{v}\boldsymbol{x}_j} \leq 1 \quad (j = 1, 2, \ldots, n) \tag{3.10}$$

$$\boldsymbol{v} \geq \mathbf{0}; \boldsymbol{u} \geq \mathbf{0}. \tag{3.11}$$

The FP_o is equivalent to LP_o. In FP_o, we assume the combination of (θ^*, $\boldsymbol{v}^*$, $\boldsymbol{u}^*$) is the optimal solution. Then we can get the necessary and sufficient condition of CCR-Efficiency:

1. DMU_o is CCR-efficient if $\theta^* = 1$ and there exists at least one optimal $(\boldsymbol{v}^*, \boldsymbol{u}^*)$, with $\boldsymbol{v}^* > \mathbf{0}$ and $\boldsymbol{u}^* > \mathbf{0}$.

2. Otherwise, DMU_o is CCR-inefficient.

From the formulae (3.5) to (3.7) and formulae (3.8) to (3.11), we can observe that CCR model measures efficiency by θ^*, while it do not take account of non-zero slacks. It is technical efficiency that can be obtained by CCR model. Hence, we introduce a real variable θ and a non-negative vector $\boldsymbol{\lambda} = (\lambda_1, \ldots, \lambda_n)^T$ and investigate the dual problem of (DLP_o) here.

$$(DLP_o) \qquad \min_{\theta,\boldsymbol{\lambda}} \quad \theta \tag{3.12}$$

$$\text{subject to} \qquad \theta \boldsymbol{x_o} - X\boldsymbol{\lambda} \geq \mathbf{0} \tag{3.13}$$

$$Y\boldsymbol{\lambda} \geq \boldsymbol{y_o} \tag{3.14}$$

$$\boldsymbol{\lambda} \geq \mathbf{0}. \tag{3.15}$$

We define the input excesses $\boldsymbol{s}^- \in R^m$ and the output shortfalls $\boldsymbol{s}^+ \in R^s$ and identify them as "slack" vectors by:

$$\boldsymbol{s}^- = \theta \boldsymbol{x}_o - X\boldsymbol{\lambda}, \ \boldsymbol{s}^+ = Y\boldsymbol{\lambda} - \boldsymbol{y}_o, \tag{3.16}$$

with $\boldsymbol{s}^- \geq \mathbf{0}, \boldsymbol{s}^+ \geq \mathbf{0}$ for any feasible solution $(\theta, \boldsymbol{\lambda})$ of (DLP_o).

We use θ^* to represent the θ under the optimal situation; ω^* to represent ω $(\omega = \boldsymbol{\omega}_x \boldsymbol{s}^- + \boldsymbol{\omega}_y \boldsymbol{s}^+)$ when $\theta = \theta^*$, where the weights $\boldsymbol{\omega}_x$ and $\boldsymbol{\omega}_y$ are positive row vectors. The definition of efficiency by CCR model shall be transformed into 1) $\theta^* = 1$; 2) $\omega^* = 0$.

3.2.2 The Improvement in Efficiency

In DEA models, we concern the comparative efficiency. That is, the DMU_o taken into inefficient should have an efficient reference with a lower inputs or higher outputs. Certainly, the inefficient DMU_o should be able to improve by augment outputs shortfalls and eliminate the input excesses consulting the reference. The references format a reference set. The gross input improvement $\Delta \boldsymbol{x}_o$ and output improvement $\Delta \boldsymbol{y}_o$ can be calculated from:

$$\Delta \boldsymbol{x}_o = (1 - \theta^*)\boldsymbol{x}_o + \boldsymbol{s}^{-*}; \tag{3.17}$$

$$\Delta \boldsymbol{y}_o = \boldsymbol{s}^{+*}. \tag{3.18}$$

After the adjustment, the $(\boldsymbol{x}_o, \boldsymbol{y}_o)$ should be an improved activity $(\widehat{\boldsymbol{x}_o}, \widehat{\boldsymbol{y}_o})$ which is called the CCR projection. $(\widehat{\boldsymbol{x}_o}, \widehat{\boldsymbol{y}_o})$ is a full efficient combination.

$$\widehat{\boldsymbol{x}_o} \leftarrow \theta^* \boldsymbol{x}_o - \boldsymbol{s}^{-*}; \tag{3.19}$$

$$\widehat{\boldsymbol{y}_o} \leftarrow \boldsymbol{y}_o + \boldsymbol{s}^{+*}. \tag{3.20}$$

The absolute values of input excesses and output shortfalls among banks are very different, which results from their scales. Hence we make α_{oi} express the input excess ratio of input i; β_{oj} expresses the output shortage ratio of output j. their formulae are:

$$\alpha_{oi} = 1 - \theta_o + \frac{s_{oi}^-}{X_{oi}}; \quad (i = 1, 2, \ldots, m) \tag{3.21}$$

$$\beta_{oj} = \frac{s_{oj}^+}{Y_{oj}}. \quad (j = 1, 2, \ldots, s) \tag{3.22}$$

3.3 Slacks-Based Measure of Efficiency (SBM)

In the last section, we introduced the principle of CCR model, which measure the efficiency by θ^*, while the slacks need to calculate in another step. In other words, the efficient ratio θ^* hasn't taken slacks into account. Hence we introduce another stricter measure, Slacks-Based Measure (SBM). SBM is proposed by Tone in 1997, which measures technical efficiency and slacks in a single scalar (ρ^*). It represents non-radial measures. There are two important properties of SBM, Units invariant and Monotone. Units invariant, or dimension free means, means the result of efficiency will not be changed by different units of inputs or outputs. Monotone means the measure is monotone decreasing in each input and output slacks. Both of these two properties note the impacts on efficiency by slacks.

SBM model relaxes the constant returns-to-scale assumption. We shall assume the returns-to-scale are variable, which includes decreasing returns-to-scale, constant returns-to-scale and increasing returns-to-scale.

Formally, we assume X_i (i = 1, 2, …, m) to be m kinds of inputs, and the production function $F(X_i)$ have 3 results:

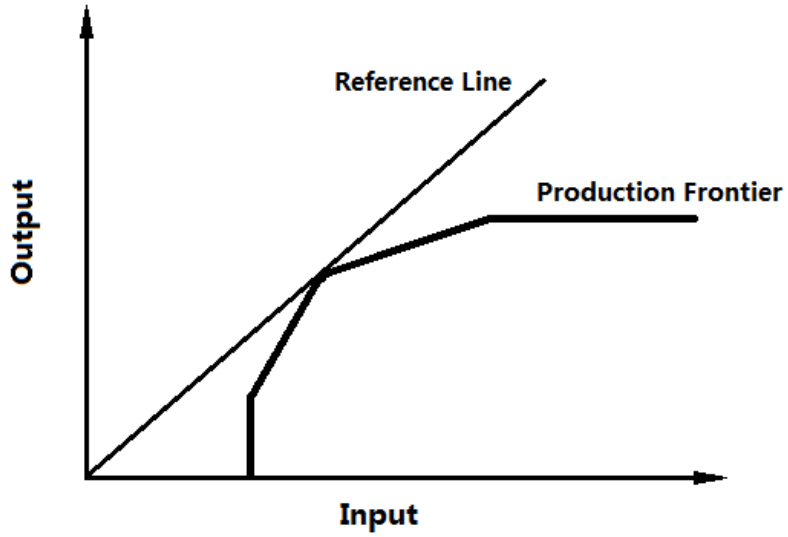
1. $F(\alpha X_i) < \alpha F(X_i)$, then it belongs to increasing returns-to-scale;

2. $F(\alpha X_i) = \alpha F(X_i)$, then it belongs to constant returns-to-scale;

3. $F(\alpha X_i) > \alpha F(X_i)$, then it belongs to decreasing returns-to-scale.

From the programs above, we can know the decreasing return-to-scale means that if all inputs increased by 100%, the new values for output should be less than twice the previous output. It may result from the managerial problems. Increasing return-to-scale means that if all inputs increased by 100%, the new values for output should be more than twice the previous output. That may result from the diminishing margin costs and specialized operating. The properties are portrayed in Figure 3.2.

Figure 3.2 Variable returns-to-scale



In Figure 3.2, the *Reference Line* is starting from the origin and through the point which satisfied CCR efficiency. It is not an indifferent line which is the line starting from the origin with the slope of 1. It means, if a point in this figure is defined as increase returns-to-scale, the input of it increasing 100% should result in more amplification of output than the increasing range of points on Production Frontier. The first and the second line segment of production frontier are increasing returns-to-scale; decreasing returns-to-scale occurs in the third and fourth line segments; and the point that go across the reference line satisfies constant returns-to-scale.

3.3.1 SBM Efficiency

Compared to the technical efficient formula as (3.5), we can formulate the fractional programs by $\boldsymbol{\lambda}, \boldsymbol{s}^-$ and $\boldsymbol{s}^+$ as (3.23).

$$(SBM) \qquad \min_{\boldsymbol{\lambda},\boldsymbol{s}^-,\boldsymbol{s}^+} \quad \rho = \frac{1-\frac{1}{m}\sum_{i=1}^{m} s_i^- / x_{io}}{1+\frac{1}{s}\sum_{r=1}^{s} s_r^+ / y_{ro}} \tag{3.23}$$

$$\text{subject to} \quad \boldsymbol{x}_o = X\boldsymbol{\lambda} + \boldsymbol{s}^- \tag{3.24}$$

$$\boldsymbol{y}_o = Y\boldsymbol{\lambda} - \boldsymbol{s}^+ \tag{3.25}$$

$$\boldsymbol{\lambda} \geq \boldsymbol{0},\ \boldsymbol{s}^- \geq \boldsymbol{0},\ \boldsymbol{s}^+ \geq \boldsymbol{0}. \tag{3.26}$$

In (3.24), we assume $X \geq O$. If x_{io}= 0, we delete the termss_i^-/x_{io}. For the same reason, if $y_{ro} \leq 0$, we replace it by a very small positive number, so that we can keep $0 \leq \frac{1}{m}\sum_{i=1}^{m} s_i^-/x_{io} \leq 1$, which can be regarded as the average value of relative rate of input slacks. For directly perceived through the sense, we can transform $1 - \frac{1}{m}\sum_{i=1}^{m} s_i^-/x_{io}$ into the form of $\frac{1}{m}\sum_{i=1}^{m}(x_{io} - s_i^-)/x_{io}$, which is the mean proportional reduction of input mix inefficiencies. Similarly, the item $\frac{1}{s}\sum_{r=1}^{s} s_r^+/y_{ro}$ will be non-negative number and the $1 + \frac{1}{s}\sum_{r=1}^{s} s_r^+/y_{ro}$, as the mean of relative reduction rate of output mix inefficiency, should be no less than 1. Hence we can find $0 \leq \rho \leq 1$. Only if $\frac{1}{m}\sum_{i=1}^{m} s_i^-/x_{io} = 0$ and $\frac{1}{s}\sum_{r=1}^{s} s_r^+/y_{ro} = 0$, we can get $\rho = 1$. And the single scalar ρ is monotone decreasing in each input and output slacks.

In this thesis we will adopt input-oriented model, hence we transform (3.21) to (3.24) into following formulae:

$$(\textit{SBM-I}) \qquad \min_{\boldsymbol{\lambda}, \boldsymbol{s}^-} \ \rho_I = 1 - \frac{1}{m}\sum_{i=1}^{m} s_i^-/x_{io} \tag{3.27}$$

$$\text{subject to} \quad \boldsymbol{x}_o = X\boldsymbol{\lambda} + \boldsymbol{s}^-$$

$$\boldsymbol{y}_o \leq Y\boldsymbol{\lambda}$$

$$\boldsymbol{\lambda} \geq \boldsymbol{0},\ \boldsymbol{s}^- \geq \boldsymbol{0}.$$

We denote the ρ_I under the optimal situation by $\rho_I{}^*$. When $\boldsymbol{s}^{-*} = \boldsymbol{0}$ and $\boldsymbol{s}^{+*} = \boldsymbol{0}$ are satisfied simultaneously, that is no input excesses and out shortfalls, we can get the $\rho_I{}^*$ = 1. The definition of efficiency by SBM model can be expressed as: a DMU $(\boldsymbol{x}_o, \boldsymbol{y}_o)$ is SBM-efficient if and only if $\rho_I{}^*$ = 1.

