A Study of Efficiency Valuation in Bank Industry – Evidence from Taiwan

Iuan-yuan Liu, Wen-hua Shen, and Wei-wen Hsiao

Abstract This study adopt fixed assets, SG&A (selling, general and administrative expenses) and interest expenses as input factors, use the amounts of loans and revenues as output factors, and employ Data Envelopment Analysis (DEA) to evaluate the efficiency performance and relative efficiency of commercial banks according to Farrell's efficiency evaluation theory. We group all sample commercial banks into three categories, namely "Old Commercial Banks", "New Commercial Banks" and "Commercial Banks Upgraded from Credit Cooperatives" and evaluate the efficiency of commercial banks, including overall efficiency, overall technical efficiency, pure technical efficiency, scale efficiency, and allocation efficiency. The empirical results find that the "Old Commercial Banks" possess highest efficiency value than the other two groups. Besides, the "Old Commercial Banks" also have the highest overall technical efficiency, pure technical efficiency and allocative efficiency. It implies that the "Old Commercial Banks" is doing well in competing with the new entrants, which makes them keep better efficiency than both the "New Commercial Banks" and the "Commercial Banks Upgraded from Credit Cooperatives".

Keywords Allocation efficiency • Overall efficiency • Overall technical efficiency • Pure technical efficiency • Scale efficiency

I. Liu • W. Hsiao
Department of Business Management, National Sun Yat-sen University, Kaohsiung, Taiwan
e-mail: iylu@bm.nsysu.edu.tw; d004010012@student.nsysu.edu.tw

W. Shen (✉)
Department of Accounting, National Kaohsiung University of Applied Sciences, Kaohsiung, Taiwan
e-mail: whshen@kuas.edu.tw

E. Qi et al. (eds.), *Proceedings of 2013 4th International Asia Conference on Industrial Engineering and Management Innovation (IEMI2013)*,
DOI 10.1007/978-3-642-40060-5_43,

1 Introduction

The economic environment is not that benefit to banks like past decades and the competition in banks industry becomes fiercer than before. From the point view of utilization of resources, a commercial bank must endeavor to maximize the utilization of resources owned to create advantages and margins in order to survive in poor economic conditions and high competitive environment. Thus, we employ Data Envelopment Analysis (hereafter DEA) to measure the efficiency of commercial banks, attempt to delineate a picture of efficiency assessment of commercial banks in Taiwan and try to capture the reason of assets utilization inefficiency in some commercial banks.

To assess the efficiency of commercial banks in Taiwan, we employ following steps to implement DEA process. First, we consider banks industry environment, and discuss with some senior bankers to find out important input variables and output variables of commercial banks, which will be used as main variables to assess efficiency value in our study. Second, we use Charnes et al.'s model (hereafter CCR model) [1] to estimate "Overall Technical Efficiency (OTE)", "Scale Efficiency (SE)", and "Allocative Efficiency" for all individual commercial banks. These estimated values range between 0 and 1. The higher the value is, the more efficient the commercial bank is. We use these efficiency values to make comparison among commercial banks, which enable us to identify which is the most efficient commercial bank and which is the worst. Then, we can provide some suggestions regarding to resources inputs and allocation decisions to individual commercial bank according to efficiency evaluation results. Third, As the CCR model assume a constant return to scale when make efficiency evaluation, Banker et al. [2] develop another model as an adjustment of "constant return to scale" assumption and an alternative model of CCR model, which is called BCC model. We adopt BCC model to measure "Pure Technical Efficiency (TPE)" as well as "Scale Efficiency (SE)" and identify the causes of inefficiency of TPE and SE, which will be useful to provide advices to individual bank about whether to increase scale, maintain recent scale, or to down size scale. Fourth, we divide commercial banks into three groups, i.e., "New Commercial Banks", "Old Commercial Banks" and "Commercial Banks Upgraded from Credit Cooperatives" according to their ages, scales and characteristics, then compare the overall efficiency of these groups to investigate whether there are significant efficiency deviations among them. Besides, we employ "Slack Variables Analysis" to examine the reason of inefficiency in these commercial banks and give some improvement directions to those relatively inefficient commercial banks.

