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The Synthetic Efficiency Measures of the Chinese Commercial Bank System with Bad Loans and Reserve Using Two-Stage DEA Model

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Abstract

Recently, the liquidity risk that exit in the b anks has constantly exposed. There was a panic when people heard the massage of money shortage and default. The bank management need to strengthen the safely and liquidity of bank as the same time to pursuit of profit maximization. According to above discover, in this article, efforts are made to analyze the synthetic efficiency of commercial banks combining the safety, liquidity, profitability of commercial banks. In this study, we utilize extend the two-stage centralized and non-cooperative DEA approach to disaggregate, evaluate and test the 16 major Chinese commercial banks in 2012 with the consideration of undesirable/bad output and reserve. The main findings of this study are as follows: i) The non-cooperative model may overestimate the efficiency of ignore the relationship between the traditional stage and financial innovation stage or disagree with the real bank operation. ii) Bad loans has significant negative effect on efficiency indicating that the large and more bad loans lead bank to lower efficiency. iii) The state-owned bank achieved relative lower efficient, it implies that the state-owned commercial banks are necessary to gradually complete their joint-equity reform.

Key words: Two-stage DEA model; Game theory; Tobit model; Reserve; Bad loans; Synthetic efficiency

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INTRODUCTION

Whether the bank is safe and stable is an important factor in national economy. Since 1985, Sherman & Goliad first applied Data envelopment analysis to calculate the efficiency of bank; many scholars have made a number of improvements so that it can be better used in real life. Experimental result shows that DEA has at least three advantages in rendered below. Firstly, DEA model can deal with multiple inputs and outputs. Second, DEA model needn't set a production function before measuring the efficiency of bank. It avoids the influence of some subjective factors. And also, it simplifies the complexity of calculation simultaneously reduces errors. Last, the traditional DEA model treats the bank as black box ignoring the complex way the bank was run. Because of above reasons, Vassiloglou and Giokas (1990), Oral and Yolalan (1990), Sherman and Ladino (1995) used the DEA model to measure the efficiency of bank in Greek, Tokyo and American. Paradi (2011) found out there are 65 articles used the DEA model in 167 articles measuring the bank's efficiency published during 1997 to 2010. Paradi (2011) proposed a benchmark and provided improvement advice. Yavas and Fisher (2005) ranked the bank by the efficiency. Sherman & Rupert (2006) sought the opportunity in bank mergers and acquisition with the help of DEA model. Cook (1999) allocated the fixed cost in the bank operation into the branch using the DEA. Scholars followed extend the DEA model in two aspects: Some studies extend the traditional DEA model, just like the SBM model and the Super-Efficiency. Drake et. al

(2009) applied SBM model in the Japanese bank sector. Chiu (2008) adopt Super Efficiency model to investigate whether a bank's technical efficiency is significantly different when capital adequacy (risk) is specified compared with when capital adequacy (risk) is not. The others analyze the bank's efficiency combined the DEA model with other methods like multivariate statistical analysis, AHP, Neural network, Support Vector Machine, Decision Tree. Luo (2012), Ho (2009), Che (2010), et.al applied the models to study the Chinese commercial bank.

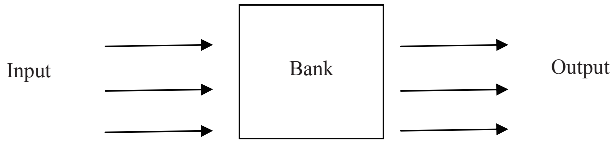

Figure 1
The DEA Structure of Bank Operation

We address certain empirical problems that have been encountered in bank efficiency studies. First, using the tradition DEA model we neglect internal linking activities, and thus, we cannot evaluate the impact of division-specific inefficiency on the overall efficiency of the bank as a whole. To address this problem, we use two-stage DEA model, which describes a bank production process as two stages: traditional service and finance innovation. Second, the fact that facing risk is common phenomenon on commercial bank operation, thus we investigate the effects of Chinese financial liberalization on the efficiency of Chinese commercial bank chosen bad loans and reserve. We also take "safety, liquidity and profitability" as commercial banks' main business objective.

So the efficiency attained by our paper is comprehensive.

As for the first problem, we consider to investigate the "black box". The network DEA model proposed by Fare & Grosskopf can evaluate the impact of traditional service and financial innovation inefficiency on the on the comprehensive efficiency of the bank. Furthermore, Tone (2008) points out that traditional DEA model might choose an inappropriate pair of input vs. output for evaluation and assign an unreasonable score to the concerned bank, since DEA selects the most favorable pair for the bank in the sense of maximizing the efficiency. As to evaluate the efficiency of divisional bank service individually, he also thinks that approach does not account for the continuity of links between bank traditional service and financial innovation.

