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BANK EFFICIENCY AND OWNERSHIP IN TAIWAN: AN EVALUATION WITH DATA ENVELOPMENT ANALYSIS

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Bank Efficiency and Ownership in Taiwan: An Evaluation with Data Envelopment Analysis

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Bank Efficiency and Ownership in Taiwan : An Evaluation with Data Envelopment Analysis

Abstract

This paper uses a data envelopment analysis (DEA) approach to create a benchmark measure for the relative operating efficiency of the publicly operated banks as well as their private counterparts in Taiwan. The estimate first indicated a lower level of overall efficiency in the public-owned banks. Then we focus on finding inefficiencies by analysis of data and the bank's context. We find that the major source of inefficiency factor was scale in nature, rather than technical efficiency factor in the publicly operated banks. The results on bank size are also discussed in-depth. Finally, this paper also discusses the implication of the estimated results.

Keywords: Technical Efficiency, Scale Efficiency, Data Envelopment Analysis, Commercial Banks.

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I. Introduction

In an economy, commercial banks normally act as a bridge to provide a major source of financial inter-mediation. The checkable deposit liabilities in commercial banks also represent the bulk of the nation's money stock. The main purpose of measuring the operating efficiency of commercial banks is to highlight the status of operation performance so that managers or regulators can improve their performance. It can also position commercial banks with respect to each other by their own efficiency scores. Evaluating their overall efficiency and monitoring their financial condition is definitively important to stock owners, depositors, investors and bank managers, etc.

In the early 1990s, Taiwan joined the trend to bank deregulation to increase operating efficiency and to attract funds into the loanable fund supply market. The primary reasons included continued dissatisfaction with these bank's low service quality and financial inefficiency under public ownership. Deregulation usually involves two changes: to privatize their ownership and to install new banks in the market. The government then invited domestic and foreign investors to participate in Taiwan's banking system and has set up a lot of new, privately-owned commercial banks since 1992. In 1996, there were 34 commercial banks in Taiwan. Of these, 7 were publicly operated and 27 were privately operated.

Moreover, Taiwan's government like many other industrialized countries, wishes to demonstrate its success by illustrating that privatization leads to higher efficiency and lower costs in the current banking system. Thus, if a positive link is examined between private ownership and efficiency, it could suggest that the privately-owned banks have provided a good example of relatively high efficiency compared with publicly-owned ones. Owing to the fact that the newly-established banks have only been in operation three years and have just passed their new-born business life cycle, it seems like an appropriate time to examine the above argument from the regulator's perspective. In addition, this paper also tries to analyze the technical efficiency of privately-owned banks and identify the sources of inefficiency. The result indicates the implicit reasons for the success of bank privatization in Taiwan.

It is interesting to note that the average bank size within 7 publicly-owned banks is obviously larger than privately-owned banks, no matter whether by bank assets, staff employed, or deposit balance. The average of publicly-owned banks is NT$ 1,147,200 million (assets), 5,092 persons (staff), and NT$ 582,000 million dollars (deposits), respectively. As to the privately-owned banks, the average bank size is $248,800 million (assets), 1,215 persons (staff), and 119,600 million (deposits) for each. Therefore, it is worthwhile to further examine the evidence of efficiency increases from the decrease in bank size. Because almost all the privately-owned banks in Taiwan, especially the 18 newly-established banks are relatively smaller. Thus if this works, it conforms with the positive effect of privatization mentioned-above and we can disentangle this direction of causality.

This paper employs non-parametric methodology and uses a data envelopment analysis (DEA) model to create a benchmark measure for the relative efficiency of the publicly operated commercial banks as well as their private counterparts. We take the role of resource manager and recognize that resources are scarce and we cannot afford to waste them. We want commercial banks to be productive so that they can provide better service in light of constraints and attract more customers. Given the circumstances, we argue that the DEA model is a mathematical model designed especially for application to business institutions like commercial banks. There are three reasons: (i) The DEA model is able to derive a single aggregate score which indicates the performance status of each bank relative to a designated group of peers. (ii) The DEA model is capable of identifying any perceived slack in input used or output produced, and provide insight on possibilities for increasing output and/or conserving input in order for an inefficient bank to become efficient (productive). (iii) The DEA model can also maintain equity in performance assessment to handle noncommensurate multiple output and input using a mathematical programming method to generate a set of weights to each input/output. In the following sections, we first review the related literature, then discuss the proposed DEA model and input/output items. Section four is the empirical results of 34 commercial banks in Taiwan. The last section is concluding remarks.

