EMPIRICAL RESEARCH OF M&A IMPACT ON CHINESE AND AMERICAN COMMERCIAL BANKS' EFFICIENCY BASED ON DEA METHOD[1]

Xiao Weiguo[2] **Li Ming[3]**

Abstract: This paper firstly introduces DEA (Data Envelopment Analysis) and its applicability for analyzing commercial banks' efficiency, and then we apply this method to carry out empirical research on top five American banks and four Chinese banks. We find merger and acquisition (M&A) has greater impact on banking efficiency of Chinese banks than that of American banks. Furthermore, the non-market oriented M&A bring some negative effects to banking efficiency of Chinese banks. M&A usually becomes the burden of the acquiring bank. Finally, we briefly put forward some M&A suggestion for Chinese banking industry to improve the banking efficiency based on the empirical conclusion.
Key words: bank M&A, banking efficiency, Date Envelopment Analysis

Banking efficiency has an accordant explanation in management theory of commercial bank. Banking efficiency is the ratio of input to output or the ratio of cost to income in banking operation. If we only analyze from the quantity of input and output, the banking efficiency is the ratio of output quantity to input quantity.

Proponents of bank M&A efficiency theory consider M&A activities can enhance the performance of bank, so banking efficiency becomes an important aspect in the study of bank M&A. This paper adopts Date Envelopment Analysis (DEA) to carry out empirical research on American and Chinese banks to determine the impact of bank M&A on banking efficiency.

1. DATE ENVELOPMENT ANALYSIS AND ITS APPLICABILITY IN BANKING EFFICIENCY RESEARCH

1.1 Summary of Date Envelopment Analysis

DEA substantially is a linear programming model. All Decision Making Units (DMU) with the best

[1] **This paper is the phasic achievement of "Research on Internationalization of Chinese Financial Industry" which is the sub-subject of 211 project and 985 innovation base project.**
[2] Economics and Management School, Wuhan University, P.R. China, 430072
[3] Wuhan Guoce Science & Technology Co., Ltd., P.R. China, 430072
* Received 24 January 2008; accepted 19 February 2008

efficiency can constitute a frontier of efficiency. So the DMUs with relative low efficiency are below the frontier. In 1957, Farrell analyzed Technical Efficiency (TE) with a model of single input and single output. Then Charnes, Cooper & Rhode (1978) developed this theory to C^2R model. So it can be used to solve the problem with multi-input and multi-output, namely the basic DEA. However, this model is not accord with the reality, because it assumes returns to scale is constant. Therefore, Banker, Charnes & Cooper put forward BC^2 model based on C^2R model in 1984. Because the model relaxes the restriction of constant returns to scale and separate Pure Technical Efficiency (PTE) and Scale Efficiency (SE) from TE, DEA becomes more functional.

As the basic model of DEA, C^2R model is developed from the theory which was first put forward by Farrell in 1957. The C^2R efficiency evaluation model assumes production technique of each DMU has constant returns to scale. It can deduce a frontier of efficiency and calculate the relative efficiency of each DMU by analyzing the input. The DMU which falls on the frontier of efficiency is called DEA efficiency and the value of it is 1. While DMU which does not fall on the frontier of efficiency is called DEA inefficiency and the value of it is between 0 and 1.

Assuming there are *n* banks, each bank use *m* kinds of inputs to produce *s* kinds of outputs. DMU_j denotes bank *j*, x_{ij} denotes the input *i* of bank *j* and $x_{ij}>0$. y_{rj} denotes the output *r* of bank *j* and $y_{rj}>0$. The relative efficiency of a specific DMU_{j0} can be calculated with the following basic model.

$$\text{Max } h_{j0} = \frac{\sum_{r=1}^{s} u_r y_{rj0}}{\sum_{i=1}^{m} v_i x_{ij0}} \quad (1)$$

$$s.t. \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1, \text{ j=1,2,……,n;}$$

$u_r, v_i \ge 0$, i=1,2,……,m; r=1,2,……,s.

In above equation, u_r and v_i denote the weight of output *r* and input *i* respectively. h_{j0} denotes the relative efficiency of bank *j*.