Wang, Gopal and Zionts (1997) utilize DEA to study the marginal benefits of IT with respect to a two-stage process in bank. Lawrence, Seiford and Zhu (1999) examines the performance of commercial banks separates the bank production process into profitability and marketability. Through the intermediate products that are outputs of the first stage while inputs of the second stage, the complicated bank production process is no specific relationship between those two sub-processes while they are considered as independent process in calculating their efficiency. To solve this question, much more effort has been devoted to breaking down the overall efficiency into components. Kao & Hwang (2008) focuses on the overall efficiency is the product of the efficiencies of the two sub-processes. While Chen (2008) assumes the overall efficiency of the two-stage process is a weighted sum of efficiencies of the individual stages, and by selecting the particular set of weights, then the non-linear model converts into a linear programming problem. But now, most scholars adopt the model based on game theory of Liang, et al. They develop a centralized model which assumes the overall efficiency is a product or sum of divisional efficiencies like the model of Kao, et al and Yao, et al. and a non-cooperative model which is characterized by the leader-follower, or Stackelberg game. The approach of Liang, et al. is developed under the assumption that the outputs from the first stage all become the only inputs to the second stage. Li, et al. extend the model by assuming that the second stage has its own inputs in addition to output from the first stage and develop procedures to found the optimal solution. The current paper also considers that all output from the first stage do not become the inputs to the second stage.

Because that the banking industry is very different from the general industrial and commercial enterprise. It has a high debt, custom can ask for deposit at any time. It can easily gather and enlarge the risk thus the risk can spread to other banks even the whole banking system, even the systemic financial crisis will appear. The deposit reserve is to protect the interest of creditor, to prevent the drawback on lack of fund in financial innovation, to enhance public confidence in the nation's financial system, and last, to make a contribution to the stability of the economy. The government eagerly requested Chinese commercial banks to hold part of deposits at the Chinese central bank. In the short term, the more deposit reserve central bank need, the less money the bank can use in the financial innovation. But in the long term, it might lead the bank seek for other sources of profit, for example the intermediary business, international banking service and wealth management. In all, deposit reserve which is not participate in the financial innovation is aim to let bank be"safety, liquidity and profitability".

In the bank aspect, when bad loans occur, it directly influence and restrict bank's own development. It can gradually become a serious problem in economy development of China for the future. The bank must settle this matter finally. Du (2010) reminds us of riskin the traditional DEA which overlook those factors; otherwise it undermines the application in the actual life. Until now many issue center around the number not the quality of the loans. In order to accomplish this, we must formally add the bad loans which are undesired outputs to evaluate the comprehensive efficiency of bank. As undesired outputs-bad loans exist, it is necessary to extend the network DEA model. There are four primary categories of methodological approaches to deal with undesired outputs as discussed in recent reviews (Chen, 2012), the undesirable output is viewed as input, the Seiford & Zhu model, the hyperbolic model, Directional distance function, each presenting its own strengths and weakness. Due to the complex calculation processof the hyperbolic model, the significant impact on the rank and classification of Seiford & Zhu model, last, the uncertainties chosen direction function of directional distance function, we just dispose the undesirable output as input. Given the process of trade financing innovation creates much more risks along with the new business; we assume that bad loans emerge in the financial innovation stage not in the traditional stage. All this leads up to more innovation of the current paper is the unique input not the intermediate input the financial innovation stage.

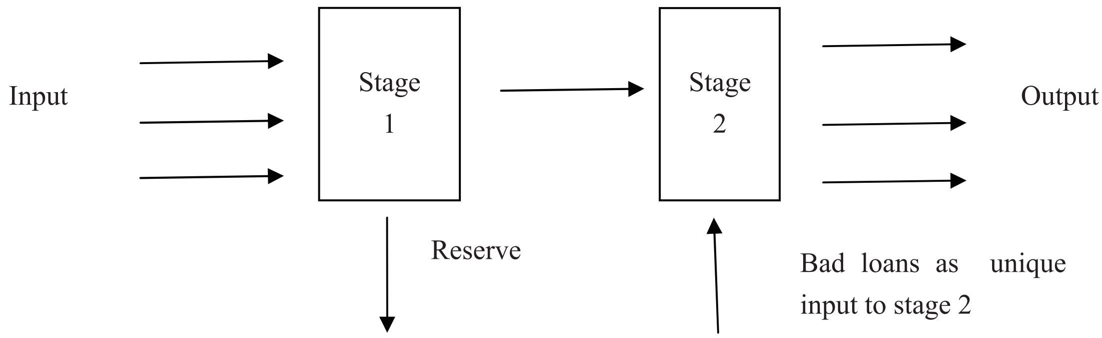

Figure 2
Two-Stage Process with Bad Loans and Reserve

1. MODEL

As shown above, suppose there are n banks (which are called DMUs in DEA), we notate every bank as DMU_j undesirable output of DMU_o is $y^{ud}_{lj}, l=1,2,\cdots,L$. The reserve of bank is y^1_0. The output of stage 2 in the bank operation is denoted as $y^2_{ro}, r=1,2,\cdots,s$. Input variable of stage 1 is x_{io}, $i=1,2,\cdots,m$. Intermediate variable is $z_{dj}, d=1,2,\cdots,D. v_i, u_r, w_d, Q_l, w_o$,are weights. The set weights (w_d) to the intermediate measures (z_{dj}) remain unchanged as the "worth" or "value" to the intermediate variables keep the same whether they are role of inputs or outputs.

