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台灣金融業成本效率評估與購併影響之研究

Cost Efficiency and the Effect of Mergers on the Taiwanese Banking Industry

Abstract: This study addresses the cost efficiency, economies of scale and scope of the Taiwanese banking industry, specifically focusing on how bank mergers affect cost efficiency. Adopting stochastic frontier analysis, we employ a translog cost function for efficiency estimation. Composite error terms are used to account for managerial inefficiency and environmental effects. Empirical results suggest that economies of scale and scope exist at small and medium-sized banks. Meanwhile, government-owned or controlled banks are the most cost efficient. Non-performing loans increase the inefficiency of the banking sector by just 10%. Further analysis reveals that bank merger activity is positively related to cost efficiency. Mergers can enhance cost efficiency, even though the number of bank employees does not decline. The banks involved in mergers are generally small and were established after the banking sector was deregulated.

Keywords: Cost Efficiency, Economies of Scale and Scope, Bank Mergers

1. INTRODUCTION

The banking industry in Taiwan is highly regulated, and new entrants were prohibited until the Commercial Bank Establishment Promotion Decree was implemented in 1991. In 1990, Taiwan had 24 banks with 953 branches, some government owned and operated. Over 16 commercial banks were established in 1991 and 1992. By 1996, the total number of banks had reached 42, with 1936 branch offices. The entry of new competitors, combined with internationalization and market liberalization, has revolutionized the banking industry. One result of the changes has been increasing competition that reduces the quality of loan portfolios. According to a report by the Ministry of Finance, the interest spread declined from 3.05% in 1991 to 2.76% in 1996. Over the same period, the non-performing loan ratio increased from 0.93% to 3.68%. Furthermore, the mean return on equity and return on assets in the banking industry drastically declined from 28.89% and 1.2% in 1990 to 9.7% and 0.7%, respectively, in 1996.

The Taiwanese government is encouraging mergers and acquisitions to solve the problems in the banking industry. Particularly, larger commercial banks have been persuaded to take over small credit institutions. From 1997 to 1999, 16 mergers occurred. The Bank Merger Act and the Bank Holding Company Act were announced in 2000 and 2001 to further facilitate transactions.

This study investigates the cost efficiency of various types of banks in Taiwan, and seeks to determine whether mergers and acquisitions among banking firms can improve productivity. Meanwhile, the impact of non-performing loans is considered as well. The operating efficiency of banks is crucial in a sound economic system, and mergers and acquisitions are believed to be one way to improve it. In addition to examining whether merged banks are more cost efficient as expected by the government, this study also seeks to determine whether newly established banks are more efficient than older banks, or vice versa, and discusses its implementation to merging activity. Results of this study are important for bank managers, investors, policy-makers, and multinational banks interested in acquiring local banks.

Many bank mergers have occurred over recent years, stimulating considerable academic interest. Prager and Hannan (1999) show that deposit rates fall at banks involved in mergers that increase market concentration. However, the results are inconclusive for mergers that do not significantly change market concentration (Simons and Stavins, 1998). For Taiwanese mergers, while market share usually increases after mergers, no effect on pricing has been observed (Chen and Chen, 2002). Cornett and Tehranian (1992) and Rhoades (1998) report an improvement in both bank profitability and market value, although other investigators do not (Berger and Humphrey, 1992; Akhavein et al., 1997; Hannan and Wolken, 1989; Pilloff, 1996).

Meanwhile, the impact of mergers on bank efficiency has also been discussed substantially in the literature. The empirical results reveal little or no efficiency improvement for U.S. mergers in the 1980s. Berger and Humphrey (1992) examine 60 large mergers in the 1980s and find no efficiency improvement. Pilloff (1994) studies 48 mergers from 1982 to 1991 and finds that the value-weighted abnormal return and efficiency change are small. DeYoung (1997) finds that mergers between equally sized banks yield smaller-than-average cost efficiency improvements.

However, the results for mergers in the 1990s are mixed. Rhoades (1998) studies mergers of large US institutions and finds efficiency gains in most cases. Resti (1998) analyzes 67 Italian bank mergers and finds that mergers of equally sized banks yield substantial efficiency gains. Berger (1998) reports that if the participating banks are less efficient than their peers prior to consolidation, then substantial efficiency gains are predicted. His result holds for both large and small banks. Lang and Welzel (1999) consider the cost effects of 283 small-scale mergers among German Cooperative Banks. Positive economies of scale and scope are realized only when merged banks close some branches. German Cooperative Bank mergers show no evidence of efficiency gains. Vennet (1996) studies 500 takeovers among European financial institutions and finds that merger gains depend on the characteristics of the deal. Cross-border acquisitions and domestic mergers of equally sized banks generate significant cost efficiency improvement. Evidence from mergers of Australian trading banks between 1986 and 1995 proves that acquiring banks are more efficient than target banks (Avkiran, 1999).