Equation (1) calculates the maximal relative efficiency of bank *j*, so it meets the requirement of $0 < h_{j0} \le 1$. But this equation is a non-linear programming model, so the result of (u_r^*, v_i^*) is infinite. In order to solve this problem, this equation should be converted into a linear programming model as the equation (2) below.

$$\text{Max } h_{j0} = \sum_{r=1}^{s} u_r y_{rj0} \quad (2)$$

$$s.t. \sum_{i=1}^{m} v_i x_{ij0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0,$$

$u_r, v_i \ge 0$, i=1,2,……,m; r=1,2,……,s.

Equation (2) calculates the maximal total weight of output after considering the restriction of the total weight of input is 1. The number of restricted equation is more than the number of variables, so the above

equation can be converted into a dual linear programming model as below. After the conversion, the equation becomes the unique form of DEA.

Min $h_{j0}=\theta$ (3)

$$s.t.\sum_{j=1}^{n}\lambda_j x_{ij} \le \theta x_{ij0}, \quad i=1,2,\ldots\ldots,m;$$

$$\sum_{j=1}^{n}\lambda_j y_{rj} \ge y_{rj}, \quad r=1,2,\ldots\ldots,s;\ \lambda_j \ge 0,\ j=1,2,\ldots\ldots,n.$$

In above equation, θ is the relative efficiency of bank *j*.

C^2R model assumes commercial banks operate under constant returns to scale. It is not accord with the reality. If variable returns to scale exist, the SE could not be separated from the TE when measuring the TE. Therefore, we should consider the circumstance of Variable Returns to Scale (VRS). In 1984, Banker, Charnes & Cooper removed the assumption of Constant Returns to Scale (CRS) from C^2R model in order to measure the relative efficiency under VRS.

BC^2 model introduces the concept of Distance Function, so TE can be divided into PTE and SE. That is to say, not only the allocation of input and output, but also the factor of scale can affect TE. So we can change the inefficiency state by adjusting the scale. Therefore, one restriction is added on the equation (3).

$$\sum_{j=1}^{n}\lambda_j = 1 \quad (4)$$

The h_{j0} we calculated here is PTE.

1.2 Separation of TE and Determining the Change of Returns to Scale

Generally speaking, PTE calculated by BC^2 model is larger than TE calculated by C^2R model. If both values have no difference, it shows the inefficiency of bank is not due to the factor of scale. But if the two values are different, it means the inefficiency of bank is due to the inefficiency of scale. We can explain the relation of TE and SE with the equation below.

$TE_{CRS}=TE_{VRS}\times SE$ (5)

In above equation, TE_{CRS} denotes the TE under CRS and TE_{VRS} denotes the TE under VRS. So TE_{VRS} we calculated here is PTE. SE denotes Scale Efficiency. From this equation, we can understand the degree of technical inefficiency comes from pure technical inefficiency or scale inefficiency or both.

Consequently, we can estimate the change of commercial bank's returns to scale with a simple method. First, we add the assumption of Non-increasing Returns to Sale (NIRS) to Equation (4) and substitute $\sum_{j=1}^{n}\lambda_j \le 1$ for $\sum_{j=1}^{n}\lambda_j = 1$. So the h_{j0} we calculated here is the TE under NIRS. Then, we can evaluate the degree of returns to scale change. If $TE_{NIRS}\neq TE_{VRS}$, the returns to scale of this bank is increasing. If $TE_{NIRS}=TE_{VRS}\neq TE_{CRS}$, the return to scale of this bank is decreasing. And if $TE_{NIRS}=TE_{VRS}=TE_{CRS}$, the returns to scale of this bank is constant.

1.3 Applicability of DEA on Banking M&A Efficiency Research

DEA method is a method in a new realm which crosses the research domains of operational research, management science and mathematical economics. It has strong applicability in complex system with

multi-input and multi-output index. Especially, it also has strong application value in evaluating issues of society, technology and economy. Its advantages are: First, it does not need to constitute a frontier for concrete function like parameter method. So it can avoid the wrong conclusion by using the improper function. Second, the unit standardization of input and output item, such as currency unit, number of employee and times of transaction, is unnecessary for DEA. Third, the index of complex system is hard to compare while the DEA method need not to determine the comparability of each index in advance. Fourth, DEA method needs not to determine the weight of input/output index in advance. It utilizes the weight of each input/output (DMU) as variable to evaluate from the aspect most suitable to DMU. So it can exclude many subjective factors and has high objectivity. Fifth, the relation among each input/output (DMU) is quite complex. But the DEA method can measure the quantitative index of each DMU's comprehensive efficiency without determining the explicit relation among them. It can determine the efficient DMU and analyze the cause of inefficiency so as to adjust the direction and extent of input (DMU).

