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Frontier Analysis of Nepalese and Chinese Commercial Banks: DEA Approach

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Abstract

In this paper, frontier analysis of operational efficiency (including technical, pure technical and scale efficiencies) between Nepalese and Chinese commercial banks are used by using data envelopment analysis (DEA) approach. Two DEA models (Models A and B) are used to show how efficiency scores vary with change in input and output variables over the period of 2012 and 2013. The result shows that the mean operational efficiency score of Chinese banking industry is higher than that of Nepalese banking industry except pure technical efficiency score in 2013. In terms of technical and pure technical efficiencies, the performance of China's 5 state-owned banks is better than that of Nepal's 3 state-owned banks, and China's other banks, respectively; however, in term of scale efficiency, the performance of China's 5 state-owned banks is worse than that of Nepal's 3 state-owned banks, and China's other banks, respectively.

Keywords: Data envelopment analysis, Banking industry, Nepal, China.

1. Introduction

The objective of this paper is to make frontier analysis of operational efficiency (including technical, pure technical and scale efficiencies) between Nepalese and Chinese commercial banks (CBs) in recent years. While many similar studies have evaluated the performance of banking industries in different countries, very few studies have evaluated the performance of banking sectors between Nepalese and Chinese economies.

Organization DMU, (decision making unit) management gets people together for organizational strategic objectives and enables the optimal use of scarce resources through planning, organizing, leading and control at the workplace. A commercial bank (CB), which is a special service organization, is a type of bank that provides services such as accepting deposits, making business loans, and offering basic investment products. The efficiency of a CB is most important factor for survival and growth in the banking industry.

It is well known that based on Farrell's [8] original work, data envelopment analysis (DEA) is a frontier analysis approach to efficiency measurement of DMUs with multi-inputs and multi-outputs using a linear programming technique, by Charnes, Cooper and Rhodes [3]. In this paper, following the previous scholars' study and using the frontier analysis method with the latest available published data, we make comparative analysis of operational efficiency between Nepalese and Chinese CBs for the span of two years, 2012 and 2013, respectively.

2. A brief overview of the Nepalese and Chinese banking industry

The Republic of Nepal is one of the landlocked countries in world. Land-lockedness is one of the geographic constraints of Nepal that is one of the major hindrances for the overall development of the country. Being in the middle of economically giant nations like India and China, Nepal has opportunity to develop its own indigenous methodologies for multiple growths, economically and socially. In 2013, the economy is passing through the stage of a low economic growth, high inflation, high consumption and low savings. The challenge of channelizing resources towards the productive sectors to restore overall economic health and also the sustainability of the banking sector [10].

The Commercial banks (CBs) of Nepal hold 80% of total financial asset of financial system of the country. In 2012-13, there are 31 CBs: 3 big state-owned banks (Rastriya Banijya, Agricultural Development and Nepal Bank), 28 joint venture and private banks which are coping with modern banking facilities and are mostly computer based [10].

The population of the People's Republic of China in 2013 is about 1.36 billion. At the end of 2013, the Chinese banking industry had 3,949 financial institutions with 3.55 million employees. The banks include: 5 large and state-owned CBs (Industrial & Commercial Bank of China, China Construction Bank, Agricultural Bank of China, Bank of China and Bank of Communications), 12 joint-stock CBs, 145 city CBs, 468 rural CBs, 122 rural cooperative banks, 1,803 rural credit cooperatives, one postal savings bank and 42 foreign financial institutions, etc. [4].

Since July 2013, the Chinese banks have been free to set their own lending rates. In comparison to their counterparts, the 5 state-owned CBs exhibit strong capabilities and competitiveness compared to either in terms of financial indicators: such as asset scale and profitability. E.g., at the end of 2013, the total sum of assets of 5 big banks is RMB 11.254 trillion (approximately, $1.844 trillion), hold 43.34% of total financial asset of the Chinese banking financial institutions [4].

3. Methodology

3.1. Data envelopment analysis

DEA the Charles, Cooper and Charnes model i.e. CCR model [3] is a frontier analysis model concerning the ratio of multi-outputs to multi-inputs of using scarce resources to produce valuable items of a DMU subjected to the condition that the similar ratios for all

other DMUs be less than or equal to one. The model does not require a priori weights on inputs and outputs.

