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The effect of bank mergers on competitive conditions and cost efficiencies in Taiwan – a simulation analysis

Abstract

Ever since the enforcement of financial liberalization in 1990, Taiwan's banking industry has been characterized as being in a state of over-banking, where many domestic and foreign commercial banks compete with one another in the nation's small marketplace. To raise banks' market power, productivity, and efficiency, the Taiwan government has encouraged bank mergers, particularly among public banks, by implementing the Second Financial Restructuring policy in 2004. This paper simulates several scenarios of bank consolidations and provides some underpinning to this policy. The results support that hypothetical mergers raise the market power of the acquiring banks and enhance scale and scope economies, the rate of technical progress, and technical efficiency scores. However, different patterns of mergers have their own advantages, such that no single pattern overwhelmingly dominates the others.

Keywords: mergers, market power, simulations, scale and scope economies, technical change, technical efficiency.
JEL Classification: C23, D24, G21, L11.

Introduction

Technological innovations, industry financial distress, deregulation, and globalization may be responsible for the wave of mergers in the banking sector around the world, beginning in the United States and followed by Europe in the 1980s and 1990s. However, past works have not found strong empirical outcomes for the benefits from mergers and acquisitions (M&As) in terms of cost efficiency (e.g., Peristiani, 1997; Ralston et al., 2001), though they do confirm improvements in profit efficiency (e.g., Akhavein et al., 1997; and Hughes et al., 1999). Most early studies on bank M&As collected data from the U.S., but for the past decade, some researchers have aimed at the European markets and cross-border bank M&As, e.g., Vander Vennet (1996), Cybo-Ottone and Murgia (2000), Cuesta and Orea (2002), Focarelli et al. (2002), Amihud et al. (2002), Diazet et al. (2004), De Guevara et al. (2005), Campa and Hernando (2006), Altunbas and Marques (2008), Beccalli and Frantz (2009), and Bernad et al. (2010).

Taiwan's banking industry before 1990 can be characterized as highly regulated with barriers to entry for foreign banks. At that time, there were 22 commercial banks consisting of 11 state-owned banks and 11 private banks, together with a small number of foreign bank branches and around 80 small-sized credit unions. To promote the performance of domestic banks in the island, the "New Banking Law" was passed and enacted starting from 1990, which deregulated the industry and removed the barriers to entry for new domestic as well as foreign banks. Several public banks have been privatized, and many new private and foreign banks have entered the market. By 2001, 51 domestic banks were competing with one another, but most of them are not large in comparison with foreign and multi-country banks. The aftermath of "over-banking" led to a low concentration ratio and a high degree of competition, resulting in each bank facing quite a low interest margin, around just 1.5%, and deteriorating loan quality.

To correct this problem, Taiwan's authorities launched the First Financial Restructuring in 2002 in an attempt to help banks write off the huge amounts of accumulated non-performing loans that had especially arisen from the Asian financial crisis of 1997, followed by the Second Financial Restructuring (SFR) in 2004. The SFR aims to lower the number of banks by encouraging M&A, particularly between public banks. Although the SFR has failed to achieve its goal of cutting the number of public banks in half by 2012, due mainly to political disputes, it is expected that the SFR will help raise the market power and profitability of banks post-merger, because with larger market shares they can exercise market power when pricing their products, take advantage of economies of scale and scope and risk diversification, adopt new innovations swiftly, and promote technical efficiency and productivity.

Akhavein et al. (1997) note that M&As could stimulate profits in three ways: cost efficiency improvement, higher market power in setting prices, and profit efficiency promotion. Following this vein, the current paper attempts to justify the SFR policy by adopting the simulation approach, an ex ante analysis, to examine the effects of different forms of hypothetical mergers on the performances of Taiwanese banks in terms of five indicators – i.e., degrees of competition (represented by the H statistic of Panzar and Rosse, 1987), scale and scope economies, rate of technical change, and technical efficiency under the framework of the translog and Fourier flexible (FF) functions. This is in contrast to most previous studies that rely on ex post analysis or event study methodology, i.e., they compare the performance of the acquiring banks with that of the target banks before and after the announcement of the merger;

see Berger and Humphrey (1992) for a review. Shaffer (1993) is the pioneer in the literature for applying a simulation technique to predict the impact of mergers between pairs of U.S. commercial banks with assets exceeding U$1 billion on cost efficiency, under the framework of thick frontier analysis. An additional reason for adopting ex ante analysis is attributed to the data lacking enough merger cases[1].

We believe that such an ex-ante, forward-looking simulation technique is preferable, since it is able to quantify and predict the potential benefits and/or costs coming from different patterns of bank consolidations to help policy-makers note the trade-off between benefits and costs in the planning stage. In this manner, society as a whole may be better off by selecting the most promising merger projects with the maximum net benefits. Specifically, we consider four types of merger: mergers between a pair of banks, and mergers among three, four, and five banks. We combine the same accounting entries in the balance sheets and/or income statements of the banks drawn throughout the whole sample period, so as to regard them as a single bank from the beginning.

The rest of the paper is organized as follows. Section 1 briefly reviews the relevant literature. Section 2 introduces the methodology to be utilized. Section 3 describes the data. Section 4 presents the empirical results as the benchmark to be compared with the simulation results in section 5. The final section concludes the paper.