These characteristics of DEA are very suitable for evaluating the banking efficiency. First, the relative efficiency is a good index to measure banks' performance in competitive market and it is also a potential signal which can determine whether a bank is failure or not. Second, efficiency index can also be used to evaluate the effect of supervision and market environment on bank's performance. Lastly, this mathematics method will help the bank to find the cause of low efficiency. So banks can adopt corresponding strategies to enhance the relative position in the market. Of course, this evaluation method can also provide the information about change of efficiency index before and after the bank M&A. So the management of banks can compare the change of index to evaluate the efficiency improvement of bank M&A.

2. DEA ANALYSIS OF M&A IMPACT ON FIVE AMERICAN BANKS' EFFICIENCY

2.1 Research Objects of DEA and Selection of Input/Output Variables

This paper employs C^2R model and BC^2 model of DEA to calculate efficiency indexes of five American banks which are top five American banks appraised by magazine *Banker* in 2006. Calculation processes of efficiency indexes during 1999 to 2006 are achieved by LINDO software of operational research. The data of input and output indexes are available in the annual reports of five American banks which release these information on corresponding banks' website.

Table 1 Define of Input and Output Variables in DEA Model

Character of Variables	Name of Variable	Description of Variable
Input Variables	Operational Expense（X_1）	It includes operating expense, expense for M&A, wage of employees and other expenses occurred during the operation of commercial bank.
	Total Deposit（X_2）	It is the total deposit of customers and interbank.
	Provision for Bad Debts（X_3）	It is the total loan loss provision bank set aside according to the different risks of different loans.
Output Variables	Net Profit（Y_1）	It is the profit after deducting expenses and taxes.
	Total Loan（Y_2）	It is the total loan after deducting the provision for bad debts.

Owing to the diversity of choosing input and output indexes, this paper comprehensively consider the

indexes chose by other scholars and availability of data. Finally, we choose operational expense, total deposit and provision for bad debts as input indexes and select net profit and total loan as output indexes (Table 1). We choose these indexes of input and output and make some adjustments based on agency method or asset method and consider the quality change of commercial banks' assets before and after the M&A. We add provision for bad debts in the input index and total loan in the output index to reflex these adjustments. The adjustments above remedy the defects of traditional definition of bank's output. The traditional methods take total deposit as bank's output without considering the different quality of each bank's loan. They assume the quality of loan, environment of market, strategy of development and technique of risk control are all same in every bank. So they get the conclusion that risks of each bank faced are also same. But above assumption and conclusion are not consistent with the reality. So we take provision for bad debts as an output index of bank in order to reflex the change trend of loan's quality more obviously.

2.2 Empirical Result and Analysis

This paper employs LINDO software of operational research to analyze the efficiency indexes of five American banks which experienced M&A from 1999 to 2006. The following Table 2 is the empirical research result.

We get the conclusion based on the empirical result. The efficiency indexes of bank will deteriorate shortly after the M&A. Moreover, the fluctuation of efficiency indexes is more obvious when more assets involved in M&A. For example, Bank of America Corp. (BAC) acquired Fleet Boston Financial Corp. through stock swap in 2003. Its TE was only 0.91 in 2003 because the cost of this M&A was too high. In 2004, the efficiency indexes of BAC were inefficiency as a whole (Inefficiency as a whole means the PTE and SE are all less than 1.) and its returns to scale was decreasing during these years. Wells Fargo acquired First Community, JS Crop Insurance and Evergreen Funding Corp. successively after 2004. But it could maintain efficiency as a whole (Efficiency as a whole means the PTE and SE are all 1.) for the scale of M&A was relative small.