3.3.2 The Improvement in Efficiency

For an SBM-inefficient DMU $(\boldsymbol{x}_o, \boldsymbol{y}_o)$, we have the expression:

$$\boldsymbol{x}_o = X\boldsymbol{\lambda}^* + \boldsymbol{s}^{-*},$$

$$\boldsymbol{y}_o = Y\boldsymbol{\lambda}^* - \boldsymbol{s}^{+*},$$

where $\boldsymbol{\lambda}^*$, $\boldsymbol{s}^{-*}$ and $\boldsymbol{s}^{+*}$ are variables in optimal solutions.

The SBM-inefficient DMU $(\boldsymbol{x}_o, \boldsymbol{y}_o)$ can be improved by augment outputs shortfalls and eliminate the input excesses consulting the reference. After the adjustment, $(\boldsymbol{x}_o, \boldsymbol{y}_o)$ shall be an improved full efficient combination $(\widehat{\boldsymbol{x}_o}, \widehat{\boldsymbol{y}_o})$, which is called the SBM projection. The set constituted by $(\widehat{\boldsymbol{x}_o}, \widehat{\boldsymbol{y}_o})$, or $(\boldsymbol{x}, \boldsymbol{y})$ based on $\boldsymbol{\lambda}^*$, is reference set.

$$\widehat{\boldsymbol{x}_o} \leftarrow \boldsymbol{x}_o - \boldsymbol{s}^{-*}; \tag{3.28}$$

$$\widehat{\boldsymbol{y}_o} \leftarrow \boldsymbol{y}_o + \boldsymbol{s}^{+*}. \tag{3.29}$$

We make α_{oi} express the input excess ratio of input i; β_{oj} expresses the output shortage ratio of output j, and the formulae are in following:

$$\alpha_{oi} = \frac{s_{oi}^-}{X_{oi}}; \quad (i = 1, 2, \ldots, m) \tag{3.30}$$

$$\beta_{oj} = \frac{s_{oj}^+}{Y_{oj}}. \quad (j = 1, 2, \ldots, s) \tag{3.31}$$

3.4 Summary

In this chapter, we introduce the general concept of DEA and two basic models, CCR model and SBM model.

DEA is a mathematic method set to study organizations' efficiency about converting inputs into outputs via the idea of linear algebra, which structure an efficient frontier to "envelop" all efficient and inefficient points.

CCR model is the most basic DEA model. It can simply reflect the knowledge of the later. What's more, it is the origin and base of other models. CCR model is the representation of radial measure with the assumption of constant returns-to-scale of activities. It measures the technical efficiency of a DMU by θ^* which do not take into account of input excesses and output shortfalls.

SBM is an improved measure based on CCR, which provides a scalar ranging from 0 to 1 that encompasses all of the inefficient factors that the model can identify. It represents non-radial models. Although it ignores the radical characteristics of inputs/outputs, the items of inputs and outputs of selected banks in our thesis have no proportional relationship. Besides, SBM model is variant returns-to-scale. In terms of our banks' scales, the property should be taken into account.

4. Application of DEA Models and Efficiency Evaluation

Application of DEA models is the core part of our thesis. In this chapter, we will apply the CCR model and SBM model into practice. Before that we will do the financial analysis of the selected 21 banks by the method we introduced in Chapter 2, hence we can get a glance of these banks' financial situation. Then, we will investigate the efficient situation of the selected banks by CCR model and SBM model. Thirdly, considering the different financial environment in the two countries, we will change some elements and constraints so that our investigation may be closer to the reality. It is an extended application of SBM model.

All interpretations of our results from the application are based on DMUs' slacks of input excesses and output shortfalls. Considered that, we will make advice for each bank to improve their efficiency. Finally, we will have a comparison and conclusion of these practices and their results.

4.1 Financial Analysis of Selected Banks

As the financial ratios we introduced in Section 2.2, we will judge the financial statement of the selected banks on their profitability, assets quality and efficiency ratios from 2009 to 2013. All the data come from the annual reports of each bank. We present them and the computational aspects of financial ratios in worksheet "Financial Ratios". For convenient to compare them, we use the weighted average value of results. The weights we set from the year 2009 to 2013 are 0.05, 0.075, 0.125, 0.25 and 0.5 respectively.

4.1.1 Profitability Ratios

In this part we calculate 4 profitability ratios. They are the Return on Equity (ROE), which measures the return earned by a bank on its equity; Return on Assets (ROA), which indicates how capable management has been in converting assets into net earnings; Net Interest Margin (NIM), measure how large a spread between interest incomes and interest costs management were achieved by total assets; and Net Profit Margin (NPM), which is the ratio of net profit to operating income.

We divide banks into two parts by their operating incomes. And the weighted average profitability ratios of banks where operating incomes are higher than 50,000 million dollars in China and U.S.A. are presented in Table 4.1.

Table 4.1 Profitability ratios of banks (unit of variance is 10^{-4})

	ROE	ROA	NIM	NPM		ROE	ROA	NIM	NPM
ICBC	21.56%	1.40%	2.33%	46.51%	**JPM**	9.24%	0.79%	1.94%	19.05%
CBC	20.10%	1.37%	2.49%	41.90%	**MS**	3.04%	0.33%	1.89%	7.99%
ABC	19.28%	1.08%	2.54%	34.28%	**COF**	12.03%	1.32%	3.02%	22.78%
BC	16.91%	1.14%	2.00%	39.83%	**USB**	5.55%	0.58%	2.53%	14.29%
$\bar{\mu}$	19.46%	1.25%	2.34%	40.63%	$\bar{\mu}$	7.47%	0.76%	2.35%	16.02%
σ^2	3.79	0.03	0.06	25.69	σ^2	15.74	0.18	0.29	40.79

In Table 4.1, the 4 banks in apricot on the left side are from China; the other side banks in blue are from U.S.A. We compute 4 basic profitability ratios of ROE, ROA, NIM and NPM of each bank from 2009 to 2013. The ratios here are all weighted average value. $\bar{\mu}$ and σ^2 are average values and variances of each column. The values of variance are all in 10^{-4}.

We can see both ROE and ROA in Chinese banks are higher than U.S. banks and the variances of Chinese banks are smaller. That means the profitability of Top 4 Chinese banks is stronger and more balanced than U.S. banks. We can explain the result from two reasons. Firstly, the net profits of U.S. banks are lower indeed. U.S. banking has been devoted to get rid of the effect of the financial crisis since it broke out, while the negative impacts can't be removed in a very short term. Once a mistake of expense management occurred, both the net operating revenue and net profit might be negative. For instance, the net operating revenues of BAC in 2009 and 2010 are -1,323 million and -230 million dollars. The second reason is the process of banks' deleveraging. The average equity multiplier of these 4 banks in China is 15.48, while that proportion of these 4 U.S. banks is 9.95. The higher proportion of equity, the lower proportion of liability will be. As we all know, a low leverage ratio and a high level of equity will increase the costs of financing, and then affect the profits of banks.

NIM indicates the profitability of the traditional business in a bank. As to WFC and CITI, although we classified them into universal banks, the traditional business is still a big part.

NPM is net profit to operating revenues. The differences between them are operating expenses and provision for credit losses. It measures the effectiveness of expense management. A higher ratio of NPM means more effective expense management. In Table 4.1, we can see the Chinese banks are higher than U.S. banks in terms of that ratio. Of U.S. banks, WFC performs well, while BAC is the worst.

The weighted average profitability ratios of selected banks where operating incomes are lower than 50,000 million dollars in China and U.S.A. are presented in Table 4.2.

Table 4.2 Profitability ratios of banks (2) (unit of variance is 10^{-4})

	ROE	ROA	NIM	NPM		ROE	ROA	NIM	NPM
BOCM	15.80%	1.06%	2.21%	38.33%	**GS**	10.14%	0.81%	0.43%	22.23%
CMBC	20.54%	1.26%	2.50%	38.50%	**MS**	4.51%	0.38%	0.06%	5.72%
CMSB	20.46%	1.22%	2.55%	35.43%	**COF**	9.42%	1.30%	5.85%	17.43%
CIB	20.82%	1.09%	2.24%	39.59%	**USB**	13.20%	1.47%	2.97%	26.86%
CITIC	16.61%	1.07%	2.38%	37.37%	**PNC**	9.18%	1.19%	3.05%	23.13%
SPD	19.31%	1.07%	2.28%	40.65%	**BNY**	6.20%	0.62%	0.88%	14.52%
CEB	18.23%	1.04%	2.12%	39.43%					
$\bar{\mu}$	18.82%	1.12%	2.33%	38.47%	$\bar{\mu}$	8.78%	0.96%	2.21%	18.32%
σ^2	4.04	0.01	0.02	2.90	σ^2	9.37	0.18	4.82	57.07

In Table 4.2, we can find the profitability ratios in Chinese banks are stable. The profitability ratios of MS are much lower than GS and BNY, where the latter are also investing banks. We compare their highlights of financial statement in the latest year of 2013 and weighted average values in 5 years as we defined before in Table 4.3. The numbers in blue are 5 years weighted average value.

Table 4.3 Compare of GS and MS. (in million dollars, except number of employees)

	5.GS		6.MS		10.BNY	
	2013		**2013**		**2013**	
Employees	32900	33015	55794	57571	51100	49723
Interest Income	10060	11141	5209	5854	3352	3437
Interest Expense	6668	7042	4431	5366	343	451
Net interest Income	3392	4098	778	488	3009	2986
Operating Revenues	34206	34441	32417	30280	14983	14395
Operating Expenses	22469	23511	27935	26622	11306	11115
Operating profit	11737	10930	4482	3659	3712	3300
Profit	8040	7740	3613	3064	2192	2187
Loans	88935	78062	57104	57355	51657	47653
Deposits	199419	194403	157125	104244	261129	237128
Cash and balance in financial institutions	61133	60633	59883	52752	146019	132840
Assets	991507	956592	832702	804479	374310	346566
Equity	78467	76297	69030	67176	35959	34873

The profitability ratios refer to net interest income, net profit, operating revenues, assets and equity. In Table 4.3, we can find MS and GS are similar to their

operating revenues and assets and equity, While MS have a low NPM, which reflect its effectiveness of expense management. The number of employees of MS is higher than GS, which becomes a huge pressure to operating expenses; meanwhile MS pays much attention to investing business and lacks of highly effective operating management ability, which results in the difference between MS and GS of profit results. On the other hand, BNY catches up with MS's operating profit and net profit for the same reason. On account of the smaller size of assets and equity, BNY presents higher ratios of ROE and ROA compared to MS.

NIM is calculated by net interest income to total assets. To investing banks, interest margin is not the main income, so NIMs of these 3 banks seem low.

4.1.2 Risk Ratios

As to risk ratios, we divide them to parts, which are liquidity ratio, credit ratios and capital adequacy ratio.

The weighted average risk ratios of selected banks where operating incomes are higher than 50,000 million dollars in China and U.S.A. are presented in Table 4.4.