1. Literature review

1.1. Degrees of market competition. There are two main approaches to gauging the degree of competition in the banking industry in the literature: structure and non-structural methods. The traditional industrial organization theory, often classified as the structure method, focuses on the association between the market structure and the levels of competition among firms. It infers competitive conditions from market structure indices, such as concentration ratios, number of firms, market shares, the Herfindahl-Hirschman index (henceforth, HHI), etc. The potential benefits from greater market power are assumed to be generated by the increase in the concentration or market shares of firms. The conventional structure-conduct-performance (SCP) hypothesis, dating back to Mason (1939) and Bain (1951), claims that firms with greater market power are able to set prices that are less favorable to consumers in more concentrated markets due to the presence of imperfect competition. This hypothesis argues that intense competition stems from a large number of firms competing within a market, which impedes potential collusion and abnormal profits. A related theory is the relative-market-power hypothesis. See, for example, Gilbert (1984), Shepherd (1982, 1986a, 1986b), Rhoades (1985), Hannan (1991a), Kurtz and Rhoades (1991), and Berger (1995). Gilbert (1984) notes that many studies in the existing literature fail to take into account the effect of regulation on bank performance and ignore the fact that the business atmosphere faced by modern banks has changed drastically, making the SCP hypothesis no longer applicable to the current banking industry.

There are another two efficiency explanations that positively relate profits to concentration. According to the X-efficiency version of the efficient-structure hypothesis, firms with superior managerial abilities and/or production technologies incur lower costs and therefore earn higher profits. On the basis of the scale-efficiency version of the efficient-structure hypothesis, firms have equal managerial ability and technology, but some firms have lower unit costs and higher unit profits, because they produce at more efficient scales than others. These two types of firms are inclined to gain large market shares that lead to high levels of concentration. See, for example, Demsetz (1973, 1974), Peltzman (1977), and Lambson (1987). On the other end of the spectrum, the theory of a contestable market, first suggested by Baumol et al. (1982), insists that the market structure is not the only determinant of competition. Even very few firms existing, competition within a market will remain prevalent due to free entry and exit conditions. See, for example, Gilbert (1984), Shaffer (2004) and Carbo et al. (2009).

Because of the innovations and diversifications of financial instruments, as well as the pressure of competition from non-banking, banks' true market shares have become difficult to accurately calculate. The mainstream that prevailed for the past decades over the structure method has converted to non-structural indicators, which deduce the degrees of competition in a market by observing banks' behaviors indirectly. Panzar and Rosse (1987), Bresnahan and Lau (1982)[2], and Iwata

[1] During the sample period, 9 announcements of M&A happened in Taiwan.

[2] Their model encompasses a separate market demand function and individual firm supply function. This firm tends to charge a price, because its own marginal cost equals the perceived marginal revenue. Bresnahan and Lau argue that oligopolistic firms will set a price no less than that under perfect competition, but no more than monopolistic price. By using a parameter λ indexing the firm's degree of market power, researchers can assess the competitive condition of such an industry.

(1974)[1] propose non-structural methods that now enjoy popularity in evaluating competitive conditions. Among them, the Panzar and Rosse (1987) (henceforth, P-R) model outweighs the other three and constitutes our study's primary approach.

The application of the P-R model to measure the competitive condition in a banking industry can be attributed to Shaffer (1982), followed by Nathan and Neave (1989), Molyneux et al. (1996), Bikker and Haaf (2002), Hempell (2002), Claessens and Laeven (2004), Jiang et al. (2004), Yuan (2006), Al-Muharrami et al. (2006), Matthews et al. (2007), Yeyati and Micco (2007), Coccorese (2004, 2009), Turk-Ariss (2009), and Klaus et al. (2009), to mention a few. Some researchers have recently applied the Lerner index (Lerner, 1934) to explore the degree of competition in a banking industry, for example, Fernández (2005), Berger et al. (2009), Carbó et al. (2009), Koetter et al. (2013) and Turk-Ariss (2010).

1.2. Merger and acquisition. Rhoades (1994), Berger et al. (1999), Amel et al. (2004), Jones and Critchfield (2005), and De Young et al. (2009) provide a broad literature survey on bank consolidation. Berger et al. (1999) point out that almost all of the past studies suggest that there are no significant scale and product mix economies to be gained. In addition, studies loooking at the effects of M&As in the 1980s on U.S. banks' cost X-efficiency show very little or no cost X-efficiency improvement on average (De Young, 1997; Peristiani, 1997), while similar studies using data from the early 1990s obtain mixed results (Rhoades, 1998; Berger, 1998; Calomiris and Karceski, 1998). De Yong et al. (2009) review the recent financial institution M&A literature, covering over 150 papers, and summarize that North American bank mergers are efficiency improving, while European bank mergers appear to generate both efficiency gains and stockholder value enhancement.

Juncker and Oldfield (1972) adopt Monte Carlo simulation to estimate the concentration ratios in Jersey commercial banking markets under four regulator policies: restrictive, moderate, permissive, and very liberal policies. Evidence shows that the more stringent the policy is, the lower the market concentration will be, and vice-versa. Using the thick frontier analysis, Shaffer (1993) simulates megamergers between pairs of U.S. commercial banks and finds that variations in X-efficiency dominate scale, product mix, and branching efficiencies, and about half of the possible pairwise mergers among banks exceeding U$1 billion in assets are expected to reduce total costs.

