The Developing Economies, XLI-3 (September 2003): 309–39

COMPETITIVE ISSUES IN THE TAIWANESE BANKING INDUSTRY: MERGERS AND UNIVERSAL BANKS

PEIYI YU

This paper investigates scale economies and scope economies in the Taiwanese banking system, looking beyond the market-power (MP) and efficient-structure (ES) hypotheses. Given the existence of overall economies of scale and the positive value of expansion path sub-additivity, we conclude that there might be large increases in profits following mergers. Moreover, since the profit-structure relationship after financial reform is determined by the relative-market-power hypothesis, this consolidation trend will not necessarily decrease the social benefit for Taiwanese consumers. With regard to scope economies and product-specific economies of scale, we are unable to recommend whether Taiwanese banks should develop as specialized banks or diversified banks in the future. Finally, we find that risk indicators play an important role in explaining the observed variation in bank profitability, and present evidence that default risk and leverage risk have negative effects on the profits of banking, although the effect of portfolio risk is uncertain.

I. INTRODUCTION

DURING the period of study, 1985 to 1997,[1] a number of regulatory changes were made[2] that made possible a major expansion of the number of banks operating in Taiwan.[3] These developments provide an opportunity for a pre- and post-analysis of the changes and an assessment of their impact on the banking sector. There are suggestions that the proliferation of banks in the early 1990s changed competitiveness[4] within the banking system, and that it is therefore respon-

I am grateful to Dr. Bac Van Luu, Dr. John Cadle, Professor Leigh Drake, and Professor Andy Mullineux for their suggestions on this paper.

1 Moreover, from 1998, some public banks started to privatize in order to make themselves more competitive. It can be inferred that, since 1998, the structure of Taiwanese banking market has changed again. Based on this, the observable period is only extended to 1997.

2 In 1991, the Taiwanese government started to liberalize and deregulate the financial markets, and allowed sixteen private commercial banks to be established around 1992.

3 Since 1991, sixteen new banks have been allowed to enter the banking market (Ministry of Finance, "Zhonghua minguo Taiwan diqu jinrong tongji zhibiao" [Annual report of the finance department of the Ministry of Finance], Taipei, 1991–97 editions).

4 Since their establishment, the return on equity (*ROE*), of some of the new private banks has declined with time and the loan loss ratio of some old banks is rising.

sible for the large loan losses recently disclosed following the impact of the Asian crisis. "Overbanking" is another important factor that is thought to have contributed to poor banking performance.

The objective for this study is to examine the nature of the Taiwanese banking industry, given that analyzing banks' characteristics is helpful for making decisions at both the macro and micro level. Our goal is to investigate whether the current wave of mergers observed elsewhere applies also to the Taiwanese banking industry. In addition, we discuss whether Taiwanese banks should develop as universal banks or specialized banks in the future.

Most of the banking literature concentrated on estimating scale economies for individual banking functions,[5] until Benston et al. (1982) used the conventional translog cost function system to estimate economies of scale in banking.[6] The latter system allows the cost structure of banks to be modeled with maximum flexibility and for each of the outputs to be considered explicitly. However, there are three major limitations to the use of the translog cost function. The first is that the translog cost function form is potentially subject to mis-specification (McAllister and McManus 1993). The second is that the ordinary translog function form cannot be modified to define zero outputs since all of the outputs are entered in logarithmic form. The final limitation is that there is a multi-collinearity between explanatory variables because the translog cost function form has a large number of parameters. In this study, we adopt the conventional translog cost function form because of its flexibility and due to the small number of banks in our sample. However, to remedy the potential drawbacks, we replace the original translog cost function with Box and Cox's (1964) transformation, which is called the hybrid translog cost function. Moreover, to achieve better results, we use the panel data and the simultaneous estimation (seemingly unrelated regression estimation, SURE) of the hybrid translog cost function with two input cost share equations.

Four major hypotheses have emerged in the banking literature to explain the profit-structure relationship.[7] The structural-conduct-performance hypothesis suggests that banks set prices that are less favorable to consumers in more concentrated markets because of competitive imperfections. The relative-market-power hypothesis asserts that only banks with large market shares and well-differentiated products

[5] Prior studies did not measure the total cost of banking operations. For example, demand deposits were separated from commercial loans.

[6] The conventional translog cost function system was developed by Christensen, Jorgenson, and Lau (1973), as a second-order Taylor expansion series in output quantities, input prices, and control variables.