In addition to cost efficiency, some studies have addressed the influence of loan quality on bank efficiency measurement. Bernstein (1996) considers the loan quality effect while estimating the translog cost function. He finds that banks with poorer loan quality have higher costs, but the direct influence is small. Berger and DeYoung (1997) also review the loan quality problem, and consider the intertemporal relationship between loan quality and cost efficiency. Their results are ambiguous on the question of whether problem loans should be considered in estimates of efficiency.

The Commercial Bank Establishment Promotion Decree of 1991 dramatically altered the market structure of the Taiwanese banking industry. Chen and Yeh (2000) employ a non-parametric approach to measure the relative operating efficiency of 34 Taiwanese commercial banks. Notably, they find that government-owned banks are less efficient than other banks, with a slightly higher Malmquist Index. Huang and Huang (2002) formulate a behavioral model under uncertainty to estimate total factor productivity in the Taiwanese banking industry. They show no significant improvement in either total factor productivity or cost efficiency. Interestingly though, their result reveals that government-owned banks are more cost efficient than other banks. Since the problem of low quality loans is exacerbated by market competition, Li et al. (2002) use the input distance function approach to elucidate the effect of non-performing loans on efficiency. Ou et al. (2002) also try to determine the relationship between bank asset quality and operating performance.

This study first examines the empirical measurement of cost efficiency in the Taiwanese banking industry. The stochastic frontier model and a translog cost function are used to estimate cost structure and cost efficiency. The model also takes into account the impact of low-quality loans on output measurement. Unlike the estimates from the model of Bernstein (1996), this approach allows the direct impact of low quality loans on costs to be estimated. Second, this study seeks to clarify the efficiency, overall economies of scale and scope of different bank sizes and organizational types. Analytical results indicate that the size of a bank affects economies of scale and scope and that government-owned or controlled banks enjoy greatest cost efficiency. Finally, the relationship between cost efficiency and merger activity is examined. Results of this study reveal that bank mergers significantly improve cost efficiency. This finding is consistent with the findings of Shaffer (1993), Vennet (1996) and Akhavein et al. (1997).

The remainder of this paper is organized as follows. Section 2 formulates the shadow cost frontier that applys translog function for efficiency estimation. Section 3 then presents and analyzes empirical results. Finally, Section 4 draws conclusions.

2. METHODLOGY

Model specification

There are several methods to study the efficiency and performance of commercial banks. The ratio approach uses financial indicators of the banking industry to evaluate production efficiency via factor analysis, one-way ANOVA, correlation analysis and cluster analysis. The nonparametric programming approach employs a mathematical programming model to measure the technical efficiency frontier. The parametric approach is based on the production or cost function. The advantage of this approach is that it can include a stochastic error term to account for environmental uncertainties. However, it needs to choose an explicit production or cost function with strong distributional assumptions on the error term. Many studies have focused on estimating the cost frontier based on various assumptions concerning the error term. (Cebenoyan et al., 1993 and Kaparakis, 1994).

This study employs the parametric method with the shadow cost frontier model to measure the operating efficiency of Taiwanese banking firms. The intermediation approach is used for the bank production process. Banking firms are assumed to transform deposits, raw materials or intermediate products into loans and investments as the outputs of the production system. Since low-quality loans incur increased labor and administrative costs, loan output is quality-adjusted. Total production cost comprises interest expenses on deposits and other operating costs of labor and capital. Consequently, the bank production process is assumed to involve a transformation of inputs (capital, labor and deposits) into outputs (loans and investments). The dual cost function can be represented as,

$C = C(Y_i, P_j)$ where Y_i is the ith output, i=1,2

and P_j is the price of input j, j=1,2,3.

In the model, outputs are measured in terms of the dollar value of the earning assets at the end of the fiscal year. Y_1 represents the loans and Y_2 the investments. Moreover, P_1 is the price of capital measured by the rentals on building, equipment and maintenance (Murray and White, 1983), and P_2 denotes the price of the labor calculated as the total salaries and benefits of each employee hour. Finally, P_3 represents the total annual interest expenses divided by average deposits and other borrowings.