Emmons et al. (2004) simulate mergers among community banks to evaluate the relative contributions of idiosyncratic risk and local market risk to the default risk assumed by community banks. They reach the conclusion that the greatest risk-reduction benefits are achieved by increasing a community bank's size, and larger community banks are likely to replace smaller community banks. Lin et al. (2008) use data from 14 bank holding companies (BHCs) in Taiwan that existed in 2004 to simulate pro forma mergers and determine the optimal number of BHCs in the industry ranges between 4 and 6, in which technical efficiency scores are measured by the data envelopment analysis. Based on an unbalanced panel of all Bavarian cooperative banks for the years 1989-97, Lang and Welzel (1999) compare actual mergers to a simulation of hypothetical mergers and show that the size effects of observed mergers are slightly more favorable than for all possible mergers.

Several case studies suggest that the cost X-efficiency effects of an M&A depend on the form of M&A, the motivations, and the way of executing its plans (Rhoades, 1998; Calomiris and Karceski, 1998). Cuesta and Orea (2002) find that merged and non-merged Spanish savings banks have distinct patterns of technical efficiency change and that merged banks are more efficient than non-merged ones, using an output distance function.

Utilizing data envelopment analysis to examine a 200-branch network formed from a merger of four banks, Sherman and Rupert (2006) identify opportunities to reduce branch operating costs by 22% for the entire merged bank, while the cost savings opportunity is under 7% when analyzed within each pre-merger bank. The empirical results of Al-Sharkas et al. (2008), using the stochastic frontier approach (SFA), indicate that mergers have stimulated the cost and profit efficiencies of the U.S. banks. Bernad et al. (2010) conclude that productivity gains can be found in only half of the mergers among Spanish savings banks during the sample period.

2. Methodology

2.1. Measuring the degree of competition. Similar to Shaffer (1993), Emmons et al. (2004) and Lin et al. (2008), this paper conducts merger simulations along the dimension of varying the number of banks from two to five. Therefore, we simulate four merger scenarios. In each replication, we randomly draw from the sample the same number of banks with replacement to form the simulated sample. Given

[1] Iwata (1974) and Bresnahan (1982) construct their models on the same basis. Iwata employs firm-specific data for the estimation, whereas Bresnahan samples industry aggregate data that frequently lead to meager sample data and imprecise estimation results.

the simulated sample, we perform four types of hypothetical mergers: two, three, four, and five banks are artificially and arbitrarily selected to combine into one larger, hypothetical bank, respectively. We then add the corresponding entries in these banks' balance sheets and income statements together. Each type of merger is replicated 1000 times. We compute five measures in each replication: the H statistic (measuring the degree of market competition), scale and scope economies, technical changes, and technical efficiency score. We obtain the H statistic from the estimation of a (log) total revenue function and derive the remaining four measures from both the translog and FF cost functions. Their definitions will be described shortly.

Following the convention, we specify the reduced-form regression equation for a bank's total revenue (TRTA), which associates its TRTA with three input prices, i.e., labor (P_1), capital (P_2), and borrowed funds (P_3), based on the intermediation approach, together with a set of control variables as:

$$\ln TRTA = \beta_{ok} + \beta_1 \ln P_1 + \beta_2 \ln P_2 + \beta_3 \ln P_3 + \\ + \beta_4 \ln LRAS + \beta_5 \ln AST + \beta_6 \ln HHI + \beta_7 \ln BDFD + \\ + \beta_8 \ln EQAS + \beta_9 \ln CFAS. \quad (1)$$

Here, "ln" denotes natural logarithm, *TRTA* is defined as a bank's total revenue divided by total assets[1], β_{ok} is either fixed- or random-effects of bank *k*, and ε is the error term with mean zero and constant variance. Equation (1) includes six control variables to describe the impact of banks' heterogeneous characteristics on total revenues. Among them, we define *LRAS* and *EQAS* as the ratio of loan loss reserves to total assets and the ratio of equity to total assets, respectively, and use them to capture the operation risk that banks may be exposed to. Their coefficients reflect how banks' bad loans and leverage ratio affect total revenues, given that all the reserves that banks prepare will be recognized as bad loans and written off.

Following Nathan and Neave (1989) and Bikker and Haaf (2002), we use total assets (AST) as a scaling factor for the purpose of testing the hypothesis of whether large banks enjoy scale economies and thus higher revenues. The variable of HHI index links the market concentration level with total revenues. The inclusion of the conventional structural indicator into the non-structural H statistic in (1) allows for examining whether the two methods generate a consistent conclusion. The ratio of interbank deposits to total liabilities (BDFD) captures the effects of differences in the deposit mix on banks' revenues. Finally, the ratio of non-interest income (including net commission income and fee income) to total assets (CFAS) attempts to explain the influence of other income on total revenues.

Estimating (1) enables us to test for the competitive conditions of a financial market under which the sample banks are operating. The main parameter of interest is the index of $H = \beta_1 + \beta_2 + \beta_3$. A value of $H \leq 0$ corresponds to a monopoly, $H = 1$ signifies perfect competition, while $0 < H < 1$ implies either an oligopoly or monopolistic competition. It is important to note that the validity of the inference on competition conditions from the H statistic depends on the presence of a long-run equilibrium. In line with Nathan and Neave (1989), Molyneux et al. (1996), De Bandt and Davis (2000), Bikker and Haaf (2002), Shaffer (2004), Casu and Girardone (2006), Schaeck et al. (2009), and Maudos and Solís (2011) among others, we re-run equation (1) with the dependent variable being replaced by the logarithm of return on assets (ROA) and formulate the equilibrium test statistic as $E = \beta_1 + \beta_2 + \beta_3$. The long-run equilibrium condition holds, provided, $E = 0$ and the reverse is true if $E < 0$, which implies that the estimation results of (1) may be meaningless. Table 1 summarizes the definitions of all variables.