Table 4.4 Risk ratios of banks (1) (unit of variance is 10^{-4})

	LR	ATTL	LTD	CCAR		LR	ATTL	LTD	CCAR
ICBC	20.91%	2.46%	65.51%	10.44%	**JPM**	1.88%	2.92%	61.02%	12.10%
CBC	20.29%	2.66%	67.52%	10.82%	**BAC**	6.54%	2.60%	84.73%	12.36%
ABC	22.80%	4.24%	59.66%	9.35%	**WFC**	1.43%	2.11%	80.10%	11.82%
BC	24.87%	2.22%	74.51%	9.96%	**CITI**	1.65%	3.80%	70.61%	13.63%
$\bar{\mu}$	22.22%	2.90%	66.80%	10.14%	$\bar{\mu}$	2.88%	2.86%	74.12%	12.48%
σ^2	4.27	0.84	37.54	0.40	σ^2	6.00	0.51	110.75	0.64

In Table 4.4, the LR ratios of Chinese banks are higher and close to each other's. The ratios of U.S. banks are lower, where the highest liquidity ratio is only 6.45. That is because of the extra items of the numerator of Chinese banks when calculating liquidity ratio. It is balances with central bank. In China, the central bank requires a high level of the reserve requirement, which is in form of deposits made with the central bank. The statutory deposit reserve ratio to ICBC, CBC, ABC and BC is 18.0%, although 20.0% is acquiescent by these banks. When calculating liquidity ratios of U.S. banks here, we use cash and due from banks, except BAC, which we can't distinguish due from banks from cash equivalent in its annual reports. The reserve requirement ratio required by Fed to the member banks, which is in form of

deposits with banks, even it included, the ratio is also much lower than Chinese central bank required. Hence, all the 4 banks, JPM, BAC, WFC and CITI, are with the lower level of liquidity ratios.

ALL reduces the book value of the institution's loans and leases to the amount that the institution reasonably expects to collect. The higher of the estimated risk of uncollectable assets in the portfolio, the larger the ALL reserve should be. In Table 4.4, Allowance for loan losses to total loan and leases of banks both in China and U.S.A. are similar. ABC and CITI with higher ratios reflect the problem with their loan structures or the conservative attitude to credit risk.

The ratio of total loan to total deposits (LTD) is another popular and long-standing credit risk measure. Only if bank's deposits transferred into loans, the bank could gain the interest margin. While as the other side of coins, loans are usually among the riskiest of all assets for depository institutions. In China, the ratio of LTD should be no more than 75%. In BAC and WFC, the weighted average ratios of LTD are higher than 80%. We can find the ratios of LTD of these two banks in Table 4.5.

Table 4.5 LTD ratios of BAC and WFC (in million dollars, percentages excepted)

		2009	2010	2011	2012	2013	WAV
	Weight	5.00%	7.50%	12.50%	25.00%	50.00%	
BAC	**Loans**	900128	940440	926200	907819	928233	922386
	Deposits	991611	1010430	1033041	1105261	1119271	1090444
	Ratio of LTD	90.77%	93.07%	89.66%	82.14%	82.93%	84.73%
WFC	**Loans**	782770	757267	769631	799574	825799	804930
	Deposits	824018	847942	920070	1002835	1079177	1010103
	Ratio of LTD	94.99%	89.31%	83.65%	79.73%	76.52%	80.10%

The 5 years weighted average ratios of LTD of BAC and WFC are higher than 80%, but when we compare them in horizon, we can find the decline trends of LTD ratios in both of the two banks.

Capital adequacy ratio (CAR) is an indicator for asset quality. Core capital, called Tier 1 capital as also, is a more precise tool that consists of actual contributed equity and retained earnings. From Table 4.4, we can find Chinese banks are all with low core capital ratios. The main reason is the structure of Chinese banking. Deposits are the main source of financing of Chinese banks. For transforming input into output and keeping the profitability, making loans are the fast and convenient channel for

banks. The result is risky assets increased. And then in the vicious circle, banks need take more deposits to meet the requirement of liquid assets. The proportion of equity, to which common stock and retained earnings belong, should narrow.

The 5 year weighted average risk ratios of selected banks where operating incomes are lower than 50,000 million dollars in China and U.S.A. are presented in Table 4.6.

Table 4.6 Risk ratios of banks (2) (unit of variance is 10^{-4})

	LR	ATTL	LTD	CCAR		LR	ATTL	LTD	CCAR
BOCM	24.42%	2.23%	78.52%	9.96%	**GS**	6.33%	-	40.04%	16.20%
CMBC	20.05%	2.19%	76.90%	8.68%	**MS**	2.00%	-	37.70%	16.22%
CMSB	21.92%	2.21%	73.30%	8.43%	**COF**	1.05%	2.67%	97.32%	12.20%
CIB	19.08%	2.19%	66.90%	8.74%	**USB**	2.72%	2.01%	91.19%	10.92%
CITIC	19.57%	2.02%	72.14%	9.04%	**PNC**	1.42%	2.21%	87.02%	12.15%
SPD	22.41%	2.28%	72.44%	8.55%	**BNY**	1.55%	0.63%	20.45%	15.34%
CEB	20.93%	2.31%	71.96%	8.49%					
$\bar{\mu}$	21.20%	2.20%	73.17%	8.84%	$\bar{\mu}$	2.51%	1.88%	62.29%	13.84%
σ^2	3.48	0.01	14.16	0.28	σ^2	3.83	0.77	1104.85	5.52

In Table 4.6, we can find the similar characters of liquidity ratios of Chinese banks and U.S. banks to Table 4.4. Differed from 4 big banks in China, Chinese Central Bank requires statutory deposit reserve ratio to BOCM of 17.5%, which is in form of deposits made with CB. The statutory ratio to CMBS and CMSB is 16.0%. Other listed banks are in 15.5%. For U.S. banks, COF, as the traditional commercial banks, prefers long-term investment rather than the petty cash with little return. GS as an investment bank, which holds more liquidity assets, are the common phenomenon. And we can't distinguish due from banks from cash equivalent in its annual reports. Hence, its liquidity ratio is higher than other U.S. banks.

BNY as an investing bank and a member of FED, which is expert to invest in short-term market, deposits in the Federal Reserve and other central banks of 40477 million dollars of 5 years weighted average value, which takes 37.00% of weighted average gross deposits and 25.32% of weighted average assets. In BNY's assets structure, interest-bearing deposits with the Federal Reserve and other central banks and securities available-for-sale are main sources of income. The item of loans is the third source; correspondently the allowance for loan losses is low. They can explain the low ratios of ATTL and LTD of BNY. As to GS and MS, their sizes of loans are

smaller than others. The item of receivables from customers and counterparties takes the place of the item of loans. Allowance for loan losses to total loans and leases can't be calculated here. Other U.S. banks, along with Chinese banks present nearly same level of ATTL.

The ratios of LTD of BOCM and CMBC are beyond the suggested ratio of 75%. It reflects the strategies and a competitive relationship of these two banks. COF, USB and PNC are traditional commercial banks, which main incomes are the margin of interest rates of loans and deposits; while their high level of LTD ratios shall go against banks' sustainable development. The targets of deleveraging and strengthening assets' quality from supervisory authorities also require banks reduce their LTD ratio. Especially COF, since with 2.67% allowance for loan losses, taking the LTD ratio of 97.32% is irrational.

Chinese banks are with lower core capital adequacy ratio than U.S. banks, which is the same conclusion to Table 4.4. Moreover, we can find the investing banks have much higher core capital adequacy ratio.

4.1.3 Efficient Ratios

Table 4.7 Efficient ratios of banks (unit of variance is 10^{-4})

Operating Incomes	China			U.S.A.		
		OER	EPR		OER	EPR
≥USD 50,000 million	ICBC	35.80%	0.20	JPM	68.31%	0.39
	CBC	36.93%	0.22	BAC	79.72%	0.35
	ABC	44.39%	0.15	WFC	58.62%	0.32
	BC	43.04%	0.21	CITI	64.94%	0.30
	$\bar{\mu}$	40.04%	0.19	$\bar{\mu}$	67.90%	0.34
	σ^2	18.53	9.00	σ^2	78.26	18.87
≤USD 50,000 million	BOCM	40.10%	0.25	GS	68.34%	1.04
	CMBC	42.18%	0.32	MS	88.49%	0.53
	CMSB	41.54%	0.34	COF	55.61%	0.54
	CIB	35.32%	0.34	USB	52.58%	0.29
	CITIC	38.99%	0.36	PNC	62.66%	0.29
	SPD	36.69%	0.39	BNY	78.35%	0.29
	CEB	40.11%	0.38			
	$\bar{\mu}$	39.28%	0.34	$\bar{\mu}$	67.67%	0.50
	σ^2	6.22	20.65	σ^2	189.20	860.19

As to efficient ratios, we present operating efficient ratios and employee productive ratios. Table 4.7 exhibits the weighted average efficient ratios of selected banks. OPRs are in unit of million dollars per employees.

Staff cost, as a main component of operating costs, should be coincident to the change of operating costs. As the increasing of number of employees, banks need pay more money to staff. And staff cost will be reflected in operating costs. Hence, we can say the higher of the OER, the lower of the EPR will be.

From Table 4.7, we can find the OER of Chinese banks are lower, while their OPR are lower than U.S. banks too. This result should be ascribed the cheaper labor force in China. Although most of these banks service for global customers, the market environment of their main land still plays an important role.

4.1.4 Summary

In this section, we analyzed the financial ratios of the Top 21 banks which are ranked by their operating incomes. By analyzing their profitability, risk ratios, assets quality and efficiency, we can find there are upper and lower lines to guide Chinese banks' operations, and then they perform well. U.S. banks are much different from banks in China. They are more diversified and competitive. Thus, they are more difficult to conclude in a word.

As to the topic of our thesis, efficiency analysis of these banks can be judged simply given the existing financial results. An efficient bank should be with the highest profitability, the lowest risk exposure and effective cost management. For instance, from the profitability analysis in Section 2.2.1 we can find ICBC have highest ratios of ROE, ROA and NPM, while the NIM is lower than CCB, ABC, CMBC and CMSB. And then in 2.2.2, its liquidity ratio is low. Allowance for loan loss is the 3rd highest. Tier 1 capital ratio of 10.44% is lower than CCB. OER is not the lowest while EPR is at a low level.

We can find the financial ratios measure different aspects of banks; moreover, some financial indicators are interactive and even present opposite results. It's hard to estimate if a bank is full efficient or not. In consideration of the deficiency, we will introduce Data envelopment analysis (DEA) and then analyze the efficiency of selected banks in succeeding sections. The interpretation and comparison of relevant results of selected banks we get from DEA models will be also presented.

4.2 The Application of DEA Models

In this section, we will investigate the comprehensive efficient situations of the selected banks by CCR model and SBM model. Then we will have an extension of SBM model to analyze banks' sensitivity to each input and output we selected.

4.2.1 Inputs and Outputs

As the essential element, the items of input and output we will use here have already been introduced in Section 2.1.3, which are number of employees, total assets and operating expenses as inputs; new deposits, new loans, operating profits and ROE as outputs. We exhibit the data of inputs and outputs of selected banks in Table 4.8.

Table 4.8 Inputs and outputs of banks (in million dollars, except number of stuffs and ratios)

	(I)Number of Staffs	(I)Operating Expenses	(I)Assets	(O)New Deposits	(O)New Loans	(O)Operating Profit	(O)ROE
ICBC	428189	31210	2896281	192375	179219	50454	21.56%
CBC	351237	28215	2333664	175787	168542	21622	20.10%
ABC	466081	30643	2211878	175085	130677	30416	19.28%
BC	297855	26373	2134682	139540	120712	31620	16.91%
BOCM	96156	9896	889506	73404	58647	12100	15.80%
CMBC	59791	8005	582197	46571	45494	9822	20.54%
CMSB	48616	6845	483806	41300	30409	8164	20.46%
CIB	41903	5120	526316	58819	27184	7567	20.82%
CITIC	42127	5861	525205	57432	40273	7498	16.61%
SPD	35538	4956	534595	47199	35828	7513	19.31%
CEB	25072	3814	360869	31183	22263	4988	18.23%
JPM	247845	66486	2341274	84067	7567	26198	9.24%
BAC	258650	72233	2138294	34729	5289	8944	3.04%
WFC	267240	49430	1440025	71803	16128	28714	12.03%
CITI	256250	48896	1876966	41399	9601	14144	5.55%
GS	33015	23511	956592	1945	10715	10930	10.14%
MS	57571	26621	804479	16707	4317	3659	4.51%
COF	37935	11376	275801	18675	16527	5432	9.42%
USB	65496	10108	350132	17144	11573	7074	13.20%
PNC	54373	9784	303640	10199	11223	4744	9.18%
BNY	49723	11115	346566	23027	3697	3300	6.20%

All data with the prefix (I) in above table are items of input (x); oppositely, data with the prefix (O) are items of output (y). Banks in the apricot of the former 11 are Chinese banks that are ranked by their operating incomes; while banks in blue are

in U.S.A., also, ranked by their operating incomes. The data in different countries have already been transformed into same units. The units of operating expenses, assets, new deposits and new loans and operating profit are U.S. dollar in million. It can be observed that former 4 banks in each country have a bigger scale.