$$\theta = Max\ \theta^1 \times \theta^2 = Max \frac{\sum_{d=1}^{D} w_d z_{do} + w_o y^1_o}{\sum_{i=1}^{m} v_i x_{io}} \times \frac{\sum_{r=1}^{s} u_r y^2_{ro}}{\sum_{l=1}^{L} Q_l y^{ud}_{lo} + \sum_{d=1}^{D} w_d z_{do}}$$

$$s.t\ \frac{\sum_{d=1}^{D} w_d z_{dj} + w_o y^1_j}{\sum_{i=1}^{m} v_i x_{ij}} \leqslant 1; \frac{\sum_{r=1}^{s} u_r y^2_{rj}}{\sum_{l=1}^{L} Q_l y^{ud}_{lj} + \sum_{d=1}^{D} w_d z_{dj}} \leqslant 1; \tag{1}$$

$$v_i, u_r, w_d, Q_l \geqslant 0; j=1,2,\cdots,n; i=1,2,\cdots,m; r=1,2,\cdots,s;$$
$$l=1,2,\cdots,L; d=1,2,\cdots,D$$

1.1 Centralized Model of Bank System

There are many cases that the banks combine the traditional stage with the financial innovation together to maximize company's profit. Li (2012) proposes a approach that use the sametwo sets of constraints in model 1, so the efficiency for the first stage 1 must under the optimal solution of model 2. Then denote the optimal value to model 3 as a function of the variable θ_o, which is range from 0 to the optimal solution of model 1,the non-linear model 3 can be converted into a linear program through the Charnes–Cooper transformation as follow. Consider the following model 2:

$$\theta^{1,\max} = Max\ \theta^1 = Max \frac{\sum_{d=1}^{D} w_d z_{do} + w_o y_o^1}{\sum_{i=1}^{m} v_i x_{io}}$$

$$s.t\ \ \frac{\sum_{d=1}^{D} w_d z_{dj} + w_o y_j^1}{\sum_{i=1}^{m} v_i x_{ij}} \leqslant 1; \frac{\sum_{r=1}^{s} u_r y_{rj}^2}{\sum_{l=1}^{L} Q_l y_{lj}^{ud} + \sum_{d=1}^{D} w_d z_{dj}} \leqslant 1$$

$$v_i, u_r, w_d, w_o \geqslant 0;\ j = 1,2,\cdots,n; i = 1,2,\cdots,m; r = 1,2,\cdots,s; d = 1,2,\cdots,D \tag{2}$$

$$\theta^{1,\max} = Max\ \theta^1 = Max\ \sum_{d=1}^{D} w_d z_{do} + w_o y_o^1$$

$$s.t\ \ \sum_{i=1}^{m} v_i x_{io} = 1; \sum_{d=1}^{D} w_d z_{dj} + w_o y_j^1 - \sum_{i=1}^{m} v_i x_{ij} \leq 0;$$

$$\sum_{r=1}^{s} u_r y_{rj}^2 - \sum_{l=1}^{L} Q_l y_{lj}^{ud} - \sum_{d=1}^{D} w_d z_{dj} \leq 0$$

$$v_i, u_r, w_d, w_o \geqslant 0;\ j = 1,2,\cdots,n; i = 1,2,\cdots,m; r = 1,2,\cdots,s; d = 1,2,\cdots,D$$

Therefore, the overall efficiency denotes as follows:

$$\theta^{1,cen} = Max\ \theta^1 \times \theta^2 = Max\, \theta_o \times \frac{\sum_{r=1}^{s} u_r y_{ro}^2}{\sum_{l=1}^{L} Q_l y_{lo}^{ud} + \sum_{d=1}^{D} w_d z_{do}}$$

$$s.t\ \ \frac{\sum_{d=1}^{D} w_d z_{dj} + w_o y_j^1}{\sum_{i=1}^{m} v_i x_{ij}} \leqslant 1;\ \ \frac{\sum_{r=1}^{s} u_r y_{rj}^2}{\sum_{l=1}^{L} Q_l y_{lj}^{ud} + \sum_{d=1}^{D} w_d z_{dj}} \leqslant 1; \tag{3}$$

$$\frac{\sum_{d=1}^{D} w_d z_{do} + w_o y_o^1}{\sum_{i=1}^{m} v_i x_{io}} = \theta_o; \theta_o \in (0, \theta^{1,\max}];$$

$$v_i, u_r, w_d \geqslant 0;\ j = 1,2,\cdots,n;$$

$$i = 1,2,\cdots,m; r = 1,2,\cdots,s; l = 1,2,\cdots,L; d = 1,2,\cdots,D$$

Set $t = \frac{1}{\sum_{l=1}^{L} Q_l y_{lo}^{ud} + \sum_{d=1}^{D} w_d z_{do}}$, $tv_i = v_i$, $tw_d = \omega_d$, $tQ_d = \Omega_d$, model 3 can be transformed via the Charnes-Cooper transformation as follows:

$$
\begin{aligned}
&\theta^{1,cen} = Max\ \theta^1 \times \theta^2 = Max\,\theta_o \times \sum_{r=1}^{s} \mu_r y_{ro}^2 \\
&\quad s.t\quad \sum_{l=1}^{L} \Omega_l y_{lo}^{ud} + \sum_{d=1}^{D} \omega_d z_{do} = 1; \\
&\quad\quad \sum_{d=1}^{D} \omega_d z_{dj} + \omega_o y_j^1 - \sum_{i=1}^{m} v_i x_{ij} \le 0; \\
&\quad\quad \sum_{r=1}^{s} \mu_r y_{rj}^2 - \sum_{l=1}^{L} \Omega_l y_{lj}^{ud} - \sum_{d=1}^{D} \omega_d z_{dj} \le 0; \\
&\quad\quad \sum_{d=1}^{D} \omega_d z_{do} + \omega_o y_o^1 - \theta_o \sum_{i=1}^{m} v_i x_{io} = 0\,;\theta_{\text{o}} \in (0,\theta^{1,\max}]; \\
&\quad\quad v_i, \mu_r, \omega_d, \Omega_l \geqslant 0;\ j = 1,2,\cdots,n; i = 1,2,\cdots,m; r = 1,2,\cdots,s; \\
&\quad\quad l = 1,2,\cdots,L; d = 1,2,\cdots,D
\end{aligned}
\tag{4}
$$

Do as Li (2012) did, let $\theta_o=\theta^{1,\max}-k\Delta\varepsilon$, $\Delta\varepsilon$ is a step size. If $k^{\max} = [\theta^{1,\max}/\Delta\varepsilon]$, k=0,1,2,⋯, $[k^{\max}]+1$ $\theta^{1,cen*}=\max_k \theta^{1,cen}(k)$ $\theta^{1*}=\theta_o(\hat{k})$ $\hat{k}=\max\{k|\theta^{1,cen*}=\theta^{cen}(k)\}$ $\theta^{1,2*}=\theta^{1,cen*}/\theta^{1,1*}$

1.2 Non-Cooperative Model of Bank System

The non-cooperative game also exists in the bank structure. The management, if assume to enlarge the financial business innovations, determines the financial innovation to maximize its profit. So the financial innovation stage is a leader and the tradition stage is a follower.

Adopting the fact that the traditional service is the leader, and the financial innovation stage, the follower, we can solve the liner programming model.

$$
\begin{aligned}
&e^{11} = Max \sum_{d=1}^{D} \omega_d z_{do} + \omega_o y_o^1 \\
&s.t\quad \sum_{i=1}^{m} v_i x_{io} = 1; i = 1,2,\cdots,m; \\
&\quad\quad \sum_{d=1}^{D} \omega_d z_{dj} + \omega_o y_j^1 - \sum_{i=1}^{m} v_i x_{ij} \le 0; d = 1,2,\cdots,D; \\
&\quad\quad v_i, \mu_r, \omega_d, \omega_o \geqslant 0;\ j = 1,2,\cdots,n; i = 1,2,\cdots,m; d = 1,2,\cdots,m.
\end{aligned}
\tag{5}
$$

After we obtain the efficiency for the first stage, the financial innovation stage's efficiency can be expressed as follows:

$$
\begin{aligned}
&e^{12} = Max\ \frac{\sum_{r=1}^{s} u_r y_{ro}^2}{\sum_{l=1}^{L} Q_l y_{lo}^{ud} + \sum_{d=1}^{D} w_d z_{do}} \\
&s.t\quad \frac{\sum_{d=1}^{D} w_d z_{dj} + w_o y_j^1}{\sum_{i=1}^{m} v_i x_{ij}} \leqslant 1; \quad \frac{\sum_{d=1}^{D} w_d z_{do} + w_o y_o^1}{\sum_{i=1}^{m} v_i x_{io}} = e^{11}; \\
&\quad\quad \frac{\sum_{r=1}^{s} u_r y_{rj}^2}{\sum_{l=1}^{L} Q_l y_{lj}^{ud} + \sum_{d=1}^{D} w_d z_{dj}} \leqslant 1; i = 1,2,\cdots,m; r = 1,2,\cdots,s; \\
&\quad\quad v_i, u_r, w_d \geqslant 0;\ j = 1,2,\cdots,n; l = 1,2,\cdots,L; d = 1,2,\cdots,D
\end{aligned}
\tag{6}
$$