Our study contributes to extant literatures in two ways. First, we select input and output variables according to the suggestion of senior bankers which will make empirical results more precisely in gauging commercial bank's efficiency. Second, we find that the "Old Commercial Banks" have highest efficiency values in overall efficiency, overall technical efficiency, pure technical efficiency and allocative efficiency. That means that the new entrants like"New Commercial Banks" and

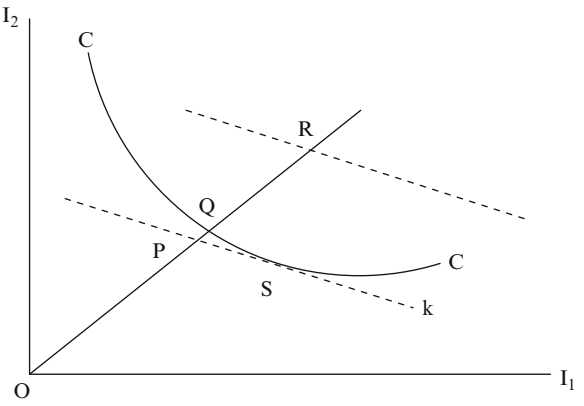

Fig. 1 Overall and allocative efficiency

"Commercial Banks Upgraded from Credit Cooperatives" may be given too much expectation on their performance just because they are new to the market. In contrast with the other two groups, the relatively high efficiency value of the "Old Commercial Banks" may imply that although the "Old Commercial Banks" confront with fiercer competition than before, they still keep a lot of advantages in the market, which will make them easier to compete with the new entrants having relatively less resources. Furthermore, as the competition in banks industry is getting fiercer than before, it may push the "Old Commercial Banks" to adjust their traditional mindset, move forward and refocus on what they live by. Thus, maybe more competition is the best way to push old financial institutions like the "Old Commercial Banks" to improve efficiency.

Plenty of prior studies use DEA model to evaluate the management efficiency of banks [3–8]. Efficiency usually represents the ratio of output over input, which mean using fewer amounts of input than needed as usual, but producing same amount of output as it used to be, or using same units of input as usual but generating more output than it used to be. High efficiency means high productivity and more cost savings. Robin [9] indicates efficiency as the relationship between input and output. Norman and Stoker [10] define efficiency as "the use made of resources in the attainment of outputs, in the context of environmental factors". The other definition provided by Cooper et al. [11] expressing efficiency as an extension statement of Pareto-Koopmans's definition, which refers "full efficiency is attained by any decision making units (hereafter DMU) if and only if none of its inputs or outputs can be improved without worsening some of its other inputs or outputs." They also defines relative efficiency as "if and only if the performances of other DMUs does not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs". Farrell's argument [12] about efficiency is a fundamental cornerstone of the theory of efficiency measurement. He decomposed overall economic efficiency into components of technical efficiency and allocative efficiency, which is presented as Fig. 1.

In Fig. 1, the curve CC represents an "isoquant" outputs produced by two different amounts of inputs (I_1, I_2). This curve means the "efficiency frontier" of the "production possibility set", for which with an output on the isoquant, it is not possible to reduce the input of I_1(or I_2) without increasing the other input I_2(or I_1). The dashed line k represents isocost line (or budget line) for which (I_1, I_2) pairs on this lines yield the same total cost with unit costs of I_1 and I_2 separately. As the k intersects the production possibility set at S and represents the minimum cost needed to produce a specific output, thus point S is therefore said to be "allocatively" as well as "technically" efficient. Furthermore, the point P intersects the cost line k with the ray from O to R. Using a radial measure, the ratio of OP over OR is identified as "overall efficiency". The ratio of OQ over OR is deemed as a radial measure of "technical efficiency", which is similar to refer "the amount of waste that can be eliminated without worsening any input or output". Technical efficiency is further distinguished by Farrell from "allocative efficiency" and "scale efficiencies". In Fig. 1, the ratio of OP over OQ is called as a radial measure of "allocative efficiency" which is also referred to as "price efficiency" by Farrell [12]. Thus, the product of allocative efficiency and technical efficiency will exactly equal to overall efficiency in these radial measures. According to Farrell's decomposition of efficiency [12], the technical efficiency can be further divided into "pure technical efficiency" and "scale efficiency".