We need note that all our data that will be use subsequently are weighted mean values in 5 years from 2009 to 2013 with the weights set as financial analysis, so that we can get a stable financial situation to investigate.

4.2.2 CCR Model

At first, we apply the CCR model. We deal with CCR model by software, DEA-Solver-Learning Version (*DEA-Solver-LV*), which is developed by Kaoru Tone; hence we can get the results directly. Then we explain the results and improve the inefficient banks' efficiency.

The Results of Bank's Efficiency by CCR Model

Inputting the data as Table 4.8 into *DEA-Solver-LV* and choosing the input-oriented CCR model, we can get the information about efficient scores, input excesses and output shortfalls, weights of each items and the reference set of inefficient banks of selected banks, which are in following tables.

Table 4.9 Efficiencies and input excesses of Chinese banks

DMU	Score θ^*	Excess (s^-)					
		number of Employees		Operating Expenses		Assets	
		Volume	Ratio	Volume	Ratio	Volume	Ratio
		person	*%*	*$ mil.*	*%*	*$ mil.*	*%*
ICBC	1.000	0	0.00	0	0.00	0	0.00
CBC	0.935	135810	45.12	0	6.45	0	6.45
ABC	0.856	219331	61.48	0	14.42	0	14.42
BC	0.866	29299	23.22	0	13.38	0	13.38
BOCM	0.901	8900	19.12	0	9.87	0	9.87
CMBC	1.000	0	0.00	0	0.00	0	0.00
CMSB	1.000	0	0.00	0	0.00	0	0.00
CIB	1.000	0	0.00	0	0.00	0	0.00
CITIC	1.000	0	0.00	0	0.00	0	0.00
SPD	1.000	0	0.00	0	0.00	0	0.00
CEB	1.000	0	0.00	0	0.00	0	0.00

Table 4.10 Efficiencies and input excesses of U.S. banks

DMU	Score	Excess					
		number of Employees		Operating Expenses		Assets	
		Volume	Ratio	Volume	Ratio	Volume	Ratio
		person	*%*	*$ mil.*	*%*	*$ mil.*	*%*
JPM	0.647	0	35.26	15644	58.79	0	35.26
BAC	0.227	0	77.31	2261	80.44	0	77.31
WFC	0.989	3378	2.38	6399	14.06	0	1.11
CITI	0.404	0	59.59	0	59.59	0	59.59
GS	1.000	0	0.00	0	0.00	0	0.00
MS	0.314	0	68.59	4607	85.90	0	68.59
COF	1.000	0	0.00	0	0.00	0	0.00
USB	1.000	0	0.00	0	0.00	0	0.00
PNC	0.804	5327	29.41	680	26.57	0	19.61
BNY	0.629	12151	61.49	3906	72.19	0	37.05

Table 4.11 Output shortfalls of selected 21 banks

DMU	Shortage (s^+)							
	New Deposits		New Loans		Operating Profit		ROE	
	Volume	β_{1n}	Volume	β_{2n}	Volume	β_{3n}	Volume	β_{4n}
	$ mil.	*%*	*$ mil.*	*%*	*$ mil.*	*%*	*%*	*Mul.*
ICBC	0	0.00	0	0.00	0	0.00	0.00	0
CBC	39884	22.69	0	0.00	11581	53.56	51.81	2.57
ABC	0	0.00	0	0.00	0	0.00	52.11	2.70
BC	0	0.00	0	0.00	0	0.00	27.19	1.61
BOCM	5447	7.42	0	0.00	0	0.00	4.96	0.31
CMBC	0	0.00	0	0.00	0	0.00	0.00	0
CMSB	0	0.00	0	0.00	0	0.00	0.00	0
CIB	0	0.00	0	0.00	0	0.00	0.00	0
CITIC	0	0.00	0	0.00	0	0.00	0.00	0
SPD	0	0.00	0	0.00	0	0.00	0.00	0
CEB	0	0.00	0	0.00	0	0.00	0.00	0
JPM	41452	49.31	87065	1150.59	0	0.00	53.08	5.74
BAC	1960	5.64	24424	461.78	0	0.00	15.30	5.03
WFC	0	0.00	33918	210.30	0	0.00	41.26	3.43
CITI	11420	27.59	30734	320.11	0	0.00	23.78	4.28
GS	0	0.00	0	0.00	0	0.00	0.00	0
MS	0	0.00	8775	203.26	0	0.00	3.63	0.80
COF	0	0.00	0	0.00	0	0.00	0.00	0
USB	0	0.00	0	0.00	0	0.00	0.00	0
PNC	4676	45.84	0	0.00	0	0.00	0.00	0
BNY	0	0.00	7825	211.67	0	0.00	2.26	0.36

Table 4.12 Weights of inputs and outputs

DMU	v_1 (%) Number of Employees	v_2 (%) Operating Expenses	v_3 (%) Assets	u_1 (%) New Deposits	u_2 (%) New Loans	u_3 (%) Operating Profit	u_4 (%) ROE
ICBC	1.28	97.32	1.39	1.39	0	102.09	1.39
CBC	0	8.83	91.17	0	93.55	0	0
ABC	0	2.40	97.60	26.11	6.62	52.85	0
BC	0	11.41	88.59	18.60	4.34	63.69	0
BOCM	0	38.61	61.39	0	48.63	41.50	0
CMBC	7.69	2.88	89.42	6.29	63.87	5.06	24.77
CMSB	15.16	32.31	52.53	0.93	0.74	94.22	4.11
CIB	95.35	1.30	3.34	76.68	2.79	2.76	17.77
CITIC	2.81	2.52	94.67	48.62	22.82	4.62	23.94
SPD	39.70	0	61.58	0.78	0.64	95.73	2.85
CEB	1.09	1.07	97.85	3.28	2.51	42.17	52.04
JPM	46.63	0	53.37	0	0	64.74	0
BAC	49.96	0	50.04	0	0	22.69	0
WFC	0	0	100	6.28	0	92.61	0
CITI	19.80	9.38	70.82	0	0	40.41	0
GS	87.27	6.32	6.41	0.20	5.412074	85.26	9.13
MS	40.93	0	59.07	0.04	0	31.37	0
COF	6.35	12.29	81.35	7.58	3.88	86.63	1.91
USB	5.56	2.03	92.41	3.53	2.56	69.68	24.24
PNC	0	0	100	0	6.62	45.31	28.46
BNY	0	0	100	28.79	0	34.16	0

Table 4.13 Reference set of inefficient banks

Inefficient banks	Scores	Reference Set (λ^*)							
CBC	0.935	CMBC	1.35	CITIC	2.66				
ABC	0.856	CMBC	0.33	CMSB	2.07	CITIC	1.23	COF	0.19
BC	0.866	ICBC	0.31	CMBC	0.64	CMSB	1.13	CIB	0.06
BOCM	0.901	ICBC	0.07	CMBC	0.03	CITIC	1.12		
JPM	0.647	CMSB	2.68	COF	0.80				
BAC	0.227	CMSB	0.45	COF	0.97				
WFC	0.989	COF	0.40	USB	3.75				
CITI	0.404	CMSB	0.67	COF	0.76	USB	0.64		
MS	0.314	CMSB	0.20	SPD	0.18	GS	0.06		
PNC	0.804	CMSB	0.10	COF	0.24	USB	0.38		
BNY	0.629	CIB	0.36	COF	0.11				

In above tables, the item of *Score* means efficient ratio of each bank; *Volume* means absolute value of each slacks; α_{mn} and β_{sn} mean percentage change of each

input or output if banks want achieve the efficient situation, which calculated by formulae (3.21) and (3.22); *$ mil* is unit of million dollars; *ROE* is a ratio of net profit to total equity, which is expressed by percentage. If the shortage of ROE existed, the relative shortage ratios of ROE might be often higher than themselves, thus we use multiple instead of percentage here.

From table 4.9, 4.10 and 4.11, we can observed that all banks with $\theta^* = 1$ have neither input excesses nor output shortfalls. That means all efficient banks are in full efficiency. In Table 4.12, v_i and u_m mean the weights of each input and output. They show the significance of each item to the DMU's efficient score. Because smaller input amounts are preferable and large output amounts are preferable, it is easily verified that the items with high weights in a DMU means efficient management of that kind resource. In the similar way, the items with low weights or no weights in a DMU means inefficient management or wasting resource. In Table 4.13, $\boldsymbol{\lambda}^* = (\lambda_1^*, \lambda_1^*, \dots, \lambda_{21}^*)^T$. We haven't exhibited the zero value of $\boldsymbol{\lambda}^*$ in that table.

Interpretation and Improvement

Banks in China

From tables above, we can find both in China and U.S.A., the efficient situation of smaller banks is better than bigger banks'. In Table 4.9, among the selected banks in China, all smaller banks are efficient, except BOCM, even as whom, the efficient score is 0.901. The mean of efficient scores of Chinese banks are 0.960. About the inefficient Chinese banks, managing the number of employees seemed a big problem. Especially in CBC and ABC, whose efficient scores are lowest compared other Chinese banks here, the input excess ratios of number of employees are high to 45.12% and 61.48% respectively. It means CBC and ABC should fire about half stuff.

From Table 4.11, the shortage of ROE, or the shortage of profit from banks' equity, also has a strong impact on inefficient Chinese bank's efficiency scores. CBC and ABC are under the worst situation. CBC should adjust almost all items to adapt the efficient conditions; while the inefficient situation of ABC is heaviest.

Table 4.12 exhibits under the optimal situation the weights of each input and output in order. We can find CIB is the best bank in terms of managing number of

employees. The operating expenses and operating profit of ICBC, assets and ROE of CEB, new deposits of CIB, new loans of CMBC are perfect on their management.

Among selected Chinese banks, only 4 banks are inefficient. In Table 4.13, we present the inefficient banks' reference set and λ^*, where $\lambda^* = 0$ haven't shown in table. As to efficient banks, reference banks are themselves and $\lambda^* = 1$. It is can be observed that $\sum \lambda^* > 1$ is satisfied to all selected Chinese inefficient banks. That means those banks, CBC, ABC, BC and BOCM, are decreasing return to scale, although as we acquiesce CCR model follows the constant return to scale. All efficient banks here are regarded as constant return to scales. We need note that, although the sum of λ^* can present banks' variable situation of return to scale, the factor hasn't been taken into account of the CCR-efficient score θ^*.

We improve the inefficient banks' efficiencies by using slacks presented in Table 4.9 and 4.11 and the vector $\boldsymbol{\lambda}^*$.

As we known:

$\theta^* = 0.935$;

$\lambda_6^* = 1.35$; $\lambda_9^* = 2.66$; other $\lambda_j^* = 0$

$s_1^{-*} = 135810$; $s_1^{+*} = 39884$; $s_3^{+*} = 11581$; $s_4^{+*} = 51.81\%$; other slacks are 0.

The reference set for CBC is: $E_2 = \{\text{CMBC}_6, \text{CITIC}_9\}$.