Model 6 is equivalent to the following linear model

$$
\begin{aligned}
e^{12} &= Max \ \sum_{r=1}^{s}\mu_r y_{ro}^2 \\
s.t \ & \sum_{l=1}^{L}\Omega_l y_{lo}^{ud} + \sum_{d=1}^{D}\omega_d z_{do} = 1; \\
& \sum_{d=1}^{D}\omega_d z_{dj} + \omega_o y_j^1 - \sum_{i=1}^{m}\nu_i x_{ij} \le 0 \\
& \sum_{r=1}^{s}\mu_r y_{rj}^2 - \sum_{l=1}^{L}\Omega_l y_{lj}^{ud} - \sum_{d=1}^{D}\omega_d z_{dj} \le 0; \\
& \sum_{d=1}^{D}\omega_d z_{do} + \omega_o y_o^1 - e^{11}\sum_{i=1}^{m}\nu_i x_{io} = 0; \\
& \nu_i, \mu_r, \omega_d, \Omega_l \geqslant 0; j=1,2,\cdots,n; i=1,2,\cdots,m; r=1,2,\cdots,s; \\
& l=1,2,\cdots,L; d=1,2,\cdots,D
\end{aligned} \tag{7}
$$

The efficiency for the entire two-stage system for DMUo is $e^{non,1}=e^{11}\times e^{12}$. In a similar way, if the second stage is the leader, the efficiency score for the first stage e^{21} can be obtained by solving a model with the second stage score e^{22} remains unchanged. The overall efficiency of the entire system in this situation is $e^{non,2}=e^{22}\times e^{21}$.

Theorem 1. $e^{11} \ge e^{21}$, $e^{12} \ge e^{22}$, where e^{11} and e^{12} are the efficiencies for the first stage and the second stage, respectively, when stage 1 is assumed the leader. e^{21} and e^{22} are the efficiencies for the first stage and the second stage, respectively, when stage 2 is assumed the leader.

Proof 9

The optimal efficiency for stage 2 as leader is solved by following model:

$$
\begin{aligned}
e^{22} &= Max \sum_{r=1}^{s}\mu_r y_{ro}^2 \\
s.t \ & \sum_{l=1}^{L}\Omega_l y_{lo}^{ud} + \sum_{d=1}^{D}\omega_d z_{do} = 1 \\
& \sum_{r=1}^{s}\mu_r y_{rj}^2 - \sum_{l=1}^{L}\Omega_l y_{lj}^{ud} - \sum_{d=1}^{D}\omega_d z_{dj} \le 0; i=1,2,\cdots,m; r=1,2,\cdots,s; \\
& \nu_i, \mu_r, \omega_d, \Omega_l \geqslant 0; j=1,2,\cdots,n; l=1,2,\cdots,L; d=1,2,\cdots,D
\end{aligned} \tag{8}
$$

The efficiency of stage is:

$$
\begin{aligned}
e^{21} &= Max \ \sum_{d=1}^{D}\omega_d z_{dj} \\
s.t \ & \sum_{i=1}^{m}\nu_i x_{io} = 1; \ \sum_{d=1}^{D}\omega_d z_{dj} + \omega_o y_j^1 - \sum_{i=1}^{m}\nu_i x_{ij} \le 0 \\
& \sum_{r=1}^{s}\mu_r y_{rj}^2 - \sum_{l=1}^{L}\Omega_l y_{lj}^{ud} - \sum_{d=1}^{D}\omega_d z_{dj} \le 0; \\
& \sum_{r=1}^{s}\mu_r y_{ro}^2 - e^{11}(\sum_{l=1}^{L}\Omega_l y_{lo}^{ud} + \sum_{d=1}^{D}\omega_d z_{do}) = 0; \\
& \nu_i, \mu_r, \omega_d, \Omega_l \geqslant 0; j=1,2,\cdots,n; i=1,2,\cdots,m; r=1,2,\cdots,s; \\
& l=1,2,\cdots,L; d=1,2,\cdots,D
\end{aligned} \tag{9}
$$

Denote the optimal solution to model 7 as $(v_i, \mu_r, \omega_d, \Omega_l, \forall i, r, d, l)$, accordingly, the optimal efficiency of stage2 is e^{12}. Let $\zeta = (v_i, \mu_r, \omega_d, \Omega_l, \forall i, r, d, l)$, then ζ is a feasible solution to model 8, as stage 2 is leader, the optimal efficiency e^{22} is bigger than or equal to the efficiency e^{12}. So $e^{12} \leq e^{22}$.Similarly, we can have $e^{11} \geq e^{21}$.

2. DATA AND VARIABLE

Our study consists of financial and management data for two group of four State-Owned Commercial Banks (SOBs) and 15 Joint-Stock Commercial Banks (JSBs). The SOBs are big four bank such as Bank of China (BOC), Agriculture Bank of China (ABC), China Construction Bank (CCB), and Industrial and Commercial Bank of China (ICBC). The remaining 15banks are Industrial Bank (IB), Nanning Bank (NB), China CITIC Bank (CNCB), China Minsheng Bank (CMBC), China Merchants Bank (CMB), Bank of Communications (BOCOM), Hua Xia Bank (HXB), China Everbright Bank (CEB), Shanghai Pudong Development Bank (SPDB), Bank of Ningbo (NBCB), Huishang Bank (HSB), Chongqing Rural Commercial Bank (CQRCB), Ping An Bank (PAB), Beijing Bank (BJB), Bank of Chongqing (CQB). Before the analysis, in the third round of the Chinese banking reform (2003-2011), the Big Four SOBs were transformed into state - controlled joint - stock commercial banks and listed on stock exchanges; a number of NPLs were stripped, and overstaffing was reduced for the SOBs.