2 Methodology

Using commercial banks' data collected from Taiwan Economic Journal (TEJ) databank and official publications of Bank Associations, We adopt DEA models to measure the efficiency of a DMU relative to similar DMUs, which make it possible to estimate a 'best practice' frontier. The initial DEA model was built on the earlier work of Farrell [12], and originally provided by Charnes et al. [1].

Regarding to DEA procedure, Golany and Roll [13] suggest following three steps in implementing DEA process: (1) define and select decision making units (DMUs); (2) seek for appropriate input and output items or analysis; (3) apply DEA model to implement efficiency evaluation. Golany and Roll [13] also suggest that the number of DMUs should be at least two times of the total number of input and output items according to rule of thumb. We collect financial and fundamental data of 38 commercial banks (as decision making units in DEA measurement) in Taiwan during the period of 2001, which is about 10 year after the banks industry deregulation, and divide those commercial banks into three groups named as "Old Commercial Banks" and "New Commercial Banks" and "Commercial Banks Upgraded from Credit Cooperatives". The number of commercial banks in those three groups is 10, 16, and 12 respectively. Then, we define input and output variables of commercial banks in accordance with theother literatures and

discussion with senior bankers. We use fixed assets, interest expenses and Selling, General and Administration Expenses (SG&A expenses) as main input variables, which represent long-term assets inputs, capital inputs, and manpower inputs respectively. Second, we use the total amount of loans and revenues as output variables which are generated by the inputs mentioned above. Finally, we implement DEA model to estimate the efficiency value of the sample banks.

3 Results

We implement CCR model to measure the "overall efficiency" of commercial banks in Taiwan using input and output data collected from TEJ. Table 1 presents the results of Slack Variable Analysis, which indicates that how many inputs should be saving and how many outputs need to be increased for individual commercial banks in order to enhance their efficiency. In average, the results shows that the commercial banks should save inputs of fixed assets by 27.66 % less than current investment amount, about 8.83 % saving in SG&A, and 4.62 % saving in interest expenses. On the other hand, they should increase the amount of loans by 2.37 % and augment revenues by 1.10 %.

Table 2 shows the overall efficiency, overall technical efficiency, pure technical efficiency, scale efficiency and allocative efficiency of commercial banks respectively. We show all the efficiency by groups and exhibit the average efficiency value on Table 3.

The results in Table 3 shows that the average of overall efficiency value of all commercial banks, "Old Commercial Banks", "New Commercial Banks", "Commercial Banks Upgraded from Credit Cooperatives" is 0.9259, 0.9743, 09419 and 0.9003 respectively, which indicates the "Old Commercial Banks" possess the higher overall efficiency than the other groups. And only the average efficiency value of "Old Commercial Banks" is above the overall average. Besides that, the "Old Commercial Banks" also have the highest overall technical efficiency, pure technical efficiency and allocative efficiency.

The results of Table 4 indicates that the mean overall efficiency, overall technical efficiency and scale efficiency of the "Old Commercial Banks" are all significantly larger than those of the "Commercial Banks Upgraded from Credit Cooperatives" at $\alpha = 0.1$ significance level. The mean pure technical efficiency of the "Old Commercial Banks" is significantly larger than that of the "New Commercial Banks" at $\alpha = 0.1$ significance level. Finally, the mean scale efficiency of the "New Commercial Banks" is significantly larger than that of the "Commercial Banks Upgraded from Credit Cooperatives" at $\alpha = 0.1$ significance level. As for the allocative efficiency, there is no significant difference among the three groups at $\alpha = 0.1$ significance level.