Estimation of cost models

The shadow cost frontier approach assumes that all banks have the same underlying production frontier, which measures loans in terms of quality-adjusted units. Suppose a commercial bank produces an output vector from an input vector. The shadow cost approach postulates that various firm-specific production possibility frontiers can be pooled and represented by a single common frontier that applies to the quality-adjusted outputs Y*. The unobserved quality-adjusted outputs Y* are related to the observed outputs Y and a quality indicator Z_Q. That is, $Y^* = Y^*(Y, Z_Q)$. Here, the quality indicator Z_Q denotes the non-performing loan ratio. The shadow cost frontier is defined as, $C^* = C^*(Y_i^*, P_j)$

Following the stochastic frontier approach, we include a composite error term in the model. Consequently, the shadow cost frontier is represented as,

$$C = C^*(Y_i^*, P_j) + \varepsilon \quad \text{and} \quad \varepsilon = U + V \qquad (1)$$

where C denotes the observed cost. ε, the composite error term, has two components, U and V. U is the neutral cost-augmenting inefficiency. Since the managerial or controllable inefficiency only increases costs above the cost frontier, U is assumed to be a one-sided error term. The three commonly assumed distributions of U are the half-normal truncated at zero, the half-normal truncated at a non-zero point and the exponential (Stevenson, 1980). However, the estimates based on these various distributions are not very different (Cowing et al., 1983; Greene, 1990; Mester, 1996). Most studies have assumed U to be half-normal and truncated at zero (Mester, 1996; Huang et. al, 1999; Hao et al., 2001; Huang and Huang, 2002). This study follows, i.e., U is from a normal distribution with mean 0 and variance σ_U^2, but is truncated from below at zero. V represents a two-sided random error, representing the fluctuations or uncontrollable factors that can either increase or decrease costs. Therefore, V is assumed normally distributed with mean 0 and variance σ_V^2. U and V are distributed independently of each other (Huang et. al, 1999).

Recent studies have suggested that the cost function of banking firms can be represented by a translog function（Hunter and Timme, 1986）. Moreover, the empirical translog model can be expressed as follows.

$$\ln C = \alpha + \sum_{i=1}^{2}\beta_i \ln Y_i^* + \sum_{j=1}^{3}\gamma_j \ln P_j + \frac{1}{2}\sum_{i=1}^{2}\sum_{k=1}^{2}\beta_{ik}\ln Y_i^* \ln Y_k^* + \frac{1}{2}\sum_{j=1}^{3}\sum_{l=1}^{3}\gamma_{jl}\ln P_j \ln P_l + \sum_{i=1}^{2}\sum_{j=1}^{3}\rho_{ij}\ln Y_i^* \ln P_j + U + V \quad (2)$$

The share equations are obtained from the partial derivatives of the above equation.

$$S_j = \frac{\partial \ln C}{\partial \ln P_j} = \gamma_j + \sum_{l=1}^{3}\gamma_{jl}\ln P_l + \sum_{i=1}^{2}\rho_{ij}\ln Y_i^* + W_j \qquad \text{j=1,2,3} \quad (3)$$

where W_j are random error terms. The quality-adjusted loan output is defined as,

$$\ln Y_1^* = (1+\delta_1 Z_Q)\ln Y_1 \quad (4)$$

As non-performing loans are related with the loan outputs (Y_1) only, the investment outputs (Y_2) need not adjust. So $\ln Y_2^* = \ln Y_2$. Since high quality loans are less costly to produce than low quality loans, the coefficient δ_1 is expected to be positive. Homogeneity and symmetry restrictions are imposed on the estimate of the cost function parameters.

Measures of cost efficiency

The residuals $\varepsilon_i = U_i + V_i$ can be estimated from the parameters of the translog cost function. The variances σ_V^2 and σ_U^2 can be calculated by the method of moments (Olson et al, 1980):

$$\hat{\sigma}_U^2 = \left(\frac{m_3}{\sqrt{2/\pi}(4/\pi - 1)}\right)^{2/3} \quad (5)$$

$$\hat{\sigma}_V^2 = m_2 - (1-\frac{2}{\pi})\hat{\sigma}_U^2 \quad (6)$$

where m_2 and m_3 represent the second and third central moments of the residuals.