The input and output selection for the Chinese bank efficiency measures depend on the research objectives. Expect for bad loans and reserve, deposit is the output of traditional process of bank operation, and latter it's used as input to the financial innovation process. For the purpose of including the appropriate and significant items of the banking system and considering the most commonly used variables for efficiency evaluation in the literature, this article regards the input of the traditional operation sub-process as i) fixed assets (x1), which refer to the asset value of physical capital, and ii) operational cost (x2), which refers to the material resources bank expended iii) staff wages and salaries (x3), which indirectly refers to the payment for the employees. The outputs of the financial innovation sub-process as follows: Net increase in bank advances to customers (y21), which refers to the profit bank earned by the innovation service to help the customers pay fees. Return of Investment (y22), which refers to the profit earned by the financial services. The data used in our study are listed in the appendix.

3. RESULTS AND DISCUSSIONS

Both the overall efficiency and the sub-process efficiency of the system can be obtained from the above two-stage DEA model. Table 1 provides the optimal efficiency for each bank based upon the centralized model ($\Delta\varepsilon$=0.001) and non-cooperative model, where columns 2-4 are the efficiencies when the stage 1 is assumed as a variable based upon the centralized model and columns 5-7 show the results when stage 1 is assumed as leader based upon the non-cooperative model. The first sub-process efficiency measure the performance of the banking system in traditional stage, whereas the second sub-process efficiency measures its performance in financial innovation. Table 1 indicates that there are fewer efficient DMUs identified by the centralized model (no DMU is efficient) than the non-cooperative model (6 and 14 DMUs are efficient). This result implies that the non-cooperative model may overestimate the efficiency of ignore the relationship between the traditional stage and financial innovation stage or disagree with the real bank operation. The differences between the two types of models are further tested and illustrated in the Table 2. On average, the overall efficiency based upon the centralized model is higher than the overall efficiency based upon the non-cooperative model at the significance levels of 5% under the Wilcoxon matched-pairs signed-ranks test. Furthermore, the efficiency of DMU 16 is found to be zero. Base on the model, it means that the second sub-process is infeasible upon the first sub-process find optimal solution. But in real life, DMU 16 (BOC) goes on manage and steady develops purport its efficiency may not be zero.

Table 1
Results Based Upon the Centralized Model with Δε=0.001and the Non-Cooperative Model

Bank	Centralized			Non-Cooperative		
	θ^{cen*}	θ^{1*}	θ^{2*}	$e^{non,1}$	e^{11}	e^{12}
BANK	0.6876	0.8261	0.8323	0.5693	0.8271	0.6884
ABC	0.9872	0.9872	1	0.9766	0.9882	0.9882
IB	0.8667	0.9177	0.9445	0.3343	0.9187	0.3639
NB	0.9303	0.999	0.9313	0.9313	1	0.9313
CEB	0.893	0.9458	0.9442	0.8464	0.9468	0.894
CCB	0.999	0.999	1	1	1	1
ICBC	0.9355	0.999	0.9364	0.9364	1	0.9364
SPDB	0.9304	0.999	0.9314	0.9314	1	0.9314
CMBC	0.8885	0.8885	1	0.7912	0.8895	0.8895
NBCB	0.8369	0.9187	0.911	0.7705	0.9197	0.8378
HXB	0.8869	0.8898	0.9968	0.7909	0.8908	0.8879
BOCOM	0.9597	0.999	0.9607	0.9607	1	0.9607
PAB	0.8909	0.9815	0.9077	0.8763	0.9825	0.8918
CNCB	0.999	0.999	1	1	1	1
BJB	0.7331	0.7331	1	0.5388	0.7341	0.7341
CMB	0.9177	0.9177	1	0	0.9187	0
BOC	0.8128	0.9051	0.898	0.7373	0.9061	0.8137
CQB	0.8219	0.9132	0.9001	0.7522	0.9142	0.8228
HSB	0.7962	0.8935	0.8912	0.713	0.8945	0.7971

Table 2
Paired Samples Test

Paired	Mean	t	Df	Sig.
$\theta^{cen*} - e^{non,1}$	-.1219	-2.328	18	.032

The article illustrates the proposed computation procedure in estimating the estimating the overall efficiency for each commercial bank. Consider Agriculture Bank of China (DMU 1). The maximal score for its first stage is $\theta_1^{1,\max} = 0.6876$ based upon model 2. If we set the step size is Δε=0.001, therefore $[k^{\max}] = [\theta_1^{1,\max} / \Delta\varepsilon] = [0.6876 / 0.001] = 687$, the iteration times are $[k^{\max}]+1=688$, last let $\theta_o = \theta_1^{1,\max} - k\Delta\varepsilon$, $k = 1,2,3,\cdots,[k^{\max}]+1$. Figure 2 graphically show the computation from model (?) for Agriculture Bank of China (DMU 1) corresponding to each k from 0 to 688. For example, when k is equal to 1 or 10, the overall efficiency for Agriculture Bank of China (DMU 1) is 0.6876 and 0.6700, respectively.