II. Literature Review

The evaluation of commercial bank efficiency/performance has been approached from various dimensions. Parametric programming approaches have generally been concerned with the production or cost function base. Voluminous studies have focused on estimating the characteristics of the (cost) functions and measuring economies of scale and scope assuming all banks were operating efficiently (Bell and Murphy, 1967; Longbrake and Johnson, 1975; Kolari and Zardkoohi, 1987, etc.). Banker and Maindiratla (1988) argues that the estimated (cost) function represents the average behavior of firms (banks) in the sample, the regression procedures can be modified to orient the estimates toward frontiers.

Another line of research uses bank efficiency frontiers to construct measures of overall, technical and scale efficiency. It uses a non-parametric programming approach and investigates inefficiencies among the sample banks. This approach considers how much total productivity in the banking sector could be improved, and ranks the efficiency scores of individual banks. Rangan et al. (1988), Berger and Humphrey (1990) ranked banking firms. Sherman and Gold (1985), Parkan (1987), and Oral and Yolalan (1990) analyzed bank branches. Recent empirical studies also utilized this tactic including: Berg et al. (1991), and Resti (1994) focused on the explanation of economies of scale to Norwegian banks. Hassan et al. (1990) focused on the allocative efficiency and pure technical efficiency issue in dependent banks. Yue (1992) extended the analysis to DEA window analysis of Missouri commercial banks for the period ranging from 1984 to 1990. Childs (1996) used the DEA approach to evaluate the value of bank assets and its cross-default clauses. This paper then extends the DEA approach by measuring technical and scale efficiency and determines whether there are significant differences in efficiency between public and private commercial banks.

Most of the limited research on efficiency/performance evaluation of banks used a variant of ratio analysis among several banks using a number of financial ratios (e.g., return on assets, return on investments). Basically, financial ratios can measure the overall financial soundness of a bank and the operating efficiency of its management. These ratios promise to provide valuable information about a bank's financial performance when compared with previous periods and for peer ranking. However, the main weakness of ratio analysis is that there is a lack of agreement on the relative importance of various types of input or output. A bank may appear to be performing well even if it is poorly managed on certain of dimensions, as long as it compensates by performing particularly well on other dimensions (Sherman and Gold, 1985). Furthermore, the financial ratio also fails to consider the value of management actions and investment decisions that will affect future as opposed to current performance. It is a short-run measure and thereby it may be inappropriate to describe the actual efficiency of a bank in the long run (Oral and Yolalan, 1990). The most notable feature of this paper is that it employs a single input/output measure to characterize bank efficiency. We then view efficiency in terms of relative operating efficiency which, simply put, is: how efficiently is a given bank performing relative to other similar banks.

III. Data Envelopment Analysis

In this section, we propose data envelopment analysis to evaluate relative efficiency for 34 banks. The DEA method was first described by Charnes, Cooper and Rhodes (1978) who employed a mathematical planning model (CCR model) to measure the efficiency frontier based on the concept of Pareto optimum. Then Banker, Charnes and Cooper (1984) developed a revised model (BCC model) to measure technical efficiency and scale efficiency. The basic idea of DEA is to identify the most efficient decision-making unit (DMU) among all DMUs. The most efficient DMU is called a Pareto-optimal unit and is considered the standard for comparison for all other DMUs. The Pareto-optimal unit is one that any change that makes some people better off makes others worse off (Gould and Ferguson, 1980). That is to say that a single bank is considered DEA Pareto efficient if it cannot increase any output or reduce any input without reducing other output or increasing other input. Conversely, a unit is Pareto nonoptimal if some people can be made better off without harming anyone else. This concept of efficiency is based on engineering and natural science which is similar to economic efficiency, that is attained when firms find the combination of input that enables them to produce the desired level of output at minimum cost. In this paper, DEA establishes a "benchmark" efficiency score of unity that no commercial bank's score can surpass. Consequently, efficient banks can enjoy efficiency scores of unity, while inefficient banks receive DEA scores of less than unity. The magnitude of the performance score of Pareto nonoptimality is then calculated by dividing the Pareto-nonoptimal bank into the Pareto-optimal bank. Therefore, the DEA score is a relative number rather than absolute.