[7] Market-power (MP) hypotheses are comprised of the structural-conduct-performance hypothesis and the relative-market-power hypothesis, and the efficient-structure (ES) hypotheses include the *X*-efficiency version of the ES hypothesis and the scale-efficiency version of the ES hypothesis. Advocates of the MP hypotheses tend to see antitrust enforcement as socially beneficial, while ES advocates tend to see policies that inhibit mergers as socially costly.

can exercise market power in pricing products and earn supernormal profits (Shepherd 1982). Under the *X*-efficiency version of the efficient-structure hypothesis, banks with superior management or production technologies have lower costs and hence can earn higher profits. Therefore, the positive profit-structure relationship is spurious, since these more efficient banks are also assumed to gain large market shares, resulting in high concentration (Demsetz 1973, 1974; Peltzman 1977). Under the scale-efficiency version of the efficient-structure hypothesis, firms have equally good management and technology, but some firms simply produce at more efficient scales than others. This hypothesis can also yield a positive profit-structure relationship as a spurious outcome, since these firms are assumed to have large market shares, possibly resulting in high levels of concentration (Lambson 1987). However, because of limited support for the two hypotheses, in that the efficiency and market power variables explain relatively little of the variance of profitability, Berger (1995) suggests that future research should look beyond the simple market structure and efficiency variables employed in the hypotheses.

In this study, we discuss three different aspects of these competitive banking issues: scale economies, scope economies, and looking beyond the tests of the market-power (MP) and efficient-structure (ES) hypotheses in banking. In the following section, we discuss the modeling procedures and the variables employed in this study. In Section III, empirical results are presented and concluding remarks are made in Section IV.

II. SPECIFICATIONS OF MODELS

In this section, we discuss the specification of models for scale economies and scope economies, and try to look beyond the profit-structure relationship in banking.

A. *Scale Economies*

Economies of scale and bank size are very important to the banking industry and to regulators. If overall scale diseconomies exist, mergers or increasing branch numbers should be discouraged. We use the modified model from Molyneux, Altunbas, and Gardener (1997) to analyze the Taiwanese banking industry from 1985 to 1997.

1. *Methodology: The hybrid translog cost function system*

The intermediation approach is chosen to measure a vector of outputs produced by multiproduct banks. Furthermore, we assume that all domestic banks can operate in a competitive environment and all of them aim to minimize costs. The cost function below explains the best production process of multiproduct banks,

$$output\ (Q_i) = f\ (input_j, B), \tag{1}$$

where

Q_i: a given vector of outputs,
$input_j$: their inputs, and
B: the number of branches.

Based on the assumption of cost minimization, the corresponding dual cost function can be inferred as follows:

$$\text{Total cost } (TC) = C(Q_1, Q_2, \ldots, Q_i; p_1, p_2, \ldots, p_j; B). \tag{2}$$

However, this unique relationship between the production function (1) and the cost function (2) only exists when the cost function satisfies the duality condition developed by Shephard (1953, 1970) and Diewert (1974). The translog cost function must satisfy the duality condition in the standard translog estimation procedure and no prior restrictions are imposed on the first and second partial derivatives.[8]

The basic form of the conventional translog cost function is described as follows:

$$\begin{aligned} \ln TC = {} & \alpha_0 + \sum_{i=1}^{2} \alpha_i \ln Q_i + \sum_{i=1}^{3} \beta_i \ln p_i + \lambda_b \ln B \\ & + \frac{1}{2} \left(\sum_{i=1}^{2} \sum_{j=1}^{2} \delta_{ij} \ln Q_i \ln Q_j + \sum_{i=1}^{3} \sum_{j=1}^{3} \gamma_{ij} \ln p_i \ln p_j + \lambda_{bb} \ln B \ln B \right) \\ & + \sum_{i=1}^{3} \sum_{j=1}^{2} \rho_{ij} \ln p_i \ln Q_j + \sum_{i=1}^{2} \lambda_{bi} \ln B \ln Q_i + \sum_{i=1}^{3} \tau_{bi} \ln B \ln p_i + \varepsilon, \end{aligned} \tag{3}$$

where

$\ln TC$: the natural logarithm of the total of interest costs, labor costs, and capital costs,
$\ln Q_i$: the natural logarithm of a vector of outputs (Q_1 = total loans, Q_2 = government bonds, total securities, and the other investments),
$\ln p_i$: the natural logarithm of ith input prices (p_1 = interest rate, p_2 = wage rate, and p_3 = capital price), and
$\ln B$: the natural logarithm of the number of branches.