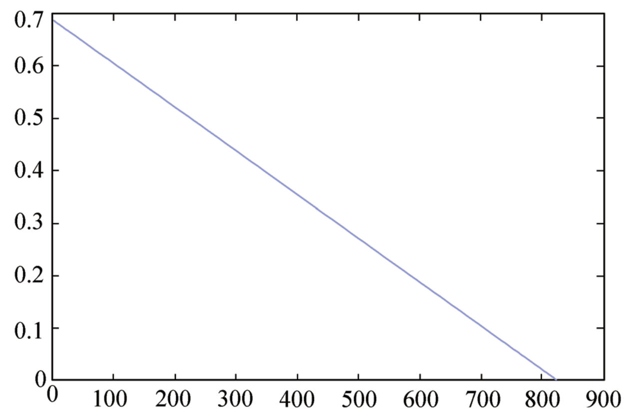

Figure 3
Efficiency Change of ABC Corresponding to Each K

Compare the corresponding efficiency of sub-process in Table 1, the result verify Theorem 1 such that $\theta^{1*} \le e^{1}$, $\theta^{2*} \le e^{12}$. The Kruskal-Wallis test is utilized here, and it further statistically confirms (at the 5% level) that $\theta^{1*} \le e^{1}$, $\theta^{2*} \le e^{12}$.

Furthermore, the results in Table 1 and the Kruskal-Wallis test are consistent with Theorem 1 that $e^{11} > e^{12}$, $e^{12} > e^{22}$.

Table 3 reports the results based upon centralized model with Δε=0.001 and Δε=0.001, respectively. The efficiencies may be increase, whereas the choice of Δε is important.

Table 3
Results Based upon the Centralized Model with Δε=0.001 and Δε=0.001

Bank	Δε=0.001			Δε=0.001		
	θ^{cen*}	θ^{1*}	θ^{2*}	$e^{non,1}$	e^{11}	e^{12}
BANK	0.6876	0.8261	0.8323	0.6883	0.827	0.8323
ABC	0.9872	0.9872	1	0.9881	0.9881	1
IB	0.8667	0.9177	0.9445	0.8676	0.9186	0.9445
NB	0.9303	0.999	0.9313	0.9312	0.9999	0.9313
CEB	0.893	0.9458	0.9442	0.8939	0.9467	0.9442
CCB	0.999	0.999	1	0.9999	0.9999	1
ICBC	0.9355	0.999	0.9364	0.9363	0.9999	0.9364
SPDB	0.9304	0.999	0.9314	0.9313	0.9999	0.9314
CMBC	0.8885	0.8885	1	0.8894	0.8894	1
NBCB	0.8369	0.9187	0.911	0.8377	0.9196	0.911
HXB	0.8869	0.8898	0.9968	0.8878	0.8907	0.9968
BOCOM	0.9597	0.999	0.9607	0.9606	0.9999	0.9607
PAB	0.8909	0.9815	0.9077	0.8917	0.9824	0.9077
CNCB	0.999	0.999	1	0.9999	0.9999	1
BJB	0.7331	0.7331	1	0.734	0.734	1
CMB	0.9177	0.9177	1	0.9186	0.9186	1
BOC	0.8128	0.9051	0.898	0.8136	0.906	0.898
CQB	0.8219	0.9132	0.9001	0.8227	0.9141	0.9001
HSB	0.7962	0.8935	0.8912	0.797	0.8944	0.8912

In order to find which factors may affect bank efficiency, a Tobit regression of profitability efficiency is run on the ratio of nonperformance of loans and the bank system. Because only the listed banks disclose the annual report then y=1,otherwise y=0,so $y = \begin{cases} 1 & if \quad y_1^* \geqslant 0 \\ 0 & if \quad y_1^* < 0 \end{cases}$. We wish to take the fact into account that the efficiency scores are limited to range to the [0, 1] interval, just as $0 \le \theta^{cen*} \le 1$, and there are always one or more observations at the upper limit.

$$\theta^{cen} = \begin{cases} 0 & \theta^{cen*} \le 0 \\ \theta^{cen*} & 0 < \theta^{cen*} \le 1 \quad \theta^{cen*} = \beta^T x_i + e_i \sim N(0, \sigma^2) \\ 1 & \theta^{cen*} > 1 \end{cases}$$

This article considers the effects of undesired output—bad loans and the type of bank. Assumed the variable C_j is associated with the type of bank, so we can set:

Table 4
Tobit Regression Result

	θ^{cen*}			θ^{1*}			θ^{2*}		
	Coeff	StdEr	Prob	Coeff	StdEr	Prob	Coeff	StdEr	Prob
y_1^{ud}	-0.7685	0.1882	0.000	-0.8654	0.1956	0.000	-0.4959	0.3367	0.1410
C_j	0.3763	0.0345	0.000	0.3994	0.0347	0.000	0.4461	0.0499	0.000

Table 4 reports the results for the Tobit estimation. A positive coefficient implies an efficiency increase whereas a negative coefficient means an association with an efficiency decline. The results of the regression are significant at 95% level or higher. The computations were conducted by Eviews. Bad loans has significant negative effect on efficiency indicating that the large and more bad loans lead bank to lower efficiency. On the other hand, the type of bank is significantly positively related to the efficiency, the adverse effect on performance may reflect that the joint-stock bank and else type banks have higher technical efficiency. This may be because the ownership structure of the state-owned bank is unfavorable for bank performance. State owned banks may have goals other than maximization efficiency. Managers in state owned banks may have a different loans police, e.g. a more conservative supply of loans depending on their perceptions of the objective that a state bank should pursue.

CONCLUSION

The objective of this paper was to extend the two-stage DEA model to investigate the real performance in the commercial banking sector. Efficiency lack of "safety, liquidity and profitability", which is the commercial banks' main business objective, motivated this study.

Initially we consider the commercial banking operational process as two-stage model, and the overall efficiency of the banking system can be obtained as same as its sub-process efficiency. In addition, we have involved the bad loans and deposit reserve into DEA model. A further analysis was conducted after proposing the centralized model and non-cooperative model. This was done to calculate the efficiency and detect any possible outlier effects of model on the efficiency measure.

Having obtained the data and variables, we utilize the centralized and non-cooperative two-stage DEA approaches to measure the overall efficiency of 19 major Chinese commercial banks in 2012 and decompose the overall efficiency into traditional stage and financial innovation stage efficiencies.

The performance evaluation of the Chinese commercial banking system in this study first indicates the non-cooperative model may overestimate the efficiency of ignore the relationship between the traditional stage and financial innovation stage or disagree with the real bank operation. Kruskal-Wallis test are consistent with the assumption.

Second the result in Table 1 and Kruskal-Wallis test verify Theorem 1 such that $\theta^{1*} \leq e^{1}$, $\theta^{2*} \leq e^{12}$.

Last, the explanation of the efficiency scores using Tobit regression offers useful economic insights. We interpret the significance of bad loans and the type of bank influence indication of efficiency of large banks. The state-owned bank achieved relative lower efficient, it implies that the state-owned commercial banks are necessary to gradually complete their joint-equity reform.

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Appendix

Bank	Fixed assets	Operational cost	Staff wage and salary	Reserve	Deposit	Bad loans rate%	Net increase in bank advances to customers	Return of Investment
ABC	141490000000	234993000000	47697000000	75349000000	10862935000000	1.33	6153411000000	827708000000
IB	9387000000	41551000000	7435000000	28923000000	1813266000000	0.43	1204542000000	784940000000
NB	2172992000	4156612000	635475000	3599094000	213655802000	0.83	121962186000	549638323000
CEB	11869000000	28405000000	7405000000	28063000000	1426941000000	0.74	997331000000	326171000000
CCB	113946000000	210460000000	32708000000	80483000000	11343079000000	0.99	7309879000000	608345000000
ICBC	132879000000	229487000000	25013000000	189071000000	13642910000000	0.85	8583289000000	965229000000
SPDB	10101000000	38533000000	7214000000	23050000000	2134365000000	0.58	1508806000000	170237000000
CMBC	12161000000	52379000000	7711000000	39480000000	1926194000000	0.76	1351512000000	135429000000
NBCB	2397820000	5297288000	624031000	1499934000	207577270000	0.76	142564629000	894308981000
HXB	7659163757	22575807641	4181414237	12948940286	1036000111752	0.88	699861279357	58206062013
BOCOM	45536000000	72957000000	6899000000	34309000000	3728412000000	0.92	2879628000000	265870000000
PAB	3536443000	22206987000	4863106000	13632932000	1021107702000	0.95	708262390000	213202127000
CNCB	11520000000	47931000000	10578000000	35326000000	2255141000000	0.74	1627576000000	547608000000
BJB	3689440000	13062066000	496817000	13348925000	713772465000	0.59	483445288000	148943216000
CMB	19287000000	54254000000	4056000000	39195000000	2532444000000	0.61	1863325000000	913430000000
BOC	150324000000	178786000000	28833000000	131909000000	9173995000000	0.95	6710040000000	1209594000000
CQB	1015688000	2126866000	142024000	1010330000	114043185000	0.33	75256873000	62387144000
HSB	1404413000	3598700000	1155569000	1472380000	239543123000	0.58	159941475000	45926089000
CQRCB	3153823000	6586185000	2689662000	2847848000	294510490000	0.98	167614916000	12015400000