The activity of M&A will affect the banking efficiency. But after analyzing the empirical research result of five American banks, we find the banking efficiency can restore to 1 after experiencing an adjustment period. From the empirical result, we can find that SEs of five American banks generally maintained above 0.9 from 1999 to 2006 and the larger the bank, the less effect was on the banking efficiency. The results of Citigroup illuminate above conclusion. We find the main reason of bank's inefficiency as a whole is the inefficiency of SE after bank M&A, another minor reason is redundant input or resource misallocation caused by of poor interior management. As the result of Table 3, the main reason of top 2 American banks' inefficiency as a whole after M&A is technical inefficiency. While the times of inefficiency as a whole of another three American banks after M&A is caused by scale inefficiency or technical inefficiency. And the inefficiency as a whole caused by scale inefficiency is increasing which shows the ability to achieve SE of higher ranking banks is stronger than that of lower ranking banks.

When we study the M&A impact on banking efficiency, we find banking efficiency of five American banks almost reach the lowest value in 2001. So world economy recession around 2001 and 911 terrorist attack in 2001 affected both American economy and American banks' efficiency. All five American banks we studied are inefficiency as a whole in 2001 which means the change of exterior economy environment can obviously affect banking efficiency.

After studying five banks' change of returns to scale, we find returns to scale of J.P. Morgan Chase who merged Bank One Corp. in 2004, Bank of America who merged Fleet Boston Financial in 2003 and Wachovia who merged JW Genesis Financial Corp. in 2001 all decreased after M&A. The main reason of decreasing returns to scale is high M&A cost. It shows the bank can benefit from M&A only by controlling the M&A impact on the banking efficiency effectively.

Table 2 Banking Efficiency of Five American Banks from 1999 to 2006

Name of Bank	Year	Technical Efficiency (TE)	Pure Technical Efficiency (PTE)	Scale Efficiency (SE)	Efficiency under NIRS	Returns to Scale
Citigroup	1999	0.987891	1	0.987891	0.987891	increasing
	2000	1	1	1	1	constant
	2001	0.950628	0.956261	0.994109	0.950628	increasing
	2002	1	1	1	1	constant
	2003	1	1	1	1	constant
	2004	0.991456	1	0.991456	0.991456	increasing
	2005	1	1	1	1	constant
	2006	1	1	1	1	constant
J.P. Morgan Chase	1999	1	1	1	1	constant
	2000	1	1	1	1	constant
	2001	0.954236	0.962094	0.991832	0.954236	increasing
	2002	0.912616	0.945615	0.965103	0.912616	increasing
	2003	0.951966	0.965853	0.985622	0.951966	increasing
	2004	1	1	1	1	constant
	2005	0.996443	0.997884	0.998556	0.997884	decreasing
	2006	1	1	1	1	constant
Bank of America	1999	0.998196	1	0.998196	0.998196	increasing
	2000	1	1	1	1	constant
	2001	0.820333	0.968162	0.847310	0.820333	increasing
	2002	0.908679	1	0.908679	0.908679	increasing
	2003	0.911306	1	0.911306	0.911306	increasing
	2004	0.958853	0.958999	0.999848	0.958999	decreasing
	2005	1	1	1	1	constant
	2006	1	1	1	1	constant
Wachovia	1999	1	1	1	1	constant
	2000	0.966525	0.988638	0.977633	0.966525	increasing
	2001	0.842483	0.881255	0.956004	0.842483	increasing
	2002	0.876402	0.929266	0.943112	0.929266	decreasing
	2003	0.846162	0.890530	0.950178	0.890530	decreasing
	2004	0.855901	0.856832	0.998913	0.855901	increasing
	2005	1	1	1	1	constant
	2006	1	1	1	1	constant
Wells Fargo	1999	1	1	1	1	constant
	2000	0.888479	0.997449	0.890751	0.888479	increasing
	2001	0.852663	0.943403	0.903816	0.852663	increasing
	2002	0.915461	0.942371	0.971444	0.915461	increasing
	2003	0.978059	0.996815	0.981184	0.978059	increasing
	2004	1	1	1	1	constant
	2005	1	1	1	1	constant
	2006	1	1	1	1	constant