The subscript numbers means the order of banks, where likes the Table 4.9 to 4.12, ICBC is the first one, where we can sign it by 1; BNY is the last one, or the 21st, we can sign it as 21. We can get the CBC's projection $(\widehat{\boldsymbol{x}_o}, \widehat{\boldsymbol{y}_o})$ by formulae (3.19) and (3.20).

$$\widehat{\boldsymbol{x}_1} \leftarrow \theta^* x_1 - s_1^{-*} = 0.935 \times 351237 - 135810 = 192755$$

$$\widehat{\boldsymbol{x}_2} \leftarrow \theta^* x_2 - s_2^{-*} = 0.935 * 28215 - 0 = 26394$$

$$\widehat{\boldsymbol{x}_3} \leftarrow \theta^* x_3 - s_3^{-*} = 0.935 * 2333664 - 0 = 2183028$$

$$\widehat{\boldsymbol{y}_1} \leftarrow y_1 + s_1^{+*} = 175787 + 39884 = 215671$$

$$\widehat{\boldsymbol{y}_2} \leftarrow y_2 + s_2^{+*} = 168542 + 0 = 168542$$

$$\widehat{\boldsymbol{y}_3} \leftarrow y_3 + s_3^{+*} = 21622 + 11581 = 33203$$

$$\widehat{\boldsymbol{y}_4} \leftarrow y_4 + s_4^{+*} = 0.20 + 0.52 = 0.72$$

By the same way, we get the projection for every inefficient bank and the results can be found in Worksheet "Efficiency Analysis-CCR-I. Projection".

Table 4.14 Projection for inefficient Chinese banks

		Number of Employees	Operating Expenses	Assets	New Deposits	New Loans	Operating Profit	ROE
CBC 0.935	Original data	351237	28215	2333664	175787	168542	21622	0.20
	Projection	192755	26394	2183028	215671	168542	33203	0.72
	Diff.	-158482	-1821	-150636	39884	0	11581	0.52
	%	-45.12	-6.45	-6.45	22.69	0	53.56	257.75
ABC 0.856	Original data	466081	30643	2211878	175085	130677	30416	0.19
	Projection	179536	26224	1892903	175085	130677	30416	0.71
	Diff.	-286545	-4419	-318975	0	0	0	0.52
	%	-61.48	-14.42	-14.42	0	0	0	270
BC 0.866	Original data	297855	26373	2134682	139540	120712	31620	0.17
	Projection	228708	22845	1849097	139540	120712	31620	0.44
	Diff.	-69147	-3528	-285585	0	0	0	0.27
	%	-23.22	-13.38	-13.38	0	0	0	161
BOCM 0.901	Original data	96156	9896	889506	73404	58647	12100	0.16
	Projection	77767	8920	801727	78852	58647	12100	0.21
	Diff.	-18389	-977	-87780	5447	0	0	0.05
	%	-19.12	-9.87	-9.87	7.42	0	0	31

Original data means the weighted mean value of each item from 2009 to 2013. *Projection* is the developed numbers of items in CCR-efficient. *Diff.* means differences between original data and projection. It is elimination of inputs and adjunction of outputs of inefficient banks. *%* means elimination and adjunction to the bank's original inputs and outputs.

Banks in U.S.A

As to U.S. banks, the efficient situation is worse than banks in China. The average value of them is only 0.701, and the standard deviation is 0.288, while Chinese banks' average efficient score is 0.960 with the standard deviation of 0.056. There are only 3 efficient banks in selected Top 10 U.S. banks. All of them are smaller banks, although the efficient score of WFC is 0.989, which is nearby 1. The shortfalls of newly added loans are main problem to inefficient banks. Especially to

JPM, the shortage ratio is high to 1150.59%. In *DEA-Solver-LV* the shortage ratio should be no more than 999.90%, so the true value doesn't present in *Solver*.

BAC and MS are two banks of the worst efficient conditions. Their efficient scores are so low that even the slacks were small, excess ratios and shortfall ratios would be high. The input excesses of BAC, for instance, are (0, 2261, 0), while the mean excess ratio is high to 78.35%. Noting that, raw data of operating expenses of BAC is 72,233 million dollars. The technical inefficiency refers to the scales of inputs and outputs instead of structure problem. And From Table 4.13, we can find in U.S. inefficient banks, JPM, BAC, WFC and CITI are decreasing return to scale; while MS, PNC and BNY are increasing return to scale. It means the improved MS, PNC and BNY can earn adjunction with its increase of inputs and scale.

To improve the inefficient banks, we get the projection for them via the method mentioned above and results can be also found in Worksheet "Efficiency Analysis-CCR-I. Projection". We attach the table to *Appendix* as *Annex 1*.

4.2.3 SBM Model

SBM is an improved measure based on CCR, which provides a scalar measure ranging from 0 to 1 that encompasses all of the inefficiencies that the model can identify. It represents non-radial models. Although it ignores the radical characteristics of inputs/outputs, the items of inputs and outputs of selected banks in our thesis have no proportional relationship. Besides, SBM model is variant return to scale. In terms of our banks' scales, it should be taken into account.

In this section, we apply the SBM model into practice. Also, we deal with it by software, *DEA-Solver-LV*. Then we explain the results and improve the inefficient banks' efficiency. After that, we will do the expansive analysis by SBM in proceed sector.

The Results of Bank's Efficiency by SBM Model

Inputting same data as CCR model into *DEA-Solver-LV* and choosing the SBM-I-V, which means input oriented SBM with variable return to scale, we can get the information about efficient scores, input excesses and output shortfalls, weights of each items and the reference set of inefficient banks of selected banks, which are in following tables.

Table 4.15 Efficiencies and input excesses of each bank

DMU	Score ρ^*	Excess (s^-)					
		Number of Employees		Operating Expenses		Assets	
		Volume	α_{1n}	Volume	α_{2n}	Volume	α_{3n}
		person	*%*	*$ mil.*	*%*	*$ mil.*	*%*
ICBC	1.000	0	0.00	0	0.00	0	0.00
CBC	1.000	0	0.00	0	0.00	0	0.00
ABC	1.000	0	0.00	0	0.00	0	0.00
BC	0.874	24532	8.24	5397	20.46	195995	9.18
BOCM	0.933	4974	5.17	728	7.35	66825	7.51
CMBC	1.000	0	0.00	0	0.00	0	0.00
CMSB	1.000	0	0.00	0	0.00	0	0.00
CIB	1.000	0	0.00	0	0.00	0	0.00
CITIC	1.000	0	0.00	0	0.00	0	0.00
SPD	1.000	0	0.00	0	0.00	0	0.00
CEB	1.000	0	0.00	0	0.00	0	0.00
JPM	0.582	41449	16.72	50106	75.36	779019	33.27
BAC	0.185	208081	80.45	65388	90.52	1574198	73.62
WFC	1.000	0	0.00	0	0.00	0	0.00
CITI	0.346	160075	62.47	39886	81.57	977654	52.09
GS	1.000	0	0.00	0	0.00	0	0.00
MS	0.342	32499	56.45	22807	85.67	443613	55.14
COF	1.000	0	0.00	0	0.00	0	0.00
USB	1.000	0	0.00	0	0.00	0	0.00
PNC	0.843	20648	37.98	883	9.03	0	0.00
BNY	0.668	22489	45.23	6030	54.25	0	0.00

Table 4.16 Output shortfalls of Chinese banks

DMU	Shortage (s^+)							
	New Deposits		New Loans		Operating Profit		ROE	
	Volume	Ratio	Volume	Ratio	Volume	Ratio	Volume	Ratio
	$ mil.	*%*	*$ mil.*	*%*	*$ mil.*	*%*	*%*	*Mul.*
ICBC	0	0.00	0	0.00	0	0.00	0.00	0
CBC	0	0.00	0	0.00	0	0.00	0.00	0
ABC	0	0.00	0	0.00	0	0.00	0.00	0
BC	0	0.00	0	0.00	0	0.00	3.97	0.23
BOCM	1610	2.19	0	0.00	0	0.00	1.42	0.09
CMBC	0	0.00	0	0.00	0	0.00	0.00	0
CMSB	0	0.00	0	0.00	0	0.00	0.00	0
CIB	0	0.00	0	0.00	0	0.00	0.00	0
CITIC	0	0.00	0	0.00	0	0.00	0.00	0
SPD	0	0.00	0	0.00	0	0.00	0.00	0
CEB	0	0.00	0	0.00	0	0.00	0.00	0

Table 4.17 Output shortfalls of U.S. banks

DMU	Shortage (s^+)							
	New Deposits		New Loans		Operating Profit		ROE	
	Volume	Ratio	Volume	Ratio	Volume	Ratio	Volume	Ratio
	$ mil.	*%*	*$ mil.*	*%*	*$ mil.*	*%*	*%*	*Mul.*
JPM	26304	31.29	90656	1198.04	0	0.00	11.05	1.20
BAC	12081	34.79	36529	690.66	0	0.00	17.03	5.60
WFC	0	0.00	0	0.00	0	0.00	0.00	0
CITI	28220	68.16	48371	503.81	0	0.00	14.11	2.54
GS	0	0.00	0	0.00	0	0.00	0.00	0
MS	14476	86.64	17946	415.70	1329	36.31	13.72	3.04
COF	0	0.00	0	0.00	0	0.00	0.00	0
USB	0	0.00	0	0.00	0	0.00	0.00	0
PNC	12569	123.24	7181	63.99	543	11.44	3.12	0.34
BNY	6053	26.29	17602	476.10	1762	53.40	10.55	1.70

Table 4.18 Reference set of inefficient banks

Inefficient banks	Scores	Reference Set (λ^*)							
BC	0.874	ICBC	0.53	CBC	0.08	CIB	0.32	CITIC	0.07
BOCM	0.933	ICBC	0.09	CBC	0.04	CITIC	0.86		
JPM	0.582	ICBC	0.44	SPD	0.57				
BAC	0.185	CMBC	0.62	SPD	0.38				
CITI	0.346	ICBC	0.15	SPD	0.84				
MS	0.342	CEB	1.00						
PNC	0.843	CEB	0.33	COF	0.67				
BNY	0.668	CEB	0.83	COF	0.17				

Interpretation and Improvement

From tables above, we can find the efficient condition achieved by SBM model is better than it by CCR model. Especially in China, only 2 banks, BC and BOCM, are inefficient. However, their efficient scores are higher than what calculated by CCR model. As we introduced in Chapter 3, the efficient ratio θ^* in CCR model hasn't taken slacks into account; while SBM model measures technical efficiency and slacks in a single scalar (ρ^*). It is verified that $\rho^* \leq \theta^*$. The efficient situation of banks presented in above tables contraries to it. At the beginning of applying SBM model, we chose SBM-I-V, that is, we took the factor of banks' scale into account. And that is the reason of $\rho^* \geq \theta^*$ in our application. Furthermore, if there were economies of scale, or said the increasing of scale, the requirement of banks' efficient

condition should be higher, and the virtual ρ^*_{IRS} should be lower. In Worksheet "Efficiency Analysis-SBM-I-V.RTS", It presents No. of decreasing RTS = 5, which is CBC, ABC, BC, BOCM and WFC. The former 4 banks are Chinese banks, where CBC and ABC are efficient banks with SBM-efficient scores of 1.

Banks in China

In Table 4.15 and 4.16, the only 2 inefficient banks in China, BC and BOCM, both have input excess problems. Since we needn't consider the effect of θ^* to real input elimination, the excess ratios totally come from the spare part of inputs. We can find the condition of BC is worse than BOCM.

As to improving the two banks' efficiencies, we calculate the projection for them via Formulae (3.28) and (3.29). The results can be found in Worksheet "Efficiency Analysis-SBM-I-V. Projection". We attach the table to *Appendix* as *Annex 3*.

Banks in U.S.A.