Table 1 Slack variable analysis of inputs and outputs

	Inputs saving needed			Outputs improvement needed	
Code of bank	Fixed assets	SG&A	Interest expenses	Loans	Revenues
A1	0	0	0	0	0
A2	0	0	0	0	0
A3	10,827	1,606	2,491	0	0
A4	0	0	0	0	0
A5	13,183	301	579	0	3,503
A6	5,385	864	1,653	84,981	0
A7	12,187	133	219	0	0
A8	3,013	129	137	0	0
A9	1,289	180	290	0	0
A10	2,287	213	466	0	0
B1	887	3,111	981	0	0
B2	327	586	971	0	328
B3	302	636	645	25,278	0
B4	0	0	0	0	0
B5	214	490	463	0	0
B6	0	0	0	0	0
B7	2,801	222	421	13,613	0
B8	2,004	37	64	0	0
B9	2,192	205	363	0	0
B10	2,028	703	1,359	0	798
B11	4,092	10,067	2,347	0	3,350
B12	0	0	0	0	0
B13	0	0	0	0	0
B14	1,699	260	467	0	0
B15	957	242	537	0	0
B16	340	623	972	0	360
C1	4,595	759	866	77,523	0
C2	1,532	458	659	0	0
C3	6,001	464	698	0	0
C4	4,796	954	164	0	26
C5	1,269	266	522	0	0
C6	1,711	97	225	0	0
C7	1,220	294	420	0	0
C8	5,006	468	872	0	303
C9	0	0	0	0	0
C10	1,268	57	125	0	0
C11	228	1,202	372	0	0
C12	1,688	121	185	0	0
Improvement ratio needed	27.66 %	8.83 %	4.62 %	2.37 %	1.10 %

Unit: Million; A1–A10: the substitute name of bank, represent 10 “Old Commercial Banks”; B1–B16: the substitute name of bank, represent 16 “New Commercial Banks”; C1–C12: the substitute name of bank, represent 12 “Commercial Banks Upgraded from Credit Cooperatives”

Table 2 Decomposition of overall efficiency of commercial banks

Code of banks	Overall technical efficiency	Pure technical efficiency	Scale efficiency	Allocative efficiency	Return on scale
A1	1	1	1	1	C
A2	1	1	1	1	C
A3	0.8417	1	0.8417	0.9979	D
A4	1	1	1	1	C
A5	0.9850	1	0.9850	0.9944	D
A6	0.9423	1	0.9423	0.9996	D
A7	0.9900	1	0.9900	0.9999	D
A8	0.9724	0.9836	0.9886	0.9979	D
A9	0.9424	0.9438	0.9985	0.9917	D
A10	0.9869	0.9880	0.9989	1	D
B1	0.8684	0.8872	0.9788	0.9970	D
B2	0.8904	0.9844	0.9045	0.9978	D
B3	0.9176	0.9253	0.9917	0.9082	D
B4	1	1	1	1	C
B5	0.9344	0.9365	0.9978	0.9992	I
B6	1	1	1	1	C
B7	0.9551	0.9722	0.9824	0.9998	D
B8	0.9929	0.9985	0.9944	1	D
B9	0.9539	0.9557	0.9981	0.9999	D
B10	0.8138	0.8268	0.9843	0.9959	I
B11	0.7195	0.7387	0.9740	0.9252	I
B12	1	1	1	1	C
B13	1	1	1	1	C
B14	0.9387	0.9724	0.9653	0.9999	D
B15	0.9258	0.9276	0.9981	0.9986	I
B16	0.8782	0.9219	0.9526	0.9971	D
C1	0.9771	1	0.9771	0.9998	D
C2	0.9061	0.9066	0.9994	1	I
C3	0.8911	0.8963	0.9942	0.9999	I
C4	0.9562	1	0.9562	0.9426	I
C5	0.8624	0.913	0.9446	0.9964	I
C6	0.9260	0.9978	0.9280	0.9821	I
C7	0.7856	1	0.7856	0.9957	I
C8	0.9185	0.928	0.9898	0.9941	I
C9	1	1	1	1.0000	C
C10	0.9563	1	0.9563	0.9862	I
C11	0.8191	1	0.8191	0.9886	I
C12	0.9173	1	0.9173	0.9934	I

C constant return to scale, *D* decreasing return to scale, *I* increasing return to scale; A1–A10: the substitute name of bank, represent 10 "Old Commercial Banks"; B1–B16: the substitute name of bank, represent 16 "New Commercial Banks"; C1–C12: the substitute name of bank, represent 12 "Commercial Banks Upgraded from Credit Cooperatives"