The major problem with the conventional translog cost methodology is that it cannot be used to evaluate scope economies when one of the outputs becomes zero. This limitation can be avoided by using the hybrid translog cost function proposed by Caves, Christensen, and Tretheway (1980).[9] The hybrid transformation methodology evaluates a translog functional form where the output levels undergo a nonlinear transformation. This means that the logarithms of outputs are replaced by the Box-Cox transformation. The Box-Cox hybrid transformation is explained as follows:

[8] See Varian (1992, pp. 71–85).
[9] Subsequently, Kolari and Zardkoohi (1987), Mester (1990), Rodriguez, Alvarez, and Gomez (1993), and others have employed the hybrid translog cost function.

$$Q^*(Q_i) = (Q_i^{\mu} - 1)/\mu \text{ for } \mu \text{ other than zero,} \tag{4}$$

$$Q^*(Q_i) = \ln Q_i \text{ for } \mu \text{ equal to zero.} \tag{5}$$

Greene (1997) pointed out that if a minimum of the sum of the squares in the translog cost function is found, it is possible, by repeating this procedure for different values of μ (from –1 to +1), to find the optimal value of μ. After determining the optimal value of μ, we can treat μ as if it were a known value in the cost function. Then, the model becomes linear again and the optimal value of μ makes up the minimum nonlinear square estimation of the parameters. In this way, the likely maximum estimators of all the parameters are obtained. The main advantage of the hybrid translog cost function is that it is also defined at zero output level. Using the Box-Cox transformation, the hybrid translog cost function used in this study has the form:

$$\begin{aligned} \ln TC = {} & \alpha_0 + \sum_{i=1}^{2} \alpha_i Q_i^* + \sum_{i=1}^{3} \beta_i \ln p_i + \lambda_b \ln B \\ & + \frac{1}{2}\left[\sum_{i=1}^{2}\sum_{j=1}^{2} \delta_{ij} Q_i^* Q_j^* + \sum_{i=1}^{3}\sum_{j=1}^{3} \gamma_{ij} \ln p_i \ln p_j + \lambda_{bb} \ln B \ln B \right] \\ & + \sum_{i=1}^{3}\sum_{j=1}^{2} \rho_{ij} \ln p_i Q_j^* + \sum_{i=1}^{2} \lambda_{bi} \ln B\, Q_i^* + \sum_{i=1}^{3} \tau_{bi} \ln B \ln p_i + \varepsilon, \end{aligned} \tag{6}$$

where

ln *TC*: the natural logarithm of the total of interest costs, labor costs, and capital costs,

Q_i^*: a vector of outputs with the Box-Cox transformation (Q_1^*= total loans, Q_2^* = government bonds, total securities, and the other investments),

ln p_i: the natural logarithm of *i*th input prices (p_1 = interest rate, p_2 = wage rate, and p_3 = capital price),

ln *B*: the natural logarithm of the number of branches, and

α, β, δ, γ, ρ, λ, and τ are coefficients to be estimated.

According to Shephard's Lemma[10] (Christensen, Jorgenson, and Lau 1973), the derived demand for an input can be inferred by partially differentiating the cost function with respect to the input price, p_i.

$$\frac{\partial \ln TC}{\partial \ln p_i} = \frac{\partial TC}{\partial p_i} \frac{p_i}{TC} = \frac{p_i x_i}{TC} = S_i. \tag{7}$$

In the equation above, S_i indicates the share of the *i*th input in the total cost. Thus, three cost share equations can be generated from the hybrid translog cost function (6) as follows:

[10] The cost-minimizing input vector is given simply by the vector of derivatives of the cost function with respect to the prices.

$$\sum_{i=1}^{3} S_i = \sum_{i=1}^{3} \beta_i + \sum_{i=1}^{3}\sum_{j=1}^{3} \gamma_{ij} \ln p_j + \sum_{i=1}^{3}\sum_{j=1}^{2} \rho_{ij} + \sum_{i=1}^{3} \tau_{bi} \ln B + u_i. \tag{8}$$

Since the duality theorem requires the cost function to be linearly homogeneous in input prices, the following restrictions have to be imposed on the parameters of the hybrid translog cost function (6):

$$\sum_{i=1}^{3} \beta_i = 1\,, \quad \sum_{i=1}^{3} \gamma_{ij} = 0 \quad \text{for all } j,$$
$$\sum_{i=1}^{3} \rho_{ij} = 0\,, \sum_{i=1}^{3} \tau_{bi} = 0 \quad \text{for all } j. \tag{9}$$

Additionally, the second order parameters of the hybrid translog cost function (6) must satisfy the symmetry condition.

$$\delta_{ij} = \delta_{ji},\ \gamma_{ij} = \gamma_{ji} \quad \text{for all } ij. \tag{10}$$

Because the hybrid translog cost function (6) is estimated jointly with the cost share equation (8) using the "seemingly unrelated regression estimation (SURE) technique," the input cost share equations will sum to unity. Hence, one cost share equation should be omitted from the estimated system of equations (Berndt, Hall, and Hausman 1974) because Zellner's (1962) iterative SURE technique will only be practicable if one of the cost share equations is dropped.[11]

Since the number of Taiwanese domestic banks is limited, we chose the panel data to analyze the complex hybrid translog cost function system.[12] Combining the cross section with time series data enabled us to explicitly address the relationships between temporal changes and cross-sectional differences. Moreover, we believe that errors between and within equations are correlated over time and across units. To overcome these problems, we chose the specified error components model developed by Avery (1977). This model can be explained as a method of jointly estimating a series of equations, each with an error component structure and correlated errors across equations. In this specific error component model, the regression errors in each equation are assumed to be composed of three independent components—one associated with time, another with cross-sectional units, and a third with different observations.[13]

$$u_{jnt} = \mu_{jn} + v_{jt} + \varepsilon_{jnt}. \tag{11}$$

[11] However, Christensen and Greene (1976) argue that the estimates will not be invariant to which equation is dropped.