Table 3 Efficiency Indexes Statistics of Five American Banks

Bank	Times of Efficiency as a Whole	Times of Scale Inefficiency	Times of Inefficiency as a Whole	
			Times of Scale Inefficiency	Times of Technical Inefficiency
Citigroup	5	2	0	1
J.P. Morgan Chase	4	0	0	4
Bank of America	3	3	1	1
Wachovia	3	0	1	4
Wells Fargo	4	0	3	1

3. DEA ANALYSIS OF M&A IMPACT ON FOUR CHINESE BANKS' EFFICIENCY

3.1 Research Objects of DEA and Selection of Input/Output Variables

As described above, production method, agency method and asset method can be used to define the input and output of bank. It is not accord with reality to directly define the total loan as output of Chinese banks without considering the quality of loan. While Chinese banks provisions for bad debts were stipulated by authority in the past. And provisions for bad debts were not set aside according to the actual quantity of loan. So provision for bad debts is not suitable to measure the quality of loan. Therefore, we should redefine the output of Chinese bank. Because agency method and asset method all put emphases on the output of bank, we pay much attention to the output, namely profit of bank. Considering income of bank can be divided into interest income and non-interest income, we choose above two kinds of income as output of bank and select work force, physical assets and loanable funds as input of bank. The work force is the total number of full-time employees of bank that include managers, common employees and all related staffs in bank's headquarter and subsidiaries. Physical asset is the net fixed asset of bank. The loanable fund includes deposit, interbank deposit, due to central bank, borrowed fund and issuing bonds. (Table 4)

Table 4 Define of Input and Output Variables in DEA Model

Character of Variable	Name of Variable	Description of Variable
Input Variables	Work Force（X_1）	It is the total number of full-time employees of bank that includes managers, common employees and all related staffs in bank's headquarter and subsidiaries.
	Physical Assets（X_2）	It is the net fixed asset of bank.
	Loanable Funds（X_3）	It includes deposit, interbank deposit, due to central bank, borrowed fund and issuing bonds.
Output Variables	Interest Income（Y_1）	It is the margin between interest income of loan and interest expenditure of deposit.
	Non-interest Income（Y_2）	It is the charge of service and commission of business bank earned.

3.2 Empirical Result and Analysis

This paper also employs LINDO software of operational research to research the efficiency indexes of four Chinese banks which experienced M&A during 8 years' research period. The following Table 5 is the empirical research result. The data used in DEA method comes from China Statistical Yearbook and Almanac of China's Finance and Banking.

Table 5 Banking Efficiencies of Four Chinese Banks before and after M&A

Name of bank	Year	Technical Efficiency (TE)	Pure Technical Efficiency (PTE)	Scale Efficiency (SE)	Efficiency under NIRS	Returns to Scale
Guangdong Development Bank	1994	1	1	1	1	constant
	1995	1	1	1	1	constant
	1996	0.991145	0.997234	0.993894	0.991145	increasing
	1997	1	1	1	1	constant
	1998	0.923719	0.946564	0.975865	0.923719	increasing
	1999	0.864357	0.895950	0.964738	0.864357	increasing
	2000	1	1	1	1	constant
	2001	1	1	1	1	constant
China Construction Bank	1994	1	1	1	1	constant
	1995	1	1	1	1	constant
	1996	1	1	1	1	constant
	1997	0.986146	0.986899	0.999237	0.986146	increasing
	1998	0.951069	0.952175	0.998838	0.951069	increasing
	1999	1	1	1	1	constant
	2000	1	1	1	1	constant
	2001	0.971917	1	0.971917	0.971917	increasing
China Everbright Bank	1996	0.916124	1	0.916124	0.916124	increasing
	1997	1	1	1	1	constant
	1998	0.993803	1	0.993803	1	decreasing
	1999	0.625168	0.725597	0.861591	0.725597	decreasing
	2000	0.640377	0.868652	0.737208	0.868652	decreasing
	2001	0.655451	1	0.655451	1	decreasing
	2002	0.656511	0.965493	0.679975	0.965493	decreasing
	2003	0.875148	1	0.875148	1	decreasing
Shanghai Pudong Development Bank	1997	1	1	1	1	constant
	1998	0.988465	1	0.988465	0.988465	increasing
	1999	0.790020	1	0.790020	0.790020	increasing
	2000	1	1	1	1	constant
	2001	0.910564	1	0.910564	1	decreasing
	2002	0.865024	0.891950	0.969812	0.865024	increasing
	2003	0.851244	0.912106	0.933273	0.851244	increasing
	2004	1	1	1	1	constant