Table 3 Efficiency comparison among three groups

Group	Efficiency	Mean	SD	Maximum	Minimum	Number
All	OE	0.9259	0.0744	1.0000	0.6657	38
	OTE	0.9333	0.0670	1.0000	0.7195	
	PTE	0.9633	0.0570	1.0000	0.7387	
	SE	0.9688	0.0477	1.0000	0.7856	
	AE	0.9915	0.0205	1.0000	0.9082	
Old Commercial Banks	OE	0.9743	0.0263	1.0000	0.9346	10
	OTE	0.9761	0.0249	1.0000	0.9417	
	PTE	0.9915	0.0178	1.0000	0.9438	
	SE	0.9845	0.0231	1.0000	0.9417	
	AE	0.9981	0.0029	1.0000	0.9917	
New Commercial Banks	OE	0.9149	0.0907	1.0000	0.6657	16
	OTE	0.9243	0.0776	1.0000	0.7195	
	PTE	0.9405	0.0726	1.0000	0.7387	
	SE	0.9826	0.0252	1.0000	0.9045	
	AE	0.9887	0.0283	1.0000	0.9082	
Commercial Banks Upgraded from Credit Cooperative	OE	0.9003	0.0618	1.0000	0.7822	12
	OTE	0.9096	0.0630	1.0000	0.7856	
	PTE	0.9701	0.0442	1.0000	0.8963	
	SE	0.9390	0.0698	1.0000	0.7856	
	AE	0.9899	0.0160	1.0000	0.9426	

OE overall efficiency, *OTE* overall technical efficiency, *PTE* pure technical efficiency, *SE* scale efficiency, *AE* allocative efficiency

4 Discussion

As efficiency is an important advantage for any kind of organizations, management will seek to pursuit most efficient way to utilize and allocate resources because of the resources scarceness. The increasing competition in banks industry, which is caused by the new entrants, may urge the "Old Commercial Banks" to seek more efficient way to run their business. The "Old Commercial Banks" has more experiences and resources in banks industry. They have plenty of industry-specific knowledge and know how to utilize their resources to create business and generate revenues. They also have strong relationships with clients and strong location advantages to access their customers, which are not easy for a new entrant to build up in a short period. Thus, the "Old Commercial Banks" may be more efficient in utilizing and allocating resources than the "New Commercial Banks". But, the alternative argument indicates that from the standpoint of new entrants in banks industry, the "New Commercial Banks" with relative less resources than "Old Commercial Banks" are more capable of utilizing their resources in a more efficient and economical way because they are new in the industry and will consider and seek an efficient way to run business, which will provide them a new thought about how to utilize resources more efficiently and earn them asustainable advantage

Table 4 Efficiency comparison among the three groups Scheffe's test

Efficiency	Groups (I)	Groups (J)	Deviation of mean between two groups (I-J)	Standard deviation	p value
Overall efficiency	1	2	0.0594	0.028	0.124
		3	0.0739	0.030	0.060
	2	1	−0.0594	0.028	0.124
		3	0.0145	0.027	0.863
	3	1	−0.0739	0.030	0.060
		2	−0.0145	0.027	0.863
Overall technical efficiency	1	2	0.0517	0.025	0.142
		3	0.0664	0.027	0.062
	2	1	−0.0517	0.025	0.142
		3	0.0146	0.024	0.832
	3	1	−0.0664	0.027	0.062
		2	−0.0146	0.024	0.832
Pure technical efficiency	1	2	0.0510	0.022	0.080
		3	0.0213	0.023	0.658
	2	1	−0.0510	0.022	0.080
		3	−0.0296	0.021	0.370
	3	1	−0.0213	0.023	0.658
		2	0.0296	0.021	0.370
Scale efficiency	1	2	0.0018	0.018	0.994
		3	0.0455	0.019	0.067
	2	1	−0.0018	0.018	0.994
		3	0.0436	0.017	0.046
	3	1	−0.0455	0.019	0.067
		2	−0.0436	0.017	0.046
Allocative efficiency	1	2	0.0094	0.008	0.529
		3	0.0082	0.009	0.651
	2	1	−0.0094	0.008	0.529
		3	−0.0012	0.008	0.988
	3	1	−0.0082	0.009	0.651
		2	0.0012	0.008	0.988