[12] The time series data are pooled across the banks, since the small number of observations makes it infeasible to rely upon either time series or cross section studies.

[13] Compared with the assumptions for a single equation model, this specific error component model only relaxes the assumption that the covariance of residuals between equations is zero.

In this case, the hybrid translog cost function system is comprised of the hybrid translog cost function (6), the two cost share equations (8), two restrictions (9), and the symmetry condition (10).

2. *Overall economies of scale*

Following Molyneux, Altunbas, and Gardener (1997) and Noulas, Ray, and Miller (1990), we estimate the overall economies of scale for each bank[14] by evaluating equation (12) to examine how changes in scale affect total cost. For example, the concept of scale economies in a single product firm applies to the behavior of total costs as output increases, and economies of scale exist if total cost increases proportionately less than output. Overall economies of scale (*OES*) can be estimated as follows:

$$OES = \sum_{i=1}^{2} \frac{\partial \ln TC}{\partial Q^*} \quad . \tag{12}$$

It is only appropriate to use equation (12) to estimate overall economies of scale if other regressors included in the hybrid translog cost function remain unchanged as outputs vary. If $OES < 1$, there are increasing returns to scale, i.e., economies of scale exist. If $OES = 1$, constant returns to scale exist. If $OES > 1$, there are decreasing returns to scale.

3. *Product-specific economies of scale*

Baumol, Panzar, and Willig (1988) define the "incremental cost of product *i*" (IC_i) as the addition to the firm's total cost resulting from the given output of product *i*. This can be explained by the following equation.

$$IC_i(Q) = TC(Q) - TC(Q_{N-i}), \tag{13}$$

where Q_{N-i} is a vector with a zero component in place of Q_i and components equal to those of Q for the remaining products.

The measurement of product-speciffic economies of scale for product *i* at output vector Q can be estimated by the ratio of the average incremental cost of the product (AIC_i) to its marginal cost (Molyneux, Altunbas, and Gardener 1997; Glass and McKillop 1992). The relationships are as follows:

$$PSES_i = \frac{\text{The average incremental cost of the product } (AIC_i)}{\text{Product } i\text{'s marginal cost}} \equiv \frac{IC_i / TC}{\partial TC / \partial Q_i} \equiv \frac{AIC_i}{\varepsilon_{TCQ_i}} \ , \tag{14}$$

[14] Although in many previous findings, all banks are divided into several groups. Then, overall economies of scale can be estimated by evaluating products at the average level in each category. However, because the number of Taiwanese banks is limited, we can estimate overall economies of scale for each bank.

where IC_i is the incremental cost of product i and ε_{TCQ_i} is the cost elasticity of the ith output.

However, the most important difference in this study is that we must adjust this estimation formula somewhat, because we chose the hybrid translog cost function rather than the conventional translog cost function to estimate the translog cost function system. The new adjusted estimation for product-specific economies of scale is described as follows:[15]

$$PSES_i \equiv \frac{IC_i / TC}{\partial TC / \partial Q_i} \equiv \frac{AIC_i}{\varepsilon_{TCQ_i}} = \frac{IC_i / TC}{\varepsilon_{TCQ_i}} = \frac{IC_i / TC}{b_1 Q_i^{\mu}} . \tag{15}$$

This means that if the marginal cost is less than the average incremental cost ($PSES_i(Q_i) > 1$), product-specific economies of scale are implied. On the other hand, if the values are smaller than one, product-specific diseconomies of scale are said to exist. If $PSES_i(Q_i) = 1$, returns to scale of product i at Q are said to be constant.

B. *Scope Economies*

Overall scope economies are also important for banks. If overall economies of scope exist, synergies can be achieved through the joint production of different bank products. In addition, expansion path sub-additivity is a more appropriate method than traditional scope economy measures for examining the cost structure of banking markets. Expansion path cost sub-additivity can measure the relative efficiency of large and small firms and consider both scale and scope economies simultaneously.

1. *Overall economies of scope*

Economies of scope generate cost savings by delivering multiple goods and services jointly through the same organization rather than specialized providers. These potential cost savings are to be differentiated from economies of scale, which refer to lower costs per unit of a single good or service as total output of that good or service rises. Panzar and Willig (1975, 1981) suggested that economies of scope