Suppose there is a set of N DMUs. Each DMUn (n =1, ..., N) produces J different outputs y^n_j (j =1, ..., J) utilizing I different inputs x^n_i (i =1, ..., I); (x^n, y^n) is a positive known input-output vector for the DMUn. The fractional programming model (Charnes, et al., 1978; Cooper et al., 1999) used as below:

$$FE_t = \max \frac{\sum_{j=1}^{J} u_j y_j^t}{\sum_{i=1}^{I} v_i x_i^t}$$

$$\begin{aligned} s.t. \quad & \frac{\sum_{j=1}^{J} u_j y_j^n}{\sum_{i=1}^{I} v_i x_i^n} \le 1, \qquad n = 1, \cdots, N; \\ & v_i, u_j \ge \varepsilon > 0; \qquad i = 1, \cdots, I; j = 1, \cdots, J, \end{aligned} \tag{3.1}$$

where ε is a non-Archimedian infinitesimal; and (v, u) is the variable input-output weight vector; The DMUt (t =1,…, N) is measured for the optimal objective value FE_t with the optimal solution (v^*, u^*) in (3.1).

It can be proved that the model (3.1) is equivalent to the linear programming model, i.e., the CCR model (Charles, Cooper and Rhodes model) (3.2) which assumes the existence of constant returns-to-scale (CRS). The maximum, TE_t (=FE_t) of the objective function given by the CCR model (3.2) is called relative technical efficiency (TE) of DMUt. There is that TE $\le$ 1.

$$TE_t = \max \sum_{j=1}^{J} u_j y_j^t$$

$$\begin{aligned} s.t. \quad & \sum_{j=1}^{J} u_j y_j^n - \sum_{i=1}^{I} v_i x_i^n \le 0, \qquad n = 1, \cdots, N; \\ & \sum_{i=1}^{I} v_i x_i^t = 1, \\ & v_i, u_j \ge \varepsilon > 0; \qquad i = 1, \cdots, I; j = 1, \cdots, J. \end{aligned} \tag{3.2}$$

TE can be decomposed as the product of pure technical efficiency (PTE) and scale efficiency (SE): PE =PTE×SE. Banker, et al. [2] extended the CCR model (3.2) to BCC model for obtaining PTE score by assuming the existence of variable returns-to-scale (VRS). TE score expresses the global operational efficiency of a DMU, since it takes no count of scale effect, but PTE score expresses the local PTE of the DMU under VRS conditions. SE, which is obtained by PE/PTE, expresses the efficiency of operating in productive scale size of the DMU. Generally, if the efficiency score is equal to value one

then the DMU is called efficient relatively, however, if the value is less than one then the DMU is called inefficient relatively.

As results more than 5000 theoretical studies on DEA models as well as applications in the real world are reported in the literature. See, for examples, Cooper et al. [5] and Emrouznejad, et al. [6, 7]. In the banking sector, for examples, Avkiran [1], Sathye [11] measured the productive efficiency (i.e. TE) of banks in Australia and India by using DEA, respectively. Two models (see also Section 3.2 of this paper) in their study have been constructed and used to show how efficiency scores vary with change in inputs and outputs. Following their works, Zhu et al. [12, 13] studied the TE of China's main CBs, respectively.

Hada and Tamang [9] measured the relative efficiency of Nepalese CBs using DEA approach with two input variables **(**total expenses, and total deposit) and two output variables **(**total loans and advances, and total investment) for the five years: 2006-2010.

3.2. Two Models and solving

In this paper, following the previous scholars' work, two models (Model A and Model B) are used to show how efficiency scores vary with change in input and output variables:

	Model A	**Model B**
Inputs	Interest expense (IE)	Deposits (Deposits)
	Non-interest expense (NIE)	Staff numbers (Employees)
Outputs	Net interest revenue (NIR)	Net loans (Loans)
	Non-interest operating income (NIOI)	Non-interest operating income (NIOI)

Data used in this study is gathered from Bankscope database and annual reports of the banks from 2012 to 2013. Through data cleansing, we have got the samples of 31 Nepalese CBs and 100 Chinese CBs in 2012 and 2013. Nepalese samples consist of 3 state-owned CBs, 22 domestic private CBs and 6 foreign CBs in Nepal (Nabil Bank, Himalayan Bank, Everest Bank, Nepal SBI Bank, Standard Chartered Bank and Nepal Bangladesh Bank). Chinese samples consist of 5 state-owned CBs, 12 joint-stock CBs, 54 city CBs, 15 rural CBs and 14 foreign CBs in China.

The DEA problems are solved in the paper using the computer software DEA-Solver. The operational efficiency (including TE, PTE and SE) is calculated in the input-oriented measure.

4. Results

The DEA results of the analysis are discussed in the following. Tables 4.1 and 4.2 show descriptive statistics results on total 131 samples of Model A and B in 2012-2013, (Employee Unit: Person; Monetary Unit: 1,000 US dollars).