The idea of calculating DEA scores can be formulated as a fractional linear programming problem. We denote Y_{kJ} as the j-th output of the k-th DMU and X_{ki} as the i-th input of the k-th DMU. If a DMU employs p input to produce q output, the score of k-th DMU, E_k, is a solution from the fractional linear programming problem (CCR model):

$$\underset{U_j V_i}{Max} \quad E_k = \frac{\sum_{j=1}^{q} U_j Y_{kj}}{\sum_{i=1}^{p} V_i X_{ki}} \qquad i=1.2....p \qquad j=1.2.....q \qquad r=1.2....K....R$$

$$\text{s.t.} \quad \frac{\sum_{j=1}^{q} U_j Y_{rj}}{\sum_{i=1}^{p} V_i X_{ri}} \leq 1 \qquad U_j, V_i \geq 0$$

where U_j and V_i give the slack in the j-th output and the i-th input, respectively. We have generalized the usual input/output ratio measure of efficiency for a given bank with fractional constraints. In the case of banks, the efficiency of a particular bank is calculated by finding the ratio of a weighted sum of output to a weighted sum of input. The BCC model is the revised version of the CCR model. The former model can be reformulated by adding $\sum_{j=1}^{n} \lambda_j = 1$ to the problem, which provides valuable information about the cost-benefit (BCC model):

$$Min \quad TE = \theta - \varepsilon\left(\sum_{j=1}^{p} S_{ki}^{-} + \sum_{j=1}^{q} S_{kj}^{+}\right)$$

s.t. $$\sum_{r=1}^{r} \lambda_r X_{ri} - \theta X_{ki} + S_{ki}^{-} = 0$$

$$\sum_{r=1}^{r} \lambda_r Y_{rj} - S_{kj}^{+} = Y_{kj}$$

$$\sum_{r=1}^{r} \lambda_r = 1 \qquad , \quad \lambda_r \geq 0$$

Where θ is the efficiency score and ε is a nonarchimedean quantity the value of which is very minute. Note that we can calculate the (pure) technical efficiency score from the BCC model, then the scale efficiency score can be derived by overall efficiency and technical efficiency scores because the overall efficiency score is equal to the power of (pure) technical efficiency and scale efficiency score (Fare et al., 1985).

This study uses the intermediary approach because we lay emphasis on the financial intermediation function of banks. The intermediary approach views bank as financial intermediaries where deposits were treated as an input because a bank's main business is to borrow funds from deposits and lend to others (Berger and Humphrey, 1990; Yue, 1992). This arrangement can also effectively benefit bank operation and improve efficiency in Taiwan's competitive environment. In accordance with this approach, we specify four types of banking output, namely providing loan services, (including business and individual loans), portfolio investment (mainly government securities and shares and securities of public and private enterprises), interest income and non-interest income. The former two types of output are the main activities of banks and the latter two types of output are revenue sources of banks. These four types of output entail operating resources in terms of three types of input, namely staff, assets, and interest expense. Note that since interest expense is the cost of loanable funds, deposits being the main part of it, we include the interest expense input and view it as a proxy of the deposits. Also note that we utilize the liquidity concept as our output definition (i.e., measure the output in dollars of total balance), rather than the transaction concept (Gilligan and Smirlock, 1984). Therefore the efficiency concept in this paper will not just be limited to pure operating efficiency, but it is broader and includes the bank's effort to affect the sizes of accounts. That is suitable for competitive business and is consistent with the intermediary approach.