2.2. Measuring cost efficiencies. We specify a standard translog cost function with fixed-effects as follows:

$$\ln TC = \alpha_{ok} + \sum_m \alpha_m \ln P_m + \frac{1}{2}\sum_m \sum_n \alpha_{mn} \ln P_m \ln P_n + \\ + \sum_i \beta_i \ln Y_i + \frac{1}{2}\sum_i \sum_j \beta_i \ln Y_i \ln Y_j + \\ + \sum_i \sum_j \gamma_{im} \ln Y_i \ln P_m + \delta_t t + \frac{1}{2}\delta_{tt} t^2 + \\ + \sum_m \delta_{tm} t \ln P_m + \sum_i \delta_{ti} t \ln Y_i + e. \quad (2)$$

Here, TC denotes total costs, α0k is bank k's fixed-effects used to estimate the technical efficiency score of individual banks, and e is the random disturbance. Notations P and Y are 3×1 input prices as shown in (1) and output quantities, respectively, and t denotes a time trend capturing potential technical progress. Table 1 also shows the detailed definitions of the outputs.

Measures of scale and scope economies, technical changes, and technical efficiency can be derived once (2) has been estimated. We present the formu-

[1] Bikker et al. (2012) show that the use of a price equation and a scaled revenue function do not yield a valid measure for competitive conduct. In addition, the employment of an unscaled revenue function generally relies on additional information about costs and market equilibrium infer the comprtitive conditions.

lae of these measures below.

Table 1. Variable definition

Variable	Definition
TRTA	(Interest revenue + Non-interest revenue) / Total assets
ROA	Return on assets
P_1*	Personnel expenses / Number of employees
P_2	Other administration expenses / Fixed assets
P_3	Interest expenses / (Total deposits + Borrowed funds)
LRAS	Loan loss reserve / Total assets
*AST**	Total assets
HHI	Herfindall-Hirschman index calculated by using total assets
BDFD	Interbank deposits / total Debts
EQAS	Equity / Total assets
CFAS	(Net commission income + Fee income) / Total assets
Y_1	Total loans
Y_2	Investments
Y_3	Fee income + Commission
TC	Personnel expenses + Other administration expenses + Interest expenses

We compute economies of scale (*ES*) as:

$$ES = \sum_{i=1}^{3} \frac{\partial \ln TC}{\partial \ln Y_i} = \sum_{i=1}^{3} \frac{\partial TC}{\partial Y_i} \times \frac{Y_i}{TC}. \quad (3)$$

A value of *ES* less than unity exhibits increasing returns to scale, corresponding to the decreasing portion of a representative bank's long-run average cost. A value of *ES* > 1 implies decreasing returns to scale, corresponding to the increasing portion of a representative bank's long-run average cost, while *ES* = 1 means that the average bank is producing at the optimal scale, i.e., constant returns to scale.

We define economies of scope (SC) as:

$$SC = \frac{TC(Y_1,0,0) + TC(0,Y_2,0,0) + TC(0,0,Y_3) - TC(Y_1,Y_2,Y_3,)}{TC(Y_1,Y_2,Y_3,)}. \quad (4)$$

The presence of scope economies requires *SC* > 0, implying that the joint production process leads to cost savings. Conversely, scope diseconomies prevail if *SC* < 0, validating the specialized production process. One difficulty is yet to be solved, i.e., (4) is not applicable for the translog cost function, since the logarithm of zero is undefined. We therefore choose to estimate (2) without transforming the dependent and independent variables by taking natural logarithms.

We formulate the rate of technical change (*RTC*) as:

$$RTC = \frac{\partial \ln TC(P,Y,t)}{\partial t}. \quad (5)$$

A bank is said to be experiencing a technical advance if *RTC* is negative, while the reverse is true if *RTC* is positive.

We can employ the estimated fixed-effects to evaluate efficiency scores for each sample bank. Following Schmidt and Sickles (1984), for all banks we first obtain:

$$\mu_k^* = \max_k(\alpha_{ok}) - \alpha_{ok} \geq 0 \quad (6)$$

We yield the relative technical efficiency (*TE*) score by: the following equation

$$TE_k = \exp\{-\mu_k^*\}, \forall k. \quad (7)$$

This must lie between zero and unity. The higher the value of *TE* is, the more technically efficient the bank will be, and vice-versa.

To confirm that our results are robust, we alternatively estimate an FF cost function, which is known to be a more general functional form than the standard translog form and can globally approximate to a true (but unknown) cost function, as claimed by Gallant (1981, 1982). The FF cost function is composed of a translog function and a trigonometric Fourier series of sin(.) and cos(.). For empirical applications, readers can refer to, e.g., McAllister and McManus (1993), Berger et al. (1997), Berger and Mester (1997), Mitchell and Onvural (1996), Altunbas et al. (2000), Huang and Wang (2004), and Huang et al. (2011). Appendix A introduces the construction of the FF cost function.

3. Data

To avoid the effects of random shocks, such as the Asian financial crisis in 1997, which may cause structural changes in Taiwan's banking industry, we compile unbalanced panel data from 1998 to 2009. The data contain 50 domestic commercial banks with 565 bank-year observations in total. Table 2 presents sample statistics of the relevant variables, in which all dollar-valued variables are expressed as thousands of New Taiwan Dollars and deflated by the consumer price index of Taiwan with base year 2006. We note from Table 2 that the average value of HHI is roughly equal to 494.8, indicating that the market lacks concentration. In fact HHI lies in a narrow range from 460 to 511.