Table 4.1 Descriptive Statistics of Model A

2013 Model A	IE	NIE	NIR	NIOI
Max	53057156.02	27974566.43	72665833.90	22032806.01
Min	6001.03	2311.34	3178.96	0.00
Average	2825003.26	1360505.62	3271244.44	897488.77
SD	8051854.61	4581535.25	10946429.67	3335615.90

2012 Model A	IE	NIE	NIR	NIOI
Max	48271907.84	25029889.92	66439358.37	17596985.01
Min	2947.99	1384.62	1321.74	0.00
Average	2455438.07	1186118.92	2874002.39	728345.28
SD	7443588.81	4075385.23	9749768.70	2812310.62

Table 4.2 Descriptive Statistics of Model B

2013 Model B	Employees	Deposits	Loans	NIOI
Max	478980	2395913820.70	1586492964.82	22032806.01
Min	132	102691.75	93104.12	0.00
Average	17780.64	102532028.90	68660306.18	897488.77
SD	68640.99	353716637.09	236831042.52	3335615.90

2012 Model B	Employees	Deposits	Loans	NIOI
Max	461100	2169121982.44	1364679591.93	17596985.01
Min	131	50644.34	47269.60	0.00
Average	16625.16	89526360.69	58673663.16	728345.28
SD	65796.89	316678712.73	203898538.95	2812310.62

Table 4.3 shows that by using two DEA models, the mean operational efficiency score of all 131 sample CBs of two countries in 2012 and 2013, respectively.

Table 4.3 Mean operational efficiency score

Model A	2013 TE	2013 PTE	2013 SE	2012 TE	2012 PTE	2012 SE
All 131	0.7014	0.8008	0.8840	0.6680	0.7836	0.8524
CH100	0.7355	0.7961	0.9281	0.7318	0.8154	0.9033
NE31	0.5915	0.8157	0.7418	0.4623	0.6808	0.6882
Model B	2013 TE	2013 PTE	2013 SE	2012 TE	2012 PTE	2012 SE
All 131	0.7277	0.7844	0.9311	0.6852	0.7468	0.9250
CH100	0.7297	0.7741	0.9453	0.7086	0.7609	0.9386
NE31	0.7211	0.8178	0.8851	0.6098	0.7012	0.8811

Through Table 4.3, we see that the mean technical efficiency (TE) scores of the whole banking samples, obtained from either Model A or Model B, are increased from 2012 to 2013. The mean scale efficiency (SE) scores in 2012 and 2013 are higher than the mean pure technical efficiency (PTE) scores, respectively, except Nepalese banking industry of Model A in 2013 (0.8157>0.7418).

Comparative analysis could be made. Mean operational efficiency score of Chinese banking industry is higher than the corresponding score of Nepalese banking industry except PTE score in 2013 (0.7961<0.8157 and 0.7741<0.8178).

Using TE=PTE×SE, we can make further factor analysis on TE. In Tables 4.4 and 4.5, "CH5State" means 5 Chinese state-owned banks, "CH95Others" means other 95 Chinese CBs, "CH12N" means 12 joint-stock banks, "CH54City" means 54 city CBs, "CH15Rural" means 15 rural CBs, "CH14Foreign" means 14 Foreign CBs in China; "NE3S" means 3 Nepalese state-owned banks, "NE28Others" means other 28 CBs, "NE22DP" means 22 domestic private banks, and "NE6F" means 6 foreign CBs in Nepal.

Table 4.4 Mean operational efficiency score of Model A

Model A	2013TE	2013PTE	2013SE	2012TE	2012PTE	2012SE
All 131	0.7014	0.8008	0.8840	0.6680	0.7836	0.8524
CH100	0.7355	0.7961	0.9281	0.7318	0.8154	0.9033
NE31	0.5915	0.8157	0.7418	0.4623	0.6808	0.6882
CH5State	0.8382	0.9741	0.8606	0.7734	0.9816	0.7872
CH95Others	0.7301	0.7868	0.9317	0.7296	0.8067	0.9094
CH12N	0.7262	0.8602	0.8468	0.6460	0.8631	0.7503
CH54City	0.7732	0.8132	0.9534	0.7479	0.8106	0.9255
CH15Rural	0.7416	0.7855	0.9459	0.7974	0.8621	0.9268
CH14Foreign	0.5549	0.6231	0.9053	0.6577	0.6839	0.9649
NE3S	0.5158	0.5397	0.9581	0.5139	0.5580	0.9227
NE28Others	0.5996	0.8452	0.7187	0.4568	0.6939	0.6631
NE22DP	0.5632	0.8549	0.6690	0.4078	0.6878	0.6044
NE6F	0.7331	0.8097	0.9007	0.6366	0.7164	0.8785