IV. Empirical Results

Four types of output and three types of input are chosen as candidates in the calculation of this paper and are employed in the empirical study of banking. We calculate the overall efficiency scores for each bank for eight cases in Table 1 . The data year is 1996. The basic case is case 1, which includes all output and input variables. The remaining seven cases are calculated as a sensitivity analysis in order to capture various aspects of overall efficiency. The Spearman correlation coefficients are calculated to evaluate the impact when we drop out or add variable(s) from case 1. The high Spearman correlation coefficient suggests that the dropped or added variable doesn't have a significant effect relating to the basic case.

Table 1 Sensitivity Analysis on Case 1

	Items	Case1	Case2	Case3	Case4	Case5	Case6	Case7	Case8
Output	Loans	*	*	*	*				
	Business loans					*	*	*	*
	Individual loans					*	*	*	*
	Investments	*	*	*	*	*	*	*	*
	Interest Revenue	*	*	*	*				
	Non-interest Revenue	*	*	*	*				
Input	Labor	*	*	*	*	*	*	*	*
	Assets	*	*	*	*	*	*	*	*
	Branches			*				*	
	Operating costs				*				*
	Interest expense	*		*	*	*		*	*
	Deposits		*				*		
Estimated Results	Scc with Case 1	—	0.698	0.936	0.867	0.589	0.607	0.733	0.655
	Number of efficient banks	15	17	20	18	13	15	16	14
	Mean efficiency score	0.960	0.964	0.979	0.981	0.930	0.949	0.965	0.958
	Minimum efficiency score	0.858	0.813	0.868	0.869	0.688	0.713	0.825	0.840

Notes: Scc means Spearman correlation coefficients ; all correlation coefficients are Significant at a level of significance.

Case 2 is calculated to observe the impact of the alternative definition of deposit on the results. The low correlation coefficient of 0.698 indicates that the new definition has a noticeable effect on the results. In addition, the number of efficient banks of case 2 (17) is larger than case 1(15) suggesting that case 1 is superior to case 2. Adding the number of bank branches itself from the calculation has a less important effect on the results, indicated by the correlation coefficient of 0.936 and the 20 efficient banks in case 3. Therefore, we don't need to consider case 3. A similar result was obtained in case 4 by adding the variable of operating costs. (0.867) and we conclude that case 4 is worse than case 1. From case 5 to case 8, we repeat the procedure of case 1 to case 4, while dropping the interest revenue and non-interest revenue variables instead of breaking the loan variable into business loans and individual loans. Because the estimated results were similar to the above cases we can ignore these cases.

The lowest mean and minimum efficiency scores are between case 1 and case 5 and the number of efficient banks tends to decrease. However, the decline may not be surprising since DEA overall efficiency is likely to decline as variables are excluded from the model. For diagnostic purposes, we choose case 1 for evaluation of technical and scale efficiency in the following discussion. Similar results are also obtained when case 5 is conducted.

Table 2 shows the descriptive statistics of the efficiency scores of case 1 for the full sample as well as separately for each group of ownership. Considering the whole sample, the mean overall efficiency score is quite high (0.969). It implies that the gap of the efficiency difference among 34 banks is not too large, because all banks must face to high competition pressure in Taiwan and have already improved their efficiency. In particular, commercial banks could have produced the same level of output using 96.9% of the input actually used. In addition, the mean overall efficiency scores of the public-owned banks (0.923) are lower than that of privately-owned banks (0.979). It reveals that relatively poorly bank operations may exist in these publicly-owned banks.

Since the overall efficiency score (OE) is a power of technical efficiency (TE) and scale efficiency (SE) score, the relative sizes of these scores provide evidence as to the source of inefficiencies. We find that the mean TE (0.983) is quite equal to mean SE (0.985), suggesting that the scale factor and technical factor have an identical importance as a source of OE among all banks. But we find the mean TE of 7 publicly-owned banks (0.971) is larger than the mean SE (0.950). It indicates that the scale factor in the publicly-owned banks is a relatively more important inefficiency source than the technical factor. That is to say, inefficiency in publicly-owned banks may be attributed to inappropriate return of scale rather than underutilization of input or selecting the incorrect input combinations.