As to U.S. banks, they seem to follow the economies of scale more. We can find, except WFC, the efficient condition of bigger banks become worse; while smaller banks become better. In Worksheet "Efficiency Analysis-SBM-I-V.RTS", No. of increasing RTS = 2, which is PNC and BNY. Except of them and WFC, which is SBM-efficient bank with decreasing return to scale, the other banks are constant return to scale, where JPM, BAC, CITI and MS are inefficient banks. There are 4 efficient banks, which are one more than those in CCR models. Even so, the situation of U.S. inefficient banks is complex.

In Table 4.15, compared with the Chinese banks, whose mean value of SBM-efficient score is 0.982, with standard deviation of 0.039, the mean value of U.S. banks is 0.697, with standard deviation of 0.302. About the U.S. inefficient banks, it can be observed that almost all inputs have huge excesses. And the excess ratios are very high. Especially to BAC, it is a terrible assessment. Meanwhile, the reference banks of U.S. efficient banks, which can be found in Table 4.18, are almost Chinese banks. As we introduced in Chapter 2, the market environment of bank sectors in these two countries are different. Hence in succeeding sector, we will change some elements and constraints used in models, and then we will analyze Chinese and U.S.

banks' efficiency separately. Meanwhile, considering that SBM is an improved and stricter model of CCR, we will analyze banks' efficiency using SBM model only.

The projection for every U.S. inefficient bank here calculated by the Formulae (3.28) and (3.29) also can be found in Worksheet "Efficiency Analysis-SBM-I-V. Projection". We attach it to *Appendix* as *Annex 3*.

4.2.4 Extension of SBM Model

In this part we will analyze banks' efficiency separately in China and U.S.A. by SBM model. Because the number of banks after division should be less than before, we relax the constraints of DMUs' number. It may be over estimate banks' efficient situation. However, considering that the efficiency of a bank calculated by DEA models are relative to its comparative banks, reducing the number of MDUs won't alter our final results. And we will process the sensitivity analysis of different items of inputs and outputs to banks' efficiency.

Turning to items of inputs and outputs, we combine new deposits with new loans, and regard them as a new output item. Meanwhile, to investigate the influence to each DMU by items, we make up 6 series of items of inputs and outputs, which are exhibited in follow. Items here in grey are inputs; outputs are in brown.

Table 4.19 Inputs and outputs

Series 1	Number of Employees	New Deposits and New Loans	Operating Profit	ROE
Series 2	Operating Expenses	New Deposits and New Loans	Operating Profit	ROE
Series 3	Assets	New Deposits and New Loans	Operating Profit	ROE
Series 4	Number of Employees	Operating Expenses	Assets	New Deposits and New Loans
Series 5	Number of Employees	Operating Expenses	Assets	Operating Profit
Series 6	Number of Employees	Operating Expenses	Assets	ROE

Efficiency of Chinese Banks

Inputting the data of Chinese banks as the arrangement in Table 4.19 into *DEA-Solver-LV* and choosing the SBM-I-V respectively, we can get 6 spreadsheet files. For the different series of inputs and outputs, we can get different assessment results of banks. Gathering the information of each bank, we can get Table 4.20,

which exhibits the variance of return to scale of banks in each case. Table 4.21 is efficient situation of the selected Chinese banks. The efficient scores, their mean value and standard deviation of different DMUs are exhibited. From this table, we illustrate the radar plot of the efficient scores in these 6 series in Figure 4.1.

Table 4.20 Return to Scale of Projected DMUs

No.	DMU	RTS of Projected DMU					
		Series 1	Series 2	Series 3	Series 4	Series 5	Series 6
1	ICBC	D	C	C	D	C	D
2	CBC	D	D	D	D	C	D
3	ABC	D	D	D	D	C	D
4	BC	D	D	D	D	C	C
5	BOCM	D	D	D	D	C	C
6	CMBC	D	D	C	C	C	D
7	CMSB	D	D	C	C	C	D
8	CIB	D	C	D	D	I	D
9	CITIC	D	D	C	C	I	C
10	SPD	C	C	D	D	C	D
11	CEB	C	C	C	C	I	C

Here in the table *D* indicates decreasing return to scale; *C* indicates constant return to scale; *I* means increasing return to scale.

Table 4.21 Efficient scores of Chinese banks

No.	DMU	Efficiency Score						$\bar{\mu}$	σ	CV
		Series 1	Series 2	Series 3	Series 4	Series 5	Series 6			
1	ICBC	1	1	1	1	1	1.000	1.000	0.000	0.01%
2	CBC	1	1	1	1	0.504	0.160	0.777	0.330	42.48%
3	ABC	0.687	0.814	0.993	0.795	0.652	0.135	0.679	0.267	39.31%
4	BC	0.903	0.792	0.897	0.804	0.826	0.133	0.726	0.269	37.02%
5	BOCM	0.929	0.912	0.913	0.889	0.825	0.351	0.803	0.205	25.54%
6	CMBC	1	0.808	1	0.7446	1	0.722	0.879	0.124	14.07%
7	CMSB	0.936	0.796	1	0.742	1	1.000	0.912	0.105	11.49%
8	CIB	1	1	1	1	0.985	1	0.998	0.005	0.55%
9	CITIC	1	1	1	1	0.911	0.644	0.926	0.130	14.05%
10	SPD	1	1	0.939	1	1	0.862	0.967	0.052	5.36%
11	CEB	1	1	1	1	1	1	1	0	0%
$\bar{\mu}$		0.950	0.920	0.977	0.907	0.882	0.637	0.879		
σ		0.090	0.093	0.038	0.108	0.161	0.357			
CV		9.49%	10.06%	3.90%	11.94%	18.20%	56.04%			

In this table, 1.000 means the efficient score is a little less than 1. Although it very close to 1, the DMU is still inefficient. If a bank was efficient, we should use integer 1 to describe its efficient score. 0.000 means a small positive value. *CV* (Coefficient of Variation) represents the value calculated by standard deviation dividing average value. A bank with a smaller *CV* reflects its relative higher value of efficient scores and relatively lower value of standard deviation.

Figure 4.1 Efficient scores of Chinese banks

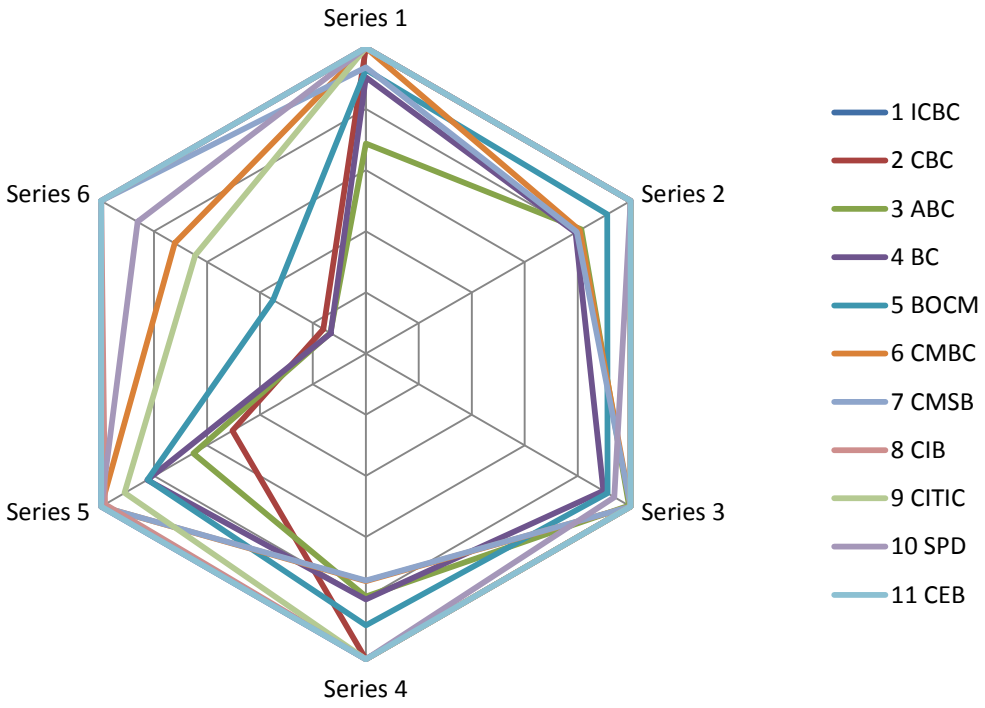


Figure 4.1 shows the situation of banks efficiency in 6 series we set. Each radial from the center to edge means the efficient score from 0 to 1 in terms of the series of inputs and outputs. We present banks by line segments in different colors. The area of hexagon circled by a line segment in one color means the comprehensive efficient situation of the bank.

From Table 4.20, we can find the types of returns-to-scale will change by changing banks' items of input and output. However, the increasing returns-to-scale always occurs in smaller banks. It has no causality with efficient scores directly.

We can find increasing returns-to-scale occurs in CIB, CITIC and CEB in Series 5 only. And Series 5 focus on the only output of net operating profit. That means the improved CIB, CITIC and CEB can improve their net operating profit by

increasing inputs such as number of employees, operating expenses and total assets. And the new added output will be higher than new added inputs. Decreasing returns-to-scale here means that the increasing inputs of projected banks can't get the same increase of outputs. Scale control is more effective.

As to the most important table, Table 4.21, we can find CEB performs best. ICBC follows by it. Other big banks are of the worst performance. CIB and SPD are in the third batch. Turing to comparison in column, we can divide series into sensitive analysis of items of input and sensitive analysis of items of output.

Among banks in former 3 series, that is, sensitive analysis of items of input, the third series has the lowest *CV* with the highest mean efficient scores and the lowest standard deviation. On the contrary, the second series has the highest *CV* value with the lowest mean efficient scores and the highest standard deviation. The results of Series 1 are very close to Series 2.

The first series investigates the influence of number of employees as input factor to banks' efficiency. Series 2 investigates banks' sensitive to operating expenses. Series 3 investigates banks' sensitive to total assets. The lowest *CV* with the highest mean efficient scores and the lowest standard deviation means Chinese banks take full advantage to input item as assets. Vice versa, management of operating expenses and number of employees is a big problem to them.

Among banks in latter 3 series, that is, sensitive analysis of items of output, Series 4 has the lowest *CV* with the highest mean efficient scores and the lowest standard deviation. Series 6 has the highest *CV* with the lowest mean efficient scores and the highest standard deviation.

Series 4 investigates the influence of new added deposits and new added loans as output factor to banks' efficiency. Series 5 investigates banks' sensitive to net operating profit. Series 6 investigates banks' sensitive to ROE. The lowest *CV* with the highest mean efficient scores and the lowest standard deviation of Series 4 means Chinese banks pay attention to new added deposits and new added loans. And the value of them is satisfied banks' requirement more than other output factors. ROE is a short slab of Chinese banks. With the relative higher leverage effect, the low value of ROE should be pinned on their profitability. The situation is portrayed in Figure 4.1 directly.

Efficiency of U.S. Banks

Inputting the data of U.S. banks as the arrangement in Table 4.19 into *DEA-Solver-LV* and choosing the SBM-I-V respectively, we can also get 6 spreadsheet files about information of efficient situation of selected banks, which are similar to last section. Table 4.22 shows the variance of return to scale of U.S. banks in each case. Table 4.23 exhibits the selected banks' efficient scores, their mean value and standard deviation. Figure 4.2 portrays the variance of efficiency in different series of items. In case of the coincident of points, we present 2-dimensional and 3-dimensional coordinate system respectively.