Jondrow et al. (1982) propose a method for estimating individual firm-specific inefficiency. This value can be defined as the conditional mean of U_i given the composite error $\varepsilon_i = U_i + V_i$.

$$E\langle U_i \,|\, \varepsilon_i \rangle = \mu_{i*} + \sigma_* \frac{\phi(\mu_{i*}/\sigma_*)}{\Phi(\mu_{i*}/\sigma_*)} \quad (7)$$

where $\mu_{i*} = \varepsilon_i \sigma_U^2 / \sigma^2$, and $\sigma^2 = \sigma_U^2 + \sigma_V^2$.

$\phi(\cdot)$ and $\Phi(\cdot)$ are the standard normal density function and the distribution function, respectively. According to Jondrow et al. (1982), if the logarithmic cost function is estimated, then the exponential of U_i represents the cost inefficiency. Battese and Coelli (1988) propose a method for estimating individual firm-specific efficiency, which can be expressed as follows.

$$E\langle e^{-U_i} \,|\, \varepsilon_i \rangle = \frac{\Phi(\mu_{i*}/\sigma_* - \sigma_*)}{\Phi(\mu_{i*}/\sigma_*)}\exp(-\mu_{i*} + \frac{1}{2}\sigma_*^2) \quad (8)$$

The model herein follows the approach of Battese and Coelli (1988). Furthermore, the 100(1-α)% confidence interval for the individual efficiency is further computed following the method of Bera and Sharma (1999). The estimates are,

$$Lower = \mu_{i*} + \Phi^{-1}(\frac{\alpha}{2} + (1-\frac{\alpha}{2})\Phi(-\frac{\mu_{i*}}{\sigma_*}))\sigma_* \quad (9)$$

$$Upper = \mu_{i*} + \Phi^{-1}(1-\frac{\alpha}{2}(1-\Phi(-\frac{\mu_{i*}}{\sigma_*})))\sigma_* \quad (10)$$

The lower bound (LB) and upper bound (UB) of the confidence interval are,

$$LB = \exp(-Upper) \quad (11)$$

$$UB = \exp(-Lower) \quad (12)$$

Economies of scale

The overall economy of scale measures the elasticity of the total cost with respect to an output vector. An overall economy of scale exists when the average or marginal costs associated with increasing output are progressively decreasing. It is measured as the inverse of the sum of the cost elasticities.

$$SE = (\Sigma\frac{\partial \ln C^*}{\partial \ln Y_i^*})^{-1} = (\Sigma E_{Yi})^{-1} \quad (13)$$

where E_{yi} denotes the cost elasticity of the ith output. Overall economies (diseconomies) of scale exist if SE is greater (less) than one. Meanwhile, if SE equals one, constant returns to scale exist.

Economies of scope

If a bank can produce two outputs together more cheaply than producing the same two outputs separately, then economies of scope exist. The relationship can be expressed as,

$$C(Y_1,0) + C(0,Y_2) > C(Y_1,Y_2)\,. \quad (14)$$

Following Panzar and Willig (1981), economies of scope can be measured by,

$$SC = [C(Y_1,0) + C(0,Y_2) - C(Y_1,Y_2)]/C(Y_1,Y_2)\;. \quad (15)$$

Since the translog cost function cannot be used to estimate the cost when one or more outputs are zero, Huang et. al (1999) present an alternative method for defining the economies of scope:

$$SC = [C(Y_1 - Y_1^m, Y_2^m) + C(Y_1^m, Y_2 - Y_2^m) - C(Y_1,Y_2)]/C(Y_1,Y_2) \quad (16)$$

where Y_1^m and Y_2^m are the minimum values of Y_1 and Y_2 in the sample. The zero value problem still exists for banks with minimum outputs Y_1 and Y_2, so only outputs that exceed the minimum values are considered here. Meanwhile, if SC is greater than zero, then overall economies of scope exist.

Cost efficiency and merging activities

This study further examines the relationship between cost efficiency and merger activity. Many variables impact the efficiency of a bank (Mester,1993; Kaparakis et al.,1994; Hao et. al, 2001). This study employs a second-stage regression to identify the sources of cost efficiency:

$$eff = f(MERGE, TA, TA2, GROWTH, BTD, ETA, TDTD, NINTOP) + \varepsilon \quad (17)$$

where

eff: cost efficiency obtained from Eqn. (8)