Table 2 Descriptive Statistics of Bank Efficiency Scores

Case 1	Number of banks	Mean Score	Standard Deviation	Maximum Value	Minimum Value
All Banks					
OE	34	0.969	0.043	1	0.858
TE	34	0.983	0.032	1	0.869
SE	34	0.985	0.028	1	0.892
Public					
OE	7	0.923	0.059	1	0.858
TE	7	0.971	0.032	1	0.917
SE	7	0.950	0.051	1	0.892
Private					
OE	27	0.979	0.033	1	0.868
TE	27	0.985	0.032	1	0.869
SE	27	0.993	0.014	1	0.941

Notes: OE means overall efficiency score; TE means technical efficiency score; SE means scale efficiency score.

The issue of next concern is whether the above two sample banks are drawn from the same efficiency populations. We conducted a Mann-Whitney test to verify the significance of these findings. Mann-Whitney is one of the non-parameter statistical methods used to test the same mean between two groups. The null hypothesis is that there is no significant difference in the efficiency scores between publicly-owned and privately-owned banks. The alternative hypothesis then is that the privately-owned banks have a higher efficiency score than the publicly-owned banks. Table 3 lists the calculated z-values and their probabilities (p-values) for corresponding efficiency scores.

If the p-value falls below the significance level chosen (say 5% level of significance), then the null hypothesis should be rejected. From Table 3 , we can find that the above null hypothesis is rejected no matter whether for OE, TE or SE. We then conclude that the privately-owned banks enjoy a higher efficiency score than that of publicly owned banks. Note that a similar result may also be obtained in the case of others.

Similar results can also be obtained between large and small bank size, no matter which size measures we use. From Table 3, we find that there is a significant difference in OE score between two different sizes of banks. This difference is obvious in the SE scores. These results can support the above finding we have derived.

Table 3 The Mann-Whitney Test Results Between: (i) Publicly-owned Banks and Privately-owned Banks, (ii) Large Sized Banks and Small Sized Banks

Test	Items	OE	TE	SE
(i) Ownership	Z value	2.41	1.85	2.54
	P-value	0.0080*	0.0322*	0.0055*
(ii) Bank size	a. staff employed			
	Z value	2.11	1.48	2.66
	P-value	0.0174*	0.0694	0.0039*
	b. Bank deposit			
	Z value	2.07	1.43	2.61
	P-value	0.0192*	0.0765	0.0045*

Notes: 1. OE means overall efficiency score ; TE means technical efficiency score ; SE means scale efficiency score. "*" means significant at 5% level of significance.

2. Z-value is calculated by $Z = \frac{u - E(u)}{\sqrt{V(u)}}$, and u is the lower figure between U_1 and U_2. $U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - W_1$; $U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - W_2$ where W_1 and W_2 are the rank sum of each selected sample. In our case, one of n has large sample sizes (n > 15), we can generate a Z-value and refer to the standardized normal distribution to test the null hypothesis.

As to the individual banks, the inidvidual overall, technical and scale efficiency scores are shown in Table 4. From Table 4, 15 commercial banks are grouped into (overall) efficient banks, while 19 commercial banks are inefficient. Similarly, there are 21 commercial banks with a unity technical efficiency score, the rest of the 13 commercial banks are technical inefficient ones. From this we can find the sources of inefficiency by the individual banks base. Twelve of them (19) shows that the technical efficiency score is higher than that of the scale efficiency score. This implies inefficiency of resource utilization 12 banks will be roughly attributed to the scale factor, rather than the technical factor. The result suggests that we need to reexamine the scale of investment among these 12 banks. It must also be noted that of the sources of inefficiency in the 7 publicly-owned banks, 5 banks have scale inefficiency, while only 1 banks is technical inefficient. It also indicates that some scale issues exist among publicly-owned banks.

V. Concluding Remarks

The Taiwan banking market is about to become more competitive, both because of deregulation of national banks, and because of entrance by foreign banks. The DEA approach here is powerful as a benchmark measure for yardstick competition among commercial banks. From the estimated results, we find that there are significant differences in efficiency between privately-owned banks and publicly-owned banks. It shows that the efficiency gains from privatization may be substantial. Therefore we can expect the development of a more efficient and competitive market should be encouraged in Taiwan and the inefficient commercial banks should make an effort to improve. By analyzing the sources of inefficiency, we can also indicate the remedy for the specific publicly-owned banks, and affirm the validity of the privatization policy.