Table 2. Descriptive statistics

Variable	Mean	Std. dev.
TRTA	0.05212	0.01857
P_1*	1029.35444	339.17012
P_2	0.38664	0.31219
P_3	0.03377	0.02642
*LRAS**	60185.8439	1430600.596
*AST**	5.39186D+08	6.09011D+08
BDFD	0.04385	0.04614
EQAS	0.08321	0.09199
CFAS	0.00378	0.00286
HHI	494.81052	37.27209
ROA	0.02704	0.01855
Y_1*	3.32881D+08	3.72646D+08
Y_2*	7.80521D+07	1.08484D+08
Y_3*	2046772	2828853

Note: * Thousands of real New Taiwan Dollars with the base year 2006.

4. Empirical results

This section conducts the empirical study using the data described in the previous section. We first proceed to the Hausman test to confirm that the fixed-effects regression model is appropriate in the test for market conditions. Next, we estimate the translog and FF cost functions and utilize their parameter estimates to compute scale and scope economies, the rate of technical change, and technical efficiency scores.

4.1. Degree of competition. We first test for the hypothesis that Taiwanese banking has achieved the long-run equilibrium. Since a few observations have a negative ROA value, we follow the convention and replace ln (*ROA*) by ln(1 + *ROA*). Table 3 presents the parameter estimates of the fixed-effects model[1]. The table shows that the coefficient estimates of the three factor prices are all quite small, implying that changes of these factor prices tend to have little effect on banks' profits. The test statistic and standard error for the null hypothesis of $E = 0$ is equal to 0.0045 and 0.0074, respectively, implying that this hypothesis cannot be rejected by the data. We conclude that the banking industry under study is already in the long-run equilibrium.

Table 4 summarizes the coefficient estimates of (1) using the fixed-effects model. All of the coefficients are significantly estimated at least at the 5% level of significance, except for ln*AST*. The coefficient estimates of the three factor price are all positive, as expected, and significantly different from zero. The implied H-statistic is equal to 0.6984 and significantly different from both zero and (less than) unity, as shown in row 1 of Table 8. This reveals that a 1% increase in all three input prices results in a 0.6984% increase in a bank's revenue, indicating that the banking market tends to be under monopolistic competition. Such a large H statistic value denotes that Taiwan's banking industry is highly competitive, in which each bank provides a relatively small amount of financial products to serve its customers. This finding is consistent with the actual situation of "overbanking" and the average HHI measure of 494.08. The two extreme market structures of monopoly and perfect competition may be excluded[2].

Table 3. Parameter estimates of equation (2) and market equilibrium test

Variable	Coefficient	Standard error
lnP_1	-0.0136**	6.89E-03
lnP_2	3.02E-04	3.65E-03
lnP_3	0.0178***	2.37E-03
ln*LRAS*	-0.0210***	2.68E-03
ln*AST*	0.0220***	5.40E-03
ln*BDFD*	-3.16E-03**	1.32E-03
ln*EQAS*	0.0407***	4.25E-03
ln*CFAS*	4.87E-03*	2.69E-03
ln*HHI*	-0.0674***	0.0180
Adjusted R-squared = .9928		

Notes: ***Significance at the 1% level. **Significance at the 5% level. *Significance at the 10% level.

Table 4. Parameter estimates of the PR model and the H statistic

Variable	Coefficient	Standard error
lnP_1	0.1322***	0.0359
lnP_2	0.0771***	0.0190
lnP_3	0.4891***	0.0124
ln*LRAS*	0.0304**	0.0139
ln*AST*	-0.0224	0.0281
ln*BDFD*	-0.0175**	6.88E-03
ln*EQAS*	0.0987***	0.0221
ln*CFAS*	0.1566***	0.0140
ln*HHI*	-1.1251***	0.0936
Adjusted R-squared = .8752		

Notes: *** Significance at the 1% level. **Significance at the 5% level. *Significance at the 10% level.

4.2. Cost efficiency measures. Tables 5 and 6 present the parameter estimates of the fixed-effects models for both translog and FF cost functions, respectively. It is worth mentioning that the homogeneity restriction on factor prices is imposed on both cost functions, as required by the microeconomic theory. Most of the coefficient estimates in the

[1] Hereafter, we do not show all of the fixed-effects estimates in order to save space.

[2] We also estimate the translog cost frontier under the assumption that each bank produces a single output, proxied by total assets. The estimated cost frontier can be used to calculated the marginal cost of the single output and the standard Lerner index. However, most of the Lerner index estimates are negative, leading the average value of the index to be negative. Although the negative Lerner index may reflect that the market is highly competitive, it lacks economic implication. We, therefore, choose to examine the Hstatistic instead.

translog cost function attain statistical significance at least at the 10% level, while less than a half of the parameters are significantly estimated in the FF cost function, reflecting that the FF function fails to be fitted very well.

Row 1 of Table 8 presents the estimated scale economies, using the parameter estimates of the two cost functions. The average measures of *ES* of the translog and FF functions are equal to 0.7016 and 0.6624, respectively. Both functions support that banks in Taiwan are operating under increasing returns to scale. Sample banks are recommended to keep expanding their production scale in order to reduce their long-run average costs. This outcome may be justified by the fact that there are so many small-scaled commercial banks competing in the island that it is cost-saving for them to build a small production scale, which hinders them from enjoying scale economies. This justifies the SFR policy in reducing the number of banks.