MERGE: 1 for banks involved in merger activity, otherwise 0

TA: total assets

TA2: square of TA

GROWTH: growth rate of bank assets over the preceding year

BTD: ratio of number of branches to total deposits

ETA: ratio of number of employees to total assets

TDTD: ratio of time deposits to total deposits

NINTOP: ratio of non-interest income to operating profits

Since the efficiency measure is bounded between 0 and 1, censored (Tobit) regression is used to estimate the parameters. The variable MERGE specifies the impact of merger activity on bank cost efficiency. Bank size may influence cost efficiency so the variable TA is included as a control variable for scale bias on efficiency. To clarify whether an optimal bank size exists for cost efficiency in banks, the square of TA, TA2, is also considered. GROWTH is a measure of the operating performance, and BTD represents the expense behavior. ETA captures the impact of the size of the labor force on cost efficiency. All these variables may affect cost efficiency. Moreover, if a bank has a high percentage of time deposits, its funds are at lower costs. Therefore, the variable TDTD is used to measure the effect of this deposit mix on cost efficiency, and its parameter is expected to be positive. The variable NINTOP is a proxy for the output mix effect. Its impact on cost efficiency can be either positive or negative, depending on whether the bank generates more service-based revenues or more lending revenues as input costs increase.

3. DATA DESCRIPTION

The study sample comprises 44 banks with a range of sizes and organizational types. Panel data from 1997 to 1999 are obtained from the financial reports of these sample banks and from the Financial Statistics Abstract published by the Ministry of Finance. Sixteen bank mergers occurred during the sample period. Appendix 1 lists the sample banks.

Table 1 provides the descriptive statistics of the related variables and shows significant variation between the merged and non-merged banks, and across different organizational types. The merged banks are smaller, with average factor prices 20% lower than those of the other banks. The majority of the merged banks are privately owned.

The government-owned or controlled banks are relatively large in terms of total assets, while the new privately owned banks are much smaller. Consequently, the government-owned or controlled banks dominate the banking industry in terms of loans and investments. The old privately owned banks have higher-than-average input prices. Notably, the government-owned or controlled banks have the highest labor costs, averaging 510 NT dollars per employee hour, compared to the industry average of just 410 NT dollars. However, the new privately owned banks face higher-than-average capital costs. Finally, the old privately owned banks have the poorest non-performing loan ratio of 7.9%.

Table 1 Descriptive statistics of sample banks

Bank Types \ Variables		Total assets	Total costs	Loans	Investments	Price of capital	Price of labor	Price of funds	Non-performing loans ratio
Non-merged banks	Mean	405592	25030	287265	51485	0.01913	0.00042	0.01732	0.05071
	Std.Dev.	414760	24067	293281	53498	0.01081	0.00011	0.00976	0.04000
Merged banks	Mean	276042	15938	188379	45075	0.01501	0.00033	0.01419	0.05310
	Std.Dev.	501407	26981	319946	109985	0.00669	0.00011	0.00609	0.03393
Government-owned or controlled banks	Mean	946685	55807	672544	119184	0.01627	0.00051	0.01256	0.05001
	Std.Dev.	503373	28099	348360	83424	0.00866	0.00004	0.00403	0.02375
Old privately owned banks	Mean	282678	18313	188845	42737	0.02152	0.00044	0.0205	0.07916
	Std.Dev.	189206	11424	111121	39085	0.01227	0.00013	0.01174	0.05879
New privately owned banks	Mean	172086	11254	124295	21517	0.01856	0.00035	0.01752	0.03919
	Std.Dev.	101657	7538	65785	16911	0.01029	0.00008	0.00951	0.02712
Total banking firms	Mean	390870	23997	276028	50757	0.01866	0.00041	0.01696	0.05098
	Std.Dev.	425323	24476	296812	61897	0.01049	0.00011	0.00945	0.03924

Note: Total assets, costs, loans and investments are measured in millions of NT dollars.

4. EMPIRICAL RESULTS

Parameter estimates of the cost model

The cost system consists of the translog cost function and share equations. The seemingly unrelated regression method proposed by Zellner (1962) is used herein to estimate the parameters of the cost model. Appendix 2 lists the estimates of parameters in Eqns. (2) and (3). Most of the estimated parameters are positive and significantly different from zero. The adjusted R^2 is 98%.

Estimation of cost efficiency

The coefficient of the quality index, δ_1, is the focus of the stochastic shadow cost frontier approach. This approach derives the distortion of the output cost associated with output quality. δ_1 is positive as expected. From Eqn. (4), the relationship between cost distortion and the quality index can be further explored.

$$\frac{Y_1^*}{Y_1} = Y_1^{\delta_1 Z_Q} = I_{CD} \tag{18}$$

I_{CD} represents the cost distortion as indicated by the quality index.