Table 4.5 Mean operational efficiency score of Model B

Model B	2013TE	2013PTE	2013SE	2012TE	2012 PTE	2012SE
All 131	0.7277	0.7844	0.9311	0.6852	0.7468	0.9250
CH100	0.7297	0.7741	0.9453	0.7086	0.7609	0.9386
NE31	0.7211	0.8178	0.8851	0.6098	0.7012	0.8811
CH5State	0.7625	0.9539	0.7940	0.7235	0.9543	0.7544
CH95Others	0.7280	0.7646	0.9533	0.7078	0.7507	0.9483
CH12N	0.8963	0.9301	0.9641	0.8675	0.9384	0.9253
CH54City	0.6839	0.7053	0.9690	0.6573	0.6881	0.9609
CH15Rural	0.7419	0.7851	0.9425	0.7181	0.7694	0.9353
CH14Foreign	0.7388	0.8294	0.8950	0.7546	0.8114	0.9334
NE3S	0.6063	0.6389	0.9507	0.5120	0.5382	0.9505
NE28Others	0.7334	0.8369	0.8781	0.6203	0.7186	0.8737
NE22DP	0.7096	0.8346	0.8541	0.6212	0.7357	0.8557
NE6F	0.8208	0.8454	0.9662	0.6169	0.6561	0.9398

Through Tables 4.4 - 4.5, we see that, in terms of TE and PTE, the performance of China's 5 state-owned CBs is better (higher) than that of Nepal's 3 state-owned CBs, and China's other CBs, respectively; however, in term of SE, the performance of China's 5 state-owned CBs is worse (lower) than that of Nepal's 3 state-owned CBs, and China's other CBs, respectively, in both of models. In term of TE, the performance of foreign CBs in China is worse than that of foreign CBs in Nepal in 2013; however, it is better than foreign CBs in Nepal in 2012, by using both of models.

By using Model A and Model B, Sathye [11] discussed three groups of indian banks for the year 1997, that is, publicly owned, privately owned and foreign owned, and obtained that the efficiency of private sector banks as a group is lower than that of public sector banks and foreign banks in India.

Through Tables 4.4 - 4.5 in this paper, it can be seen that, in the term of TE, the performance of Nepal's 3 state-owned banks is worse than that of Nepal's 22 domestic private CBs, and 6 foreign CBs, respectively, except model A in 2012; in 2012, the performance of Nepal's 3 state-owned banks is better than that of Nepal's 22 domestic private CBs (0.5139>0.4078), however, worse than that of 6 foreign CBs in Nepal in Model A (0.5139<0.6366).

5. Conclusion

In this paper, we make frontier analysis of operational efficiency (including TE, PTE and SE) between Nepalese and Chinese commercial banks in 2012 and 2013 by using DEA approach. Two DEA models (Models A and B) have been used to show how efficiency scores vary with change in input and output variables.

The mean technical efficiency scores of the whole banking industry, obtained from either Model A or Model B, are increased from 2012 to 2013. The mean SE scores are higher than the mean PTE scores, respectively, except Nepalese banking industry of Model A in 2013.

The mean operational efficiency score of Chinese banking industry is higher than the corresponding score of Nepalese banking industry at the same time except PTE score in 2013. In term of PTE, the performance of Chinese banking industry is worse than that of Nepalese banking industry in 2013.

In terms of TE and PTE, the performance of China's 5 state-owned CBs is better than that of Nepal's 3 state-owned CBs, and China's other CBs, respectively; however, in term of SE, the performance of China's 5 state-owned CBs is worse than that of Nepal's 3 state-owned CBs, and China's other CBs, respectively, in both of models. In term of TE, the performance of foreign CBs in China is worse than that of foreign CBs in Nepal in 2013; however, it is better than foreign CBs in Nepal in 2012, by using both of models.

In term of TE, the performance of Nepal's 3 state-owned banks is worse than that of Nepal's 22 domestic private CBs, and 6 foreign CBs, respectively, except model A in

2012; in 2012, the performance of Nepal's 3 state-owned banks is better than that of Nepal's 22 domestic private CBs, however, worse than that of 6 foreign CBs in Model A.

Being a friendly neighbor each other, the baking industries of Nepal and China have many opportunities to learn from each other and develop their own indigenous methodologies for multiple growths economically of two countries. The next step of this study could collect more samples and use DEA Malmquist index method to conduct the study, make further competitive power analysis on both of banking industries of Nepal and China, in order to promot development of two countries healthily and sustainablly.

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