Recall that we estimate (2) without transforming the dependent and independent variables by taking natural logarithms in such a way as to employ formula (4) to calculate the measure of scope economies. Table 7 lists coefficient estimates of the fixed-effects model, where most of them attain statistical significance at least at the 10% level. We compute the *SC* measure for each observation and the mean of *SC* is found to be equal to 0.3096, as shown in row 1 of Table 8. This reflects that joint production of the three outputs by a single bank is advantageous over three specialized banks that individually offer the same levels of outputs. Product diversification seems to be an effective way to lower sample banks' production costs by around 31% of current costs, resulting from information and resource sharing among different sectors of banks.

Table 5. Parameter estimates of the translog cost function

Variable	Coefficient	Standard error
C	21.6731***	4.4407
$\ln P_1$	0.6013	0.5002
$\ln P_3$	0.8581**	0.3730
$\ln Y_1$	-3.0154***	0.4404
$\ln Y_2$	1.2983***	0.2181
$\ln Y_3$	0.4626**	0.2126
$\ln P_1 * \ln P_1$	0.1433**	0.0552
$\ln P_3 * \ln P_3$	0.1642***	0.0412
$\ln P_1 * \ln P_3$	-0.1187***	0.0423
$\ln Y_1 * \ln Y_1$	0.3670***	0.0354
$\ln Y_2 * \ln Y_2$	0.0236	0.0158
$\ln Y_3 * \ln Y_3$	0.0613***	0.0137
$\ln Y_1 * \ln Y_2$	-0.0686***	0.0217
$\ln Y_1 * \ln Y_3$	-0.0983***	0.0168
$\ln Y_2 * \ln Y_3$	7.76E-03	8.73E-03
$\ln Y_1 * \ln P_1$	-0.0845***	0.0322
$\ln Y_1 * \ln P_3$	0.0219	0.0219
$\ln Y_2 * \ln P_1$	-0.0435**	0.0190
$\ln Y_2 * \ln P_3$	0.0730***	0.0160
$\ln Y_3 * \ln P_1$	0.0451**	0.0201
$\ln Y_3 * \ln P_3$	-0.03704***	0.0119
t	0.1718***	0.0590
$t * t$	-5.97E-03***	1.43E-03
$t * \ln P_1$	-6.04E-03	6.71E-03
$t * \ln P_3$	-4.28E-03	6.06E-03
$t * \ln Y_1$	-0.0171***	4.17E-03
$t * \ln Y_2$	0.0105***	2.48E-03
$t * \ln Y_3$	5.07E-03*	2.92E-03
Adjusted R-squared = .9937		

Notes: *** Significance at the 1% level. ** Significance at the 5% level. * Significance at the 10% level.

Table 6. Parameter estimates of the FF cost function

Variable	Coefficient	Standard error
$\ln P_1$	0.3497	0.4533
$\ln P_3$	1.6582***	0.3880
$\ln Y_1$	-1.5708	2.4619

Table 6 (cont.). Parameter estimates of the FF cost function

Variable	Coefficient	Standard error
lnY_2	1.6820	1.8949
lnY_3	2.5643**	1.2613
lnP_1*lnP_1	0.0660	0.048864
lnP_3*lnP_3	0.1314***	0.043055
lnP_1*lnP_3	-0.0648	0.0398
lnY_1*lnY_1	0.2069	0.1351
lnY_2*lnY_2	-0.0794	0.1303
lnY_3*lnY_3	-0.0978	0.1023
lnY_1*lnY_2	2.05E-03	0.02153
lnY_1*lnY_3	-0.0999***	0.0220
lnY_2*lnY_3	-6.83E-03	0.0117
lnY_1*ln P_1	-0.05676*	0.0319
lnY_1*ln P_3	0.0330	0.0239
lnY_2*ln P_1	-0.0149	0.0181
lnY_2*ln P_3	-1.35E-03	0.0150
lnY_3*ln P_1	0.040027**	0.0203
lnY_3*ln P_3	-0.0518***	0.0162
t	0.1284*	0.0677
t*t	-6.17E-03***	1.33E-03
t*lnP_1	-4.19E-03	6.34E-03
t*lnP_3	-4.64E-03	6.19E-03
t*lnY_1	-3.97E-03	4.57E-03
t*lnY_2	1.84E-03	2.39E-03
t*lnY_3	-2.11E-05	3.24E-03
$COSZ_1$	0.3394	0.2500
$SINZ_1$	-0.1582**	0.080348
$COSZ_2$	0.1244	1.1746
$SINZ_2$	1.0035***	0.2458
$COSZ_3$	1.4133*	0.7926
$SINZ_3$	0.1026	0.1287
$COS2Z_1$	-0.1039*	0.0578
$SIN2Z_1$	0.0320	0.0301
$COS2Z_2$	-0.1306	0.2117
$SIN2Z_2$	0.1463	0.2122
$COS2Z_3$	0.2654	0.1722
$SIN2Z_3$	0.1377	0.1093
$COSZ_1Z_2$	-0.0173	0.0496
$SINZ_1Z_2$	0.1939***	0.0633
$COSZ_1Z_3$	0.2151***	0.0574
$SINZ_1Z_3$	0.0904*	0.0546
$COSZ_2Z_3$	-0.0265	0.0547
$SINZ_2Z_3$	0.0370	0.0621
$COS3Z_1$	-0.0365*	0.0200
$SIN3Z_1$	0.0542***	0.0145
$COS3Z_2$	-0.1133***	0.0352
$SIN3Z_2$	0.0455	0.0616
$COS3Z_3$	0.0189	0.0268
$SIN3Z_3$	0.0850*	0.0464
Adjusted R-squared = .9957		

Notes: *** Significance at the 1% level. **Significance at the 5% level. *Significance at the 10% level.