Table 2 Mean cost distortion and cost efficiency by types of banks

Bank types	I_{CD}	Cost efficiency	Upper bound	Lower bound
Non-merged banks	1.09923 (0.08117)	0.94369 (0.02154)	0.99668 (0.00433)	0.85620 (0.03343)
Merged banks	1.09767 (0.06420)	0.94751 (0.01678)	0.99750 (0.00160)	0.86149 (0.02954)
Government-owned or controlled banks	1.1068 (0.0541)	0.9487 (0.0167)	0.9976 (0.0016)	0.8636 (0.0294)
Old privately owned banks	1.1537 (0.1186)	0.9344 (0.0216)	0.9957 (0.0042)	0.8410 (0.0321)
New privately-owned banks	1.0716 (0.0509)	0.9462 (0.0216)	0.9969 (0.0048)	0.8604 (0.0331)
Pooled sample	1.0991 (0.0792)	0.9441 (0.0210)	0.9968 (0.0041)	0.8568 (0.0329)

Note: The sample standard deviations are in parentheses.

As shown in Table 2, the overall cost inefficiency due to non-performing loans is approximately 9.9 % of the total outstanding loans. The merged banks have a cost distortion 0.2% lower than that of the non-merged banks. Meanwhile, the cost inefficiency is greater for old privately owned banks, at about 15 percent, significantly higher than the industry average. Since $\delta_1 Z_Q$ is less than one, $\partial I_{CD}/\partial Y_1 > 0$ and $\partial^2 I_{CD}/\partial Y_1^2 < 0$. Therefore, the cost of lower quality loans increases at a decreasing rate with respect to the total amount of loans.

Table 2 also summarizes the cost efficiencies and confidence intervals across various types of banks. The merged banks are more cost-efficient, implying that merging affects cost efficiency. This relationship is further elucidated by the regression analysis (Table 6). Furthermore, the old privately owned banks perform worst, while the government-owned or controlled banks enjoy high cost efficiency. The differences in cost efficiency and cost distortion across organizational types are also examined using the Kruskal-Wallis test. The results are statistically significant, as shown in Table 3.

Table 3 Results of the Kruskal-Wallis test

Organizational types	I_{CD}	Cost efficiency
Government owned or controlled banks	W_1=2414 N_1=33	W_1=2550 N_1=33
Old privately owned banks	W_2=1402 N_2=30	W_2=2627 N_2=30

New privately owned banks	W_3=4962 N_3=69	W_3=3601 N_3=69
H statistic	10.397	21.378
$\chi^2_{0.01}(2) = 9.210$	Significant at 1%	Significant at 1%

Note: 1. $H = \frac{12}{N(N+1)} \sum \frac{W_i^2}{N_i} - 3(N+1)$

2. N: total sample number, N_i: sample number of the ith set, W_i: rank sum of the ith set.

Economies of scale and scope

As shown in Table 4, most Taiwanese banks exhibit economies of scale and scope, regardless of the organizational types. This study further decomposes the samples into three size categories - small, medium and large. Table 4 indicates that increasing returns to scale exist for small and medium banks, while decreasing returns to scale exist for large banks. Thus, economies of scale are larger for smaller banks. This finding implies that size expansion can yield greater cost advantages for small banks than for large banks. Specifically, banks with assets of under 1,000 billion NT dollars may improve their cost efficiency by size expansion, possibly through mergers and acquisitions. The sample mean of SE (economies of scale) for merged banks is 1.2211, larger than 1.1529 for non-merged banks. The percentage of banks that operate with economies of scale is also larger for merged banks (93.3%). Merged banks benefit more from the economies of scale than the non-merged banks. Since all banks have SC (economies of scope) values larger than zero, cost savings can be achieved from the joint production of loans and investments. However, large banks benefit more than small banks from economies of scope.

Table 4 Economies of scale and scope by types of banks

Bank types	Sample number	Sample mean of SE	Sample mean of SC	Sample no. and percentage with SE>1
Government-owned or controlled banks	33	1.0406 (0.0696)	0.8618 (0.4188)	23 69.7%
Old privately owned banks	30	1.1676 (0.0707)	0.2591 (0.1174)	30 100%
New privately owned banks	69	1.2151 (0.0782)	0.1821 (0.0655)	69 100%
Asset size < 250	83	1.2194 (0.0729)	0.1724 (0.0395)	83 100%
Asset size 250-1,000	33	1.0950 (0.0458)	0.4531 (0.2159)	33 100%
Asset size > 1,000	16	0.9911 (0.0181)	1.2141 (0.2033)	6 37.5%
Total	132	1.1606 (0.1033)	0.3718 (0.3633)	—

Note: 1. The sample standard deviations are in parentheses.