Table 4.22 Return to Scale of Projected DMUs

No.	DMU	RTS of Projected DMU					
		Series 1	Series 2	Series 3	Series 4	Series 5	Series 6
1	JPM	D	D	D	D	D	C
2	BAC	D	D	D	D	D	C
3	WFC	D	D	D	D	D	C
4	CITI	D	D	D	D	D	C
5	GS	C	D	D	I	C	C
6	MS	C	I	C	C	C	C
7	COF	C	C	C	C	C	C
8	USB	D	C	C	I	C	C
9	PNC	C	I	C	I	I	I
10	BNY	C	I	C	I	I	I

Table 4.23 Efficient scores of U.S. banks

No.	DMU	Efficiency Score						$\bar{\mu}$	σ	CV
		Series 1	Series 2	Series 3	Series 4	Series 5	Series 6			
1	JPM	1	1.000	1.000	1	0.740	0.147	0.814	0.313	0.384
2	BAC	0.254	0.220	0.210	0.204	0.239	0.144	0.212	0.035	0.164
3	WFC	1	1	1	1	1	0.218	0.870	0.292	0.335
4	CITI	0.442	0.493	0.377	0.405	0.453	0.176	0.391	0.103	0.263
5	GS	1	0.728	0.569	1	1	1	0.883	0.172	0.195
6	MS	0.605	0.368	0.343	0.476	0.476	0.476	0.457	0.086	0.188
7	COF	1	1	1	1	1	1	1	0	0
8	USB	1	1	1	1	1	1	1	0	0
9	PNC	0.642	1	0.908	1	1	1	0.925	0.131	0.141
10	BNY	0.726	0.901	0.796	0.875	0.875	0.875	0.842	0.061	0.073
$\bar{\mu}$		0.767	0.771	0.720	0.796	0.778	0.604	0.739		
σ		0.261	0.287	0.300	0.294	0.273	0.383			
CV		0.341	0.373	0.416	0.369	0.351	0.635			

Figure 4.2 Efficient scores of U.S. banks in each series (1)

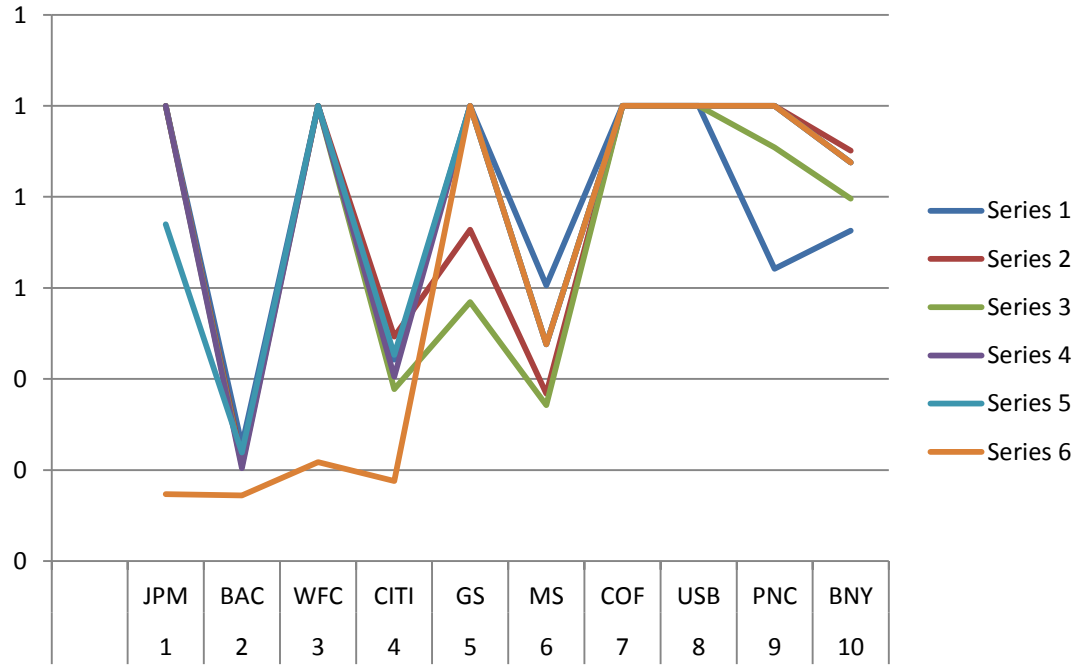
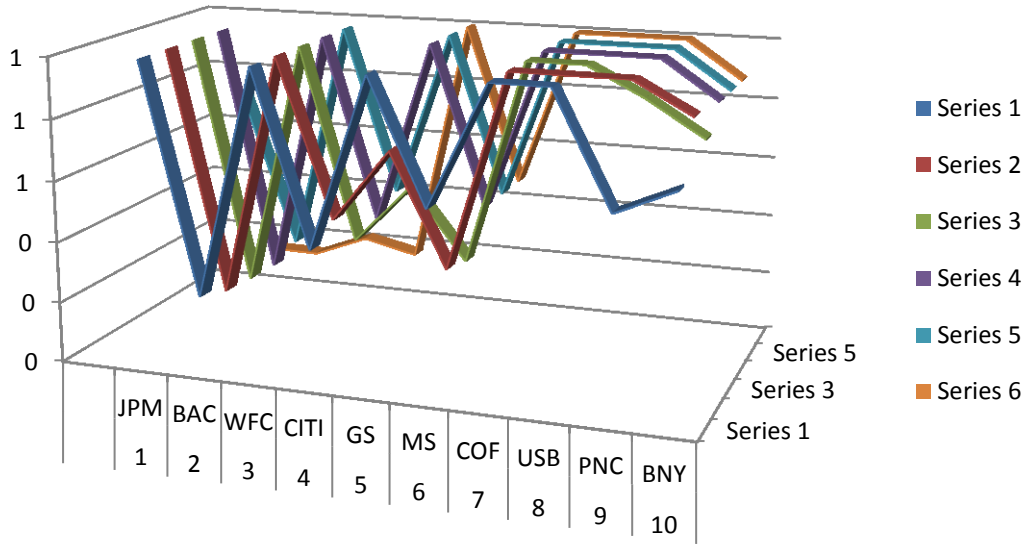


Figure 4.3 Efficient scores of U.S. banks in each series (2)



From Table 4.22, we can find the decreasing returns-to-scale always occurs in bigger banks, and the increasing returns-to-scale always occurs in smaller banks. It has no causality with efficient scores directly. Projected PNC and BNY are increase returns-to-scale in 4 series.

Figure 4.2 and 4.3 show the trends of banks' efficient scores in different case. We can find the trends of each banks are similar, except of Series 6. In series 6, both JPM and WFC, which perform well in other series, are with low level of efficiency. It exposes the deficiency of ROE in these two banks.

Turning to Table 4.23, we can find COF and USB performs best. BAC is of the worst performance. To compare series, we also divide them into sensitive analysis of input items and sensitive analysis of output items.

Among banks in former 3 series, which focus on change of input items, the first series has the lowest *CV* because of its lowest standard deviation. Their mean value is close to each other. And in these 3 series, BAC is always of the lowest efficiency.

Among banks in latter 3 series, which focus on change of output items, Series 4 has the highest mean efficient scores while Series 5 is of the lowest standard deviation. Series 6 has the highest *CV* with the lowest mean efficient scores and the highest standard deviation, which means these U.S. banks are also with the problem of ROE.

4.3 Summary

In this chapter, we did the financial analysis of the selected 21 banks and compared their financial situations as the first part. Hence we had a glance of these banks' financial situations about their profitability, assets quality and efficiency ratios. Secondly, we investigate the efficient situations of the selected banks by CCR model and SBM model. After that we interpret and compare the results of two models. We found the disparity of efficient scores between Chinese banks and U.S. banks. In the third part, to analyze banks' sensitivity to each input and output and meanwhile considering the different financial environment in the two countries, we changed some elements and constraints used in models and expanded the SBM model's application.

Financial ratio analysis is a comprehensive description of banks financial situation. It presents different aspects of banks' performance. Moreover, some financial indicators are interactive and even present opposite results. It's hard to estimate if a bank is full efficient. Similarly, financial ratio analysis exhibit the situation of banks only, it's difficult to make a plan for banks to increase a financial

ratio while keep other ratios constant. Via financial ratio analysis, we can't get a result of which bank is better or more efficient, neither the suggestion to improve banks' performance. DEA model is a mathematic method to assess a bank's efficiency by a certain number. It is easy to compare different banks directly. As to the two models we applied in the thesis, CCR model is the most basic model in DEA, and SBM model cover the shortage of it in the aspects of radial change of data, constant returns-to-scale assumption and the deficiency of take no account of slacks into its efficient scores. Extension of SBM model for these banks is to investigate the factors which one is the most sensitivity to those banks. It can disclose the best and worst factors of banks' management directly.

Turning to the results of our analysis, the first section in this chapter is about financial ratio analysis, we found the Chinese banks perform better and more stable than U.S. banks; while the latter pays more attention to assets equity and its leverage ratio is lower than the former.

In the second section, we applied CCR model and SBM model into practice. We choose number of employees, operating expenses and total assets as input items; new added deposits, new added loans, net operating profit and ROE as outputs. In the comparison of total selected banks, Chinese banks also have a better performance than U.S. banks both in application of CCR model and SBM model. As to Chinese banks, the excess of number of employees and shortage of ROE are main deficiency. Among U.S. banks, BAC has the lowest efficient situation. Technical inefficiency is the main reason of it, that is, the problem is the scale of inputs rather than the illogical distribution of resource. We presented the improvement of each inefficient bank at the end of two models' application respectively. In Section 4.2.4, we extended the DEA analysis for the two countries' banks' efficient situation by SBM model respectively. With the decrease of DMUs, we proposed 6 series of variables to proceed with banks' sensitive analysis. As we analyzed before, Chinese banks took full advantage of their assets while had problems with management of number of employees and ROE. The ROE problem is also the shackles of U.S. banks.

5. Conclusion

In this thesis, we applied the CCR model which is regarded as the basic DEA model, and SBM model that covered the shortage of the former, to analyze the efficient situation of selected 21 banks, the top banks in two countries, China and U.S.A. ranked by their operating incomes in 2013.

In the second chapter, we introduced the balance sheet and income statement firstly, and talked about the items of input and output what were used in DEA model application. Then we analyzed the financial situation of the selected banks via macro market introduction and the SWOT analysis. The methodology of micro financial ratio analysis was introduced after that. We found government supporting policy is the strength of Chinese banks; while on the other hand, it limits banks' autonomous management and independence. U.S. banks have an advanced management model and brand effects. Over competition and unstable financial condition are their main deficiencies.

Chapter 3 is the introduction of the models we applied in the thesis. CCR model is the most basic DEA models. It is the representation of radial measure with the assumption of constant returns-to-scale of activities. It measures the technical efficiency of a DMU by θ^* which does not take account of slacks. SBM provides a scalar ranging from 0 to 1 that encompasses all of the inefficiencies that the model can identify. It is an improved measure based on CCR, which covers the shortage of the former.

Chapter 4 is the application part. In the first part, we did the financial analysis about the selected banks' profitability, assets quality and efficient ratios, and we found Chinese banks perform better than U.S. banks, while the latter pays more attention to assets quality recent years. The financial ratio analysis presented each part of the selected banks' performance, while we can't get a result of their efficiency directly. Hence in the second part, we applied the CCR model and SBM model into practice. We choose number of employees, operating expenses and total assets as input items; newly added deposits, newly added loans, net operating profit and ROE as outputs to analyze banks' performance. By inputting them into *DEA-Solver-LV*, we got the results of the efficient situation of selected banks. After that, we proposed 6 series of variables to perform banks' sensitive analysis in extension of SBM model. It

investigated the sensitive factors to those banks and disclosed the best and worst factors of banks' management directly.

Combining the information of financial analysis and the analysis results got by DEA models, we found Chinese banks have better performances than U.S. banks. The excess of number of employees and shortage of ROE are main deficiencies of Chinese banks. The improvement and projection of each bank are presented at the end of application of each model and *Annexes*. As to U.S. banks, the problems are complex. Among them, BAC has the lowest efficient situation. Technical inefficiency is the main reason for it, that is, the problem is the scale of inputs rather than the illogical distribution of the resource. We also presented the improvement of each U.S. inefficient bank at the end of two models' application.

All in all, Chinese banks have better efficient situations than U.S. banks; while, in a fair environment of completion, Chinese banks lack independence and the ability to take risks.