We apply the coefficient estimates of the translog and FF cost functions to evaluate the rate of technical progress for each observation according to (5). Row 1 of Table 8 displays that the average values of RTC are equal to 0.0200 and 0.0208, respectively. Slight technical regression prevails in Taiwan's banking industry during 1997-2009. We finally compute technical efficiency scores for all sample banks using formulae (6) and (7). The same row of Table 8 reveals that the mean efficiency scores of the translog and FF cost functions respectively equal 0.3032 and 0.2765. Substantial technical inefficiency exists in the sample. We suggest that Taiwanese commercial banks improve their managerial abilities to lower production costs and to be viable in the market.

Table 7. Estimates of scope economies

Variable	Coefficient	Standard error
C	-1.21E+06	5.15E+06
P_1	4419.61***	1134.5
P_3	-8.21E+07***	2.35E+07
Y_1	6.90E-03	0.0185
Y_2	-0.1328***	0.0486
Y_3	1.9925	1.6363
P_1*P_1	0.0653	0.13677
P_3*P_3	-1.12E+08***	2.40E+07
P_1*P_3	-647.911	3545.53
Y_1*Y_1	-1.67E-10***	1.87E-11
Y_2*Y_2	1.15E-10	1.70E-10
Y_3*Y_3	-4.43E-07**	1.76E-07
Y_1*Y_2	-2.69E-10***	3.86E-11
Y_1*Y_3	9.99E-09***	1.64E-09
Y_2*Y_3	7.80E-09*	4.74E-09
Y_1*P_1	1.04E-05***	1.17E-06
Y_1*P_3	0.8896***	0.0511
Y_2*P_1	-1.23E-05***	4.16E-06
Y_2*P_3	1.9061***	0.2120
Y_3*P_1	3.68E-04	2.59E-04
Y_3*P_3	-17.1032**	6.8411
t	-1.02E+06	870454
$t*t$	39765.6	111217
$t*P_1$	-592.521***	129.725
$t*P_3$	2.05E+07***	3.27E+06
$t*Y_1$	5.17E-03***	1.32E-03
$t*Y_2$	0.019516***	4.19E-03
$t*Y_3$	-0.52082***	0.169924
Adjusted R-squared = .9993		

Notes: *** Significance at the 1% level. ** Significance at the 5% level. * Significance at the 10% level.

5. Simulation results

This study randomly draws 50 banks with replacement from our data, described in section 4, to form the simulated sample. We then sum up the accounting items in the balance sheets and income statements of a pair of banks and treat this as a new and pro forma bank. The resulting 25 hypothetical banks construct a simulated sample, and the estimation procedures introduced in the previous section are executed to get the five indicators of the H statistic and the measures of ES, SC, RTC, and TE. The above steps are repeated 1000 times, and their average values are shown in the second row of Table 8, labeled by 2-banks.

Figures in the remaining rows of Table 8 are similarly obtained, where in each replication, 48, 48, and 50 banks are randomly drawn with replacement and every three, four, and five banks are arbitrarily united into one bigger bank. The resulting 16, 12, and 10 banks are treated as simulated samples, and the estimation procedures in the previous section are performed again to yield the same five indicators. Their average values on the basis of 1000 replications are in the third, fourth, and fifth rows of Table 8, labeled by 3-banks, 4-banks, and 5-banks, respectively.

Table 8. Simulation results

Merger type	H statistic (Std. err.)	ES-translog (Std. dev.)	ES-FF (Std. dev.)	SC (Std. dev.)	RTC-translog (Std. dev.)	RTC-FF (Std. dev.)	TE-translog (Std. dev.)	TE-FF (Std. dev.)
Before merger	0.6984 (0.0385)	0.7016 (0.1344)	0.6624 (0.2492)	0.3096 (2.9409)	0.0199 (0.02279)	0.0208 (0.0222)	0.3032 (0.1469)	0.2765 (0.1320)
2-banks	0.6075	0.7915	0.7412	0.5828	0.0089	0.0110	0.6642	0.6550
3-banks	0.5801	0.7583	0.7262	0.4634	0.0076	0.0086	0.7374	0.7226
4-banks	0.5568	0.7486	0.7251	0.5219	0.0073	0.0080	0.7759	0.7616
5-banks	0.5434	0.7245	0.6850	0.6127	0.0078	0.0091	0.8005	0.7837

Column one of Table 8 uncovers that the simulated inter-bank merger is able to increase market power since the H statistic gradually decreases as the number of united banks grows, i.e., from 0.6984 (before merger) to 0.5434 (5-banks). A merger strategy does help enhance the degree of market concentration and reduce the degree of competition in Taiwan's banking market. Among them, we see the case of a merger between two banks to have the largest effect on the increase in market concentration, because it causes the largest size reduction of the H statistic (from 0.6984 to 0.6075). These results rationalize the SFR policy in 2004. The remaining forms of a merger incur lesser magnitudes of changes in market competition. The problem of "over-banking" in Taiwan can be disentangled at least to some extent by encouraging bank consolidations, especially cutting down the number of banks by one half.