2. Asset size is measured in billion NT$.

3. SE represents the economies of scale and SC represents the economies of scope.

Relationship between cost efficiency and merger activity

Table 5 summarizes the descriptive statistics of variables used in the censored regression model Eqn. (17). The nonparametric Kruskal-Wallis test is used to check intertemporal improvement in cost efficiency during the sample period. Notably, the H statistic (2.6468) is below the critical value, implying that there is no significant difference in cost efficiency from 1997 to 1999.

Table 5 Descriptive statistics of variables used in the censored regression model

Variable	Mean	Std. Dev.	Maximum	Minimum
eff	0.944122	0.021031	0.976674	0.850260

TA	390870	425323	2074455	43569
GROWTH	0.123932	0.121097	0.533819	-0.110819
ETA	0.007274	0.002282	0.014247	0.002834
BTD	0.000260	0.000135	0.000768	0.000068
TDTD	0.750232	0.069555	0.865700	0.524200
NINTOP	2.379456	5.943318	65.47368	-1.735294

Note: TA is measured in million NT dollars.

Table 6 presents the estimates of the parameters in the regression model. All the variables except TA, TA2, GROWTH and NINTOP markedly affect cost efficiency. The estimated coefficient of ETA (ratio of number of employees to total assets) is significantly negative. Mergers in Taiwan generally do not lead to large-scale layoffs. Such action can provoke employee protests and create political problems, which in turn may impede the approvals of mergers by the authorities. Consequently, cost efficiency decreases as the size of the labor force increases. The positivity of the influence of TDTD (ratio of time deposits to total deposits) shows that banks with high proportions of time deposits enjoy higher cost efficiency because such funds are stable, manageable and much cheaper than other funds. The positive BTD (ratio of number of branches to total deposits) implies that this variable affects outputs more strongly than inputs. While branching can increase input expenses, it also expands the revenue base from the outputs.

Table 6 Estimates of parameters in censored regression model

Variables	Coefficient	z-Statistic
Intercept	0.942353	35.93907***
MERGE	0.010230	1.836319*
TA	-1.93E-08	-1.157650
TA2	5.83E-15	0.681308
GROWTH	-0.007842	-0.867365
BTD	63.93026	3.060575***
ETA	-8.329762	-6.618873***
TDTD	0.069533	2.438017**
NINTOP	-0.000305	-1.133296
Adjusted R-squared	0.307836	

Note: ***, ** and * represent significance levels of 1%, 5% and 10%, respectively.

With the effects of other variables controlled, a statistically significant relationship clearly exists between bank mergers and cost efficiency. Mergers can enhance cost efficiency, even though the number of employees does not decline. The banks involved are generally small and were established after the banking sector was deregulated. Since the banking industry remains highly regulated even after its deregulation, branching barriers persisted after 1991. New branches require special approval by the Ministry of Finance and normally no more than two new branches are permitted for each bank in a given year. This is an important constraint for banks that are considering aggressive expansion, especially for new banks with insufficient market coverage. Banks that take over other financial institutions may transfer newly acquired branches to other locations. Through mergers, these banks can quickly penetrate other market areas and thus make better use of their combined resources. This argument is also supported by the positive BTD parameter.

Since cost efficiency is derived not from closing branches or laying off personnel, merging obtains operational synergies relying on economies of scale and scope. As discussed in the earlier sections, smaller banks exhibit better economies of scale than larger banks, while larger banks enjoy better economies of scope than smaller banks. Consequently, size has a mixed effect on cost efficiency. However, branching privileges show that Taiwanese banks can probably enjoy greater economies of scope through mergers. Therefore, bank mergers are positively related to cost efficiency.

5. CONCLUSION

This work studies cost efficiency, economies of scale and economies of scope of the Taiwanese banking industry, and further elucidates the potential impact of bank mergers on cost efficiency. Adopting stochastic frontier analysis, this study employs a translog cost function with composite errors to explain managerial inefficiency and environmental effects. Furthermore, loan outputs are adjusted to account for non-performing loans. The sample period is from 1997 to 1999, which covers the main wave of bank mergers in Taiwan. The empirical results suggest that economies of scale and scope do exist, but depend on bank size. Further regression analysis reveals that merger activity significantly affects cost efficiency. The evidence also demonstrates variations in cost efficiency among different organizational types. Government-owned or controlled banks enjoy the highest cost efficiencies, while old privately owned banks have the lowest cost efficiencies.