In conclusion, we claim that the DEA approach is not only a helpful complement to traditional financial ratios, but also a powerful bank management tool in identifying inefficient input/output and in achieving a higher operating efficiency. However, there are three key limitations we encountered in our research: First, output measures do not include

Table 4 Case 1 Individual Efficiency Scores.

Name of banks	OE	TE	SE	Scale type
1 First	0.9873	1.0000	0.9873	DRS
2 Hua-Nan	0.8585	0.9557	0.8982	DRS
3 Chang-Hua	0.8668	0.9715	0.8922	DRS
4 Taiwan	1.0000	1.0000	1.0000	CRS
5 Taipei	0.9098	0.9839	0.9247	DRS
6 Kaohsiung	0.9159	0.9172	0.9985	IRS
7 Taiwan Province	0.9787	1.0000	0.9787	DRS
8 Taipei City	1.0000	1.0000	1.0000	CRS
9 Hsinchu City	0.9890	1.0000	0.9809	DRS
10 Taichung City	1.0000	1.0000	1.0000	CRS
11 Tainan City	1.0000	1.0000	1.0000	CRS
12 Kaohsiung City	1.0000	1.0000	1.0000	CRS
13 Overseas Chinese	0.8682	0.8692	0.9987	IRS
14 Shanghai	0.9766	0.9980	0.9785	DRS
15 United World Chinese	1.0000	1.0000	1.0000	CRS
16 International China	1.0000	1.0000	1.0000	CRS
17 Grand	0.9995	1.0000	0.9995	DRS
18 Dah An	1.0000	1.0000	1.0000	CRS
19 Union	0.9596	0.9609	0.9986	IRS
20 Chinese	0.9204	0.9215	0.9988	IRS
21 Far Eastern	1.0000	1.0000	1.0000	CRS
22 Asia Pacific	0.9819	1.0000	0.9819	DRS
23 SinoPac	1.0000	1.0000	1.0000	CRS
24 E. Sun	1.0000	1.0000	1.0000	CRS
25 Cosmos	0.9166	0.9180	0.9984	IRS
26 Pan Asia	0.9413	1.0000	0.9413	DRS
27 Chung Shing	0.9888	0.9904	0.9983	IRS
28 Taishin	1.0000	1.0000	1.0000	CRS
29 Fubon	1.0000	1.0000	1.0000	CRS
30 Our Corp.	0.9538	0.9793	0.9740	DRS
31 Baodao	0.9664	0.9968	0.9694	DRS
32 Entie	1.0000	1.0000	1.0000	CRS
33 Chinatrust	0.9750	0.9853	0.9895	IRS
34 Chinfon	1.0000	1.0000	1.0000	CRS
Items	Total Sample	Public-owned	Private-owned	
CRS	15	1	14	
IRS	7	1	6	
DRS	12	5	7	

Notes: Number 1 to 7 banks are publicly-owned banks. The remaining are privately-owned banks. CRS, IRS and DRS means constant, increasing and decreasing return of scale, respectively.

quality-type measures, e .g., service quality and equipment quality , because the data is unavailable. Second, bank samples do not include foreign banks due to limited data. We thus may be unable to fully describe the whole picture in Taiwan's competitive banking system. Third, it is not easy to convey our empirical results to related bank managers because of complicated quantitative process. This issue will become less critical as we gain experience. Furthermore, the evaluation of banks usually contains on-site visits, more in-depth research is needed to combine on-site visits (qualitative) and DEA measurement (quantitative). It is worthy to find a new method to solve this issue to save the costs of bank staff and budget utilization. In addition, it a more objective conclusion can also be derived. Finally, DEA does not guarantee the cause or remedy for the identified inefficiencies. Internal audits or follow-up review procedures are also needed to define the types of operating changes that can effect efficiency improvements. It would be a meaningful task to fulfill them in the future.

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