The translog and FF cost functions in general provide quite similar information on the four measures of ES, SC, RTC, and TE. No matter which type of merger is chosen, all four measures are superior to the non-merger case, even though different scenarios of a merger have their own advantages in the four measures. Taking the translog function of the 2-banks merger as an example, the average ES and SC measures increase roughly 12% and 90%, respectively, the average rate of technical regression substantially slows down by about 50%, and the mean technical efficiency score is more than doubled. We reach similar outcomes by using the FF function and conducting the remaining merger scenarios.

The foregoing appears to support the enforcement of the SFR policy and is consistent with the outcomes of Lin et al. (2008), who suggest the original 14 BHCs in Taiwan to decrease to 4 to 6 in number. It is interesting to note that the highest and lowest mean values of ES and RTC occur at the cases of 2-banks and 4-banks, respectively, while the case of 5-banks attains the greatest SC and TE measures. No single merger scenario dominates the others. Our simulation technique is helpful in predicting patterns of mergers, to the extent that future consolidation will be affected chiefly by cost consideration and market structure.

Some articles perform different forms of simulated mergers, e.g., "mergers of equals", in-market M&As, and when the acquiring bank is more efficient than the acquired bank, in order to help predict efficiency changes from consolidation. Their results are mixed. Therefore, we further simulate other dimensions of mergers as robustness tests. For example, we divide the original sample banks into two groups: large banks and small banks. We then randomly draw and consolidate pairs of a large bank and a small bank to yield 25 hypothetical banks. The H statistic and the four measures are then estimated. The above procedure is repeated 1000 times, and the average values of the five indicators are quite close to those of 2-banks shown in Table 8 and hence not shown[1]. We conclude that bank consolidation indeed raises market concentration and prompts the four measures, irrespective of the consolidation scenario.

Conclusions

This paper has carried out an empirical study in section 4 and simulations in section 5. The simulation approach offers a forward-looking picture of what the sector may see from the possible cost impacts of bank consolidation, on the basis of ex ante financial information. According to the previous two sections, Taiwan's banking industry can be described as highly competitive and full of many relatively small-scaled commercial banks, each having a small market share. These banks produce under increasing returns to scale technology, and the joint production of financial services tends to be cost saving. However, technical regression and a lack of technical efficiency prevail in the industry, possibly due to the fact that these small-sized banks cannot afford to invest in research and development and adopt financial innovations and advanced production technology in a sluggish manner.

Encouraging bank consolidation seems to be an economically meaningful policy, which underlies the SFR initiated in 2004. According to the simulation results in the previous section, bank consolidations can essentially solve the problem of "over-banking" to some extent, expand production scale and product diversification, reduce the speed of technical regression, and promote managerial skills. All of them make the industry and the society as a whole better off. Although the merger type of 5-banks can achieve the lowest H statistic and the highest SC and TE measures, it is likely to be very difficult to implement in practice, because of its involvement of many parties that are apt to incur considerable transaction costs. Conversely, the scenario of 2-banks appears to be the most feasible alternative due to its simplicity and at least superiority to the non-merger case in all the five indicators. In other words, the merger pattern of a pair of banks may be a compromise between social benefits and costs. More importantly, the positive impacts from mergers on the five indicators are independent of the methods of the mergers.

In conducting merger simulations, we simply sum over the same items in the balance sheets and income statements among banks. This ignores the possible synergy of inter-bank mergers and implicitly assumes that the production functions of inputs and outputs are additive among banks. These potential problems are suggested as future research topics.

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[1] Moreover, we randomly draw pairs of large banks and pairs of small banks to construct a sample of 24 hypothetical banks, which are applied to estimate the five indicators. These average values from 1000 replications do not differ considerably from the respective ones shown in Table 8.

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Appendix A. Construction of the FF cost function

The current paper transforms each output quantity into the range of zero and 2π by defining:

$$z_j = \mu_j (\ln Y_j + \ln a_j), j = 1, 2, 3.$$

Here $\ln a_j$ is the location parameter.

Following Gallant (1982), Chalfant and Gallant (1985), and Mitchell and Onvural (1996), we choose:

$$\ln a_j = 10^{-5} - \min(\ln Y_j), \ j = 1, 2, 3.$$

Parameter μ_j (j = 1, 2, 3) is the scaling factor of output j and expressed as: $\mu_j = \frac{6}{\ln Y_j^{\max} + \ln a_j}, j = 1, 2, 3.$

Here, $Y_j^{\max} = \max(\ln Y_j)$ is the maximum observed values of the jth output in the sample.

We specify the FF cost function as follows:

$$\ln TC = \alpha_k + \sum_m \alpha_m \ln P_m + \frac{1}{2}\sum_m \sum_n \alpha_{mn} \ln P_m \ln P_m + \sum_i \beta_i \ln Y_i + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln Y_i \ln Y_j + \sum_i \sum_m \gamma_{im} \ln Y_I \ln P_m +$$

$$+\delta_t t + \frac{1}{2}\delta_{tt} t^2 + \sum_m \delta_{tm} t \ln P_m + \sum_i \delta_{ti} t \ln Y_i + \sum_i [\alpha_i \cos(z_i) + b_i \sin(z_i)] + \sum_i \sum_j [\alpha_{ij} \cos(z_i + z_j) + b_{ij} \sin(z_i + z_j)] +$$

$$+ \sum_i \sum_j \sum_k [\alpha_{ijk} \cos(z_i + z_j + z_k) + b_{ijk} \sin(z_i + z_j + z_k) + v.$$

Here, sin(.) and cos(.) represent the trigonometric functions of sine and cosine, and v denotes the statistical noise.