Bibliography

Publications

[1] ADAM, Alexandre. *Handbook of Asset and Liability Management: From models to optimal return strategies*. New York: Wiley, 2007. 576 p. IBSN 978-0470034965

[2] BANKER, R.D., CHARNES, A., and COOPER, W. W. Some models for estimating technological and scale inefficiencies in data envelopment analysis, *Management Science* 30 (9), 1984, 1078-1092.

[3] COOPER, W. W., L. M. SEIFORD and K. TONE. *Data envelopment analysis: a comprehensive text with models, applications, references and DEA-solver software*. 2nd ed. New York: Springer, 2007. 489 p. ISBN 978-0387452814

[4] GEORGE, E. H., DIMITRIOS, S. S. *Efficiency measurement of the Greek commercial banks with the use of financial ratios: a data envelopment analysis approach*, *Management Accounting Research* 15, 2004, 201-224.

[5] HU, Y.C. *The Performance of State-owned Commercial Banks in the Course Reform*, *Finance & Trade Economics* 06, 2006.

[6] KLEINE, A. *A general model framework for DEA*, Omega, 32, 2004, 17-23.

[7] MISHKIN, Frederic S. and Stanley G. EAKINS. *Financial Markets and Institutions*. 8th ed. London: Prentice Hall, 2014. 704 p. IBSN 978-0133423624

[8] SUBRAMANYAM, K. R. and Joe WILD. *Financial Statement Analysis*. 10th edition. New York: McGraw-Hill/Irwin, 2008. 784 pages. ISBN 978-0073379432

[9] WANG, J.P. *An Empirical Study on the Scale Effects and Intensive Farming of Commercial Bank*, *China University of Mining and Technology*, 2005.

[10] XUE, J.B. *A research on the regional efficiency based on the DEA model*, *Chinese Academy of Sciences* 06, 2008.

[11] YANG, G.L. *Extended utility and DEA models without explicit input*, *Journal of the Operational Research Society* 65, 2014, 1212-1220.

Electronic documents and others

[12] China Banking Regulatory Commission [on line]. [21.3.2014]. Available on: http://www.cbrc.gov.cn/english/index.html

[13] Banking Survey [on line]. [21.3.2014]. Available on:
https://www.kpmg.com

[14]Sina Finance [on line]. [21.3.2014]. Available on
http://finance.sina.com.cn/stock/y/20150112/050121273346.shtml

[15] Banking Rating Report [21.3.2014]. Available on:
http://www.icbc.com.cn/SiteCollectionDocuments/

[16] The financial reports on the official website of each bank

List of Abbreviations

DEA	Data Envelopment Analysis
DMU	Decision-Making Unit
CCR	Charnes, Cooper and Rhodes
SBM	Slacks-Based Measure of Efficiency
DEA-Solver-LV	DEA-Solver-Learning Version
FTE	Full Time Equivalent
ROE	Return on Equity
ROA	Return on Assets
ICBC	Industrial & Commercial Bank of China Ltd.
CBC	China Construction Bank Corp.
ABC	Agricultural Bank of China Ltd.
BC	Bank of China Ltd.
BOCM	Bank of Communication Co., Ltd.
CMBC	China Merchants Bank Co., Ltd.
CMSB	China Minsheng Bank Corp,. Ltd.
CIB	China Industrial bank Co., Ltd.
CNCB	China Citic bank Corp., Ltd.
SPD	Shanghai Pudong Development Bank Co.,Ltd.
CEB	China Everbright Bank Co.,Ltd.
JPM	J.P. Morgan Chase & Co.
BAC	Bank of America Corp.
WFC	Wells Fargo & Co.
CITI	Citigroup Inc.
GS	Goldman Sachs Group, Inc.)
MS	Morgan Stanly

COF	Capital One Financial Group
USB	U.S. Bancorp
PNC	PNC Financial Services Group
BNY	The Bank of New York Mellon Corp.
USD	U.S. Dollar
SWOT	Strengths, Weaknesses, Opportunities and Threats
T-bills	Treasury Bills
NIM	Net Interest Margin
NPM	Net Profit Margin
LR	Liquidity Ratio
ATTL	Allowance to Total Loans Ratio
ALL	Allowance for Loan Losses
LTD	Loans to Deposits
CAR (CCAR)	Capital Adequacy Ratio (Core Capital Adequacy Ratio)
OER	Operating Efficiency Ratio
EPR	Employee Productivity Ratio
CHY	Chinese Yuan
FP	Fractional Program
LP	Linear Program
D-RTS	Decreasing Returns-to-Scale
C-RTS	Constant Returns-to-Scale
I-RTS	Increasing Returns-to-Scale
Aver.	Average
St.d	Standard Deviation
CV	Coefficient Variation

Annex 3: Declaration of Utilization of Results from a Diploma (Bachelor) Thesis

Herewith I declare that

- I am informed that Act No. 121/2000 Coll. – the Copyright Act, in particular, Section 35 – Utilization of the Work as a Part of Civil and Religious Ceremonies, as a Part of School Performances and the Utilization of a School Work – and Section 60 – School Work, fully applies to my diploma (bachelor) thesis;
- I take account of the VSB – Technical University of Ostrava (hereinafter as VSB-TUO) having the right to utilize the diploma (bachelor) thesis (under Section 35(3)) unprofitably and for own use ;
- I agree that the diploma (bachelor) thesis shall be archived in the electronic form in VSB-TUO's Central Library and one copy shall be kept by the supervisor of the diploma (bachelor) thesis. I agree that the bibliographic information about the diploma (bachelor) thesis shall be published in VSB-TUO's information system;
- It was agreed that, in case of VSB-TUO's interest, I shall enter into a license agreement with VSB-TUO, granting the authorization to utilize the work in the scope of Section 12(4) of the Copyright Act;
- It was agreed that I may utilize my work, the diploma (bachelor) thesis, or provide a license to utilize it only with the consent of VSB-TUO, which is entitled, in such a case, to claim an adequate contribution from me to cover the cost expended by VSB-TUO for producing the work (up to its real amount).

Ostrava dated 23.04.2015

WENMENG HU

List of Annexes

Annex 1: Projection for Selected U.S. Inefficient Banks by CCR Model

(*In million dollars, except of number of employees and percentage*)

		Number of Employees	Operating Expenses	Assets	New Deposits	New Loans	Operating Profit	ROE
JPM 0.674	Original data	247845	66486	2341274	84067	7567	26198	0.09
	Projection	160465	27402	1515835	125519	94632	26198	0.62
	Difference	-87380	-39084	-825439	41452	87065	0	0.53
	%	-35.26	-58.79	-35.26	49.31	999.90	0.00	574.42
BAC 0.227	Original data	258650	72233	2138294	34729	5289	8944	0.03
	Projection	58693	14130	485225	36689	29713	8944	0.18
	Difference	-199957	-58103	-2000000	1960	24424	0	0.15
	%	-77.31	-80.44	-77.31	5.64	461.78	0	503.26
WFC 0.989	Original data	267240	49430	1440025	71803	16128	28714	0.12
	Projection	260889	42481	1424006	71803	50046	28714	0.53
	Difference	-6351	-6949	-16019	0	33918	0	0.41
	%	-2.38	-14.06	-1.11	0	210.30	0	342.99
CITI 0.404	Original data	256250	48896	1876966	41399	9601	14144	0.06
	Projection	103552	19759	758489	52819	40335	14144	0.29
	Difference	-152698	-29137	-1000000	11420	30734	0	0.24
	%	-59.59	-59.59	-59.59	27.59	320.11	0	428.43
MS 0.314	Original data	57571	26621	804479	16707	4317	3659	0.05
	Projection	18083	3754	252682	16707	13092	3659	0.08
	Difference	-39488	-22867	-551797	0	8775	0	0.04
	%	-68.59	-8.59	-68.59	0	203.26	0	80.56
PNC 0.804	Original data	54373	9784	303640	10199	11223	4744	0.09
	Projection	38382	7185	244092	14875	11223	4744	0.09
	Difference	-15991	-2599	-59548	4676	0	0	0
	%	-29.41	-26.57	-19.61	45.84	0	0	0
BNY 0.629	Original data	49723	11115	346566	23027	3697	3300	0.06
	Projection	19150	3091	218162	23027	11522	3300	0.08
	Difference	-30573	-8024	-128404	0	7825	0	0.02
	%	-61.49	-72.19	-37.05	0	211.67	0	36.52

Annex 2: Variable Returns-to-Scale of Banks by SBM Model

No.	DMU	Score	RTS of Projected DMU
1	ICBC	1	Constant
2	CBC	1	Decreasing
3	ABC	1	Decreasing
4	BC	0.874	Decreasing
5	BOCM	0.933	Decreasing
6	CMBC	1	Constant
7	CMSB	1	Constant
8	CIB	1	Constant
9	CITIC	1	Constant
10	SPD	1	Constant
11	CEB	1	Constant
12	JPM	0.582	Constant
13	BAC	0.185	Constant
14	WFC	1	Decreasing
15	CITI	0.346	Constant
16	GS	1	Constant
17	MS	0.342	Constant
18	COF	1	Constant
19	USB	1	Constant
20	PNC	0.843	Increasing
21	BNY	0.668	Increasing

Annex 3: Projection for Inefficient Chinese Banks by SBM Model

(*In million dollars, except of number of employees and percentage*)

		Number of Employees	Operating Expenses	Assets	New Deposits	New Loans	Operating Profit	ROE
BC 0.874	Original data	297855	26373	2134682	139540	120712	31620	0.17
	Projection	273323	20976	1938688	139540	120712	31620	0.21
	Difference	-24532	-5397	-195995	0	0	0	0.04
	%	-8.24	-20.46	-9.18	0	0	0	23.46
BOCM 0.933	Original data	96156	9896	889506	73404	58647	12100	0.16
	Projection	91182	9169	822682	75014	58647	12100	0.17
	Difference	-4974	-728	-66825	1610	0	0	0.01
	%	-5.17	-7.35	-7.51	2.19	0	0	8.98
JPM 0.582	Original data	247845	66486	2341274	84067	7567	26198	0.09
	Projection	206396	16380	1562255	110371	98223	26198	0.20
	Difference	-41449	-50106	-779019	26304	90656	0	0.11
	%	-16.72	-75.36	-33.27	31.29	999.9	0	119.58
BAC 0.185	Original data	258650	72233	2138294	34729	5289	8944	0.03
	Projection	50569	6845	564096	46810	41818	8944	0.20
	Difference	-208081	-65388	-1574198	12081	36529	0	0.17
	%	-80.45	-90.52	-73.62	34.79	690.66	0	560.27
CITI 0.346	Original data	256250	48896	1876966	41399	9601	14144	0.06
	Projection	96175	9010	899312	69619	57972	14144	0.20
	Difference	-160075	-39886	-977654	28220	48371	0	0.14
	%	-62.47	-81.57	-52.09	68.16	503.81	0	254.19
MS 0.342	Original data	57571	26621	804479	16707	4317	3659	0.05
	Projection	25072	3814	360866	31183	22263	4988	0.18
	Difference	-32499	-22807	-443613	14476	17946	1329	0.14
	%	-56.45	-85.67	-55.14	86.64	415.7	36.31	304.21
PNC 0.843	Original data	54373	9784	303640	10199	11223	4744	0.09
	Projection	33725	8901	303640	22768	18404	5287	0.12
	Difference	-20648	-883	0	12569	7181	543	0.03
	%	-37.98	-9.03	0	123.24	63.99	11.44	34.02
BNY 0.668	Original data	49723	11115	346566	23027	3697	3300	0.06
	Projection	27233.9799	5085.1108	346566	29079.99	21299	5062.3079	0.17
	Difference	-22489.02	-6029.889	0	6052.993	17602	1762.3079	0.11
	%	-45.23	-54.25	0	26.29	47.61	5.34	170.14