Group 1: "Old Commercial Banks"; Group 2: "New Commercial Banks"; Group 3: "Commercial Banks Upgraded from Credit Cooperatives"

in resources allocation and utilization. Although the "New Commercial Banks" has relatively less customers and branches than the "Old Commercial Banks", they must put more endeavors to manage business and pursuit an efficient way to utilize resources in order to survive in more and fiercer competition environment. At the same time, although the "Old Commercial Banks" have advantages in the number of clients and more branches with better location, they run business in a relative traditional way, which may result in more "waste" in resources and hamper efficiency maximization. Likewise, the "Commercial Banks Upgraded from Credit Cooperatives" is originally local "Credit Cooperatives". Theyare also traditional

financial institutions with old mindset in resources management. It may not easy for them to catch up with the efficiency of the "New Commercial Banks". But they still have more strong relationship with clients and have plenty of knowledge about how to locate resources to generate revenues, which will make them have better efficiency value than the "New Commercial Banks". Thus, we hypotheses that the mean efficiency value of the "Old Commercial Banks" and the mean efficiency value of the "Commercial Banks Upgraded from Credit Cooperatives" will be significantly different than that of "New Commercial Banks" and the hypotheses are supported in empirical analysis.

5 Conclusion

This study employs Data Envelopment Analysis to evaluate management efficiency of 38 commercial banks in Taiwan. The empirical results show as follows. First, we find that the "Old Commercial Banks" possess highest efficiency value than the other two groups. Both the "New Commercial Banks" and the "Commercial Banks Upgraded from Credit Cooperatives" have efficiency value below the average efficiency value of all subjects, which is different from the expectation that "New Commercial Banks" should have the highest efficiency value among all three groups. Only the average efficiency value of "Old Commercial Banks" is above the overall banks' average. Besides, the "Old Commercial Banks" also have the highest overall technical efficiency, pure technical efficiency and allocative efficiency. It implies that the "Old Commercial Banks" are doing well in competing with the new entrants, which makes them keep better efficiency values than both the "New Commercial Banks" and the "Commercial Banks Upgraded from Credit Cooperatives". Second, the results also indicate some directions for those "less-efficient" subjects to implement efficiency improvement. In order to raise the efficiency of banks, the top management of those banks with low efficiency value may refer to the allocation of resources and strategies application of those subjects with overall efficiency value of 1 and focus on the direction to restructure or reallocate their resources. And finally, according to Scheffe's test, we find that the difference on overall efficiency was derived from the overall technical efficiency and scale efficiency because the mean overall efficiency, overall technical efficiency and scale efficiency of the "Old Commercial Banks" are all significantly larger than those of the "Commercial Banks Upgraded from Credit Cooperatives" at $\alpha = 0.1$ level. The mean pure technical efficiency of the "Old Commercial Banks" is significantly larger than that of the "New Commercial Banks" at $\alpha = 0.1$ level. Finally, the mean scale efficiency of the "New Commercial Banks" is significantly larger than that of the "Commercial Banks Upgraded from Credit Cooperatives" at $\alpha = 0.1$ level. As for the allocative efficiency, there is no significant difference among the three group at $\alpha = 0.1$ level.

References

1. Charnes A, Cooper WW, Rhdoes E (1978) Measuring the efficiency of decision making units. Eur J Oper Res 2(6):429–444
2. Banker RD, Charnes A, Cooper WW (1984) Some models for estimating technical and scale inefficiencies in data envelopment analysis. Manage Sci 30:1078–1092
3. Sherman HD, Gold F (1985) Bank branch operating efficiency evaluation with data envelopment analysis. J Bank Finance 9:297–315
4. Rangan N, Garbowski RH, Aly Y, Pasurka C (1988) The technical efficiency of U.S. banks. Econ Lett 28:169–175
5. Yue P (1992) Data envelopment analysis and commercial bank performance: a primer with application to Missouri banks. Fed Reserv Bank St Louis Rev 74(1):31–45
6. Siems TF (1992) Quantifying management's role in bank survival. Fed Reserv Bank Dallas Econ Rev 1992(Q I):29–41
7. Thanassoulis E (1999) Data envelopment analysis and its use in banking. Interfaces 29(3):1–13
8. Sathye M (2001) X-efficiency in Australian banking: an empirical investigation. J Bank Finance 25:613–630
9. Robin SP (1994) Management, 4th edn. Prentice-Hall, Upper Saddle River
10. Norman M, Stoker B (1991) Data envelopment analysis: the assessment of performance. Wiley, Chichester
11. Cooper WW, Seiford LM, Zhu J (2004) Handbook on data envelopment analysis. Springer/Kluwer Academic, Boston
12. Farrell MJ (1957) The measurement of productive efficiency. J R Stat Soc Ser A 120:253–281
13. Golany B, Roll Y (1989) An application procedure for DEA. Omega 1(3):237–250