The Taiwanese government has always encouraged bank merger activity to promote economic stability. This study supports this policy. Although entry barriers were lifted following the deregulation of the banking sector, expansion via branching remains restricted. The opening of new branches requires special approval by the authorities. However, banks that take over other financial institutions are allowed to transfer the new branches to other locations. The branching privileges associated with mergers and acquisitions in Taiwan may explain the positive effect of merging on efficiency, despite the fact that the workforce is generally not reduced.

Though merged and non-merged banks in Taiwan have different sizes and organizational types, how these factors affect cost efficiency remains unsolved. This study only considers the cost side of mergers. A complete evaluation of the effects of mergers would have to consider also the revenue side (profit efficiency). All these are left for future studies.

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APPENDIX

Appendix 1 Sample banks listed according to organizational types

Organization type	Name of banks	Total
Government-owned or controlled banks	The Farmers Bank of China、Chiao Tung Bank、Bank of Taiwan、Land Bank of Taiwan、Taiwan Cooperative Bank、First Commercial Bank、Hua Nan Bank、Chang Hwa Bank、Bank of Kaohsiung、Taipeibank、Bank of Taiwan Province	11
Old privately owned banks (Established before 1991)	The International Commercial Bank of China、International Bank of Taipei、Hsinchu International Bank、Taichung Bank、Tainan Business Bank、Kaohsiung Bank、Taitung Bank、Bank of Overseas Chinese、The Shanghai Commercial and Savings Bank、United World Chinese Bank	10
New privately owned banks (Established after 1991)	Makoto Bank、Sunny Bank、Bank of Pan Shin、Lucky Bank、Kao Shin Bank、Grand Bank、Dah An Bank、Union Bank of Taiwan、The Chinese Bank、Bank Sinopac、Asia Pacific Bank、E. Sun Bank、Cosmos Bank Taiwan、Pan Asia Bank、Chung Shing Bank、Taishin Bank、Far Eastern Bank、Fubon Bank、Ta Chong Bank、Baodao Bank、Chinatrust Bank、En Tie Bank、Chinfon Bank	23

Appendix 2 Translog cost function estimates

Variable	Coefficient	Estimate	t-Statistic	Variable	Coefficient	Estimate	t-Statistic
Intercept	α	10.7192	7.7456***	$(\ln P_1)(\ln P_3)$	γ_{13}	-0.1223	-19.4509***
$\ln Y_1^*$	β_1	-0.7924	-1.9346*	$(\ln P_2)(\ln P_3)$	γ_{23}	-0.0388	-5.7169***

$\ln Y_2$	β_2	0.5841	1.7111*	$(\ln Y_1^*)(\ln P_1)$	ρ_{11}	0.0052	0.9659
$\ln P_1$	γ_1	0.2934	5.9599***	$(\ln Y_2)(\ln P_1)$	ρ_{21}	-0.0082	-1.7202*
$\ln P_2$	γ_2	0.5788	9.6287***	$(\ln Y_1^*)(\ln P_2)$	ρ_{12}	-0.0093	-2.6646***
$\ln P_3$	γ_3	0.1278	1.7898*	$(\ln Y_2)(\ln P_2)$	ρ_{22}	-0.0050	-1.4347
$(\ln Y_1^*)^2$	β_{11}	0.2470	3.0814***	$(\ln Y_1^*)(\ln P_3)$	ρ_{13}	0.0076	1.1490
$(\ln Y_2)^2$	β_{22}	0.1289	2.8901***	$(\ln Y_2)(\ln P_3)$	ρ_{23}	0.0124	2.1336**
$(\ln Y_1^*)(\ln Y_2)$	β_{12}	-0.1448	-2.3629**	z_Q	δ_1	0.1509	5.7479***
$(\ln P_1)^2$	γ_{11}	0.1449	26.9089***		σ_U^2	0.0093	
$(\ln P_2)^2$	γ_{22}	0.0650	8.5648***		σ_V^2	0.0087	
$(\ln P_3)^2$	γ_{33}	0.1580	13.4347***				
$(\ln P_1)(\ln P_2)$	γ_{12}	-0.0211	-5.7934***	Adjusted R^2		0.9845	

Note: ***, ** and * represent significance levels of 1%, 5% and 10%, respectively.