After comparing the empirical result of four Chinese banks with that of five American banks, we find American banks show the state of scale inefficiency or inefficiency as a whole after the bank M&A. And management ability of these banks improved with the increasing times of M&A. However, the fluctuation of Chinese banks' scale efficiency was relative strong and the efficiency index of these banks

was deteriorated during the period of bank M&A. The times of Chinese banks' SEs below 0.9 are more than that of American banks. Generally, five top American banks can achieve efficiency as a whole within three years after the M&A while Chinese banks need relative longer time, especially large state-owned banks. Moreover, the bank M&A of China would lead to the chaos of interior management and turn the former banks with efficiency as a whole into banks with inefficiency as a whole. So the banking efficiency of Chinese banks after M&A should be improved rapidly. Because the effects of Asia financial crisis affected four Chinese banks profoundly, the TE of them decreased to the lowest value around 1998. We also get conclusion that the change of exterior economy environment can obviously affect banking efficiency which is same with that of American banks.

Because the efficiency of Guangdong Development Bank and Shanghai Pudong Development Bank can quickly restore to the optimum value after M&A, we can get the following conclusion: Banks can achieve efficiency as a whole rapidly if they adopt market oriented method in M&A while the banks can not achieve efficiency as a whole within a relative short time if they adopt non-market oriented method in M&A. Moreover, the banks who adopt non-market oriented method in M&A will result in the waste of resources and the cost of scale expansion can not be easily recovered from bank operation after M&A.

4. CONCLUSION AND ITS IMPLICATION

After researching on the efficiency change of American and Chinese banks before and after M&A, we get the conclusion that M&A is an important path for Chinese banking industry to develop. M&A can also enhance the management efficiency and core competitiveness of Chinese banking industry. But Chinese banking industry should consider negative effects of M&A on banks seriously and calmly. The internal motivation of M&A is to achieve the expansion of bank's scale so as to improve banking efficiency through the market oriented measures instead of government-dominance methods. Bank M&A should focus on enhancement of core competitiveness, cultivation of self-character and development of service advantage during M&A. The main goal of M&A is to achieve efficiency instead of scale.

Chinese banks must learn the international experience of M&A sufficiently and participate in international bank M&A activities actively in order to confront the fiercely competition and challenge after fully open of Chinese finance industry. In the same time, Chinese banking industry should learn the experience and lesson from successful bank M&A through the related efficiency research on international bank M&A in order to establish the enhancement of efficiency as the goal of Chinese bank M&A.

REFERENCES

Amel, D., Barnes,C., Panetta,F., Salleo,C., Consolidation and efficiency in the financial sector: A review of the international evidence. *Journal of Banking & Finance*, 28 (2004) pp2493–2519.

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

Campa,J.M., Hernando,I, M&As performance in the European financial industry. *Journal of Banking & Finance*, 30 (2006), 3367–3392.

Charnes, W.W.Cooper & E. Rhodes, Measuring the Efficiency of Decision Making Units, *European Journal of Operational Research*, 1978(2), 429- 444.

Farrell, M.J.., The Measurement of Productive Efficiency. *Journal of Royal Statistical Society*, 1957(120), 253- 281.

Ismail,A.,Davidson,I., Further analysis of mergers and shareholder wealth effects in European banking, *Applied Financial Economics*, 15(2005), 13–30.

Li Qi, Li Guangquan & Han Zhexian, DEA Model to the Measurement of the Efficiency of Chinese Commercial Banks, *Journal of Tianjin University (Social Sciences)*, 2005(1).

Wang Ning, Li zhi, The Application of DEA to the Research of Efficiency of Commercial Banks in China, *Contemporary Economy & Management*, 2006(2).

Wei Li, Wang Li, Research on Chinese Banks' Efficiency Based on a Non-parameter Analysis, *Journal of Financial Research*, 2000(3).

Zhang Jianhua, The Application of DEA to the Research of Efficiency of Commercial Banks in China and Empirical Research on Banking Efficiency from 1997 to 2001, *Journal of Financial Research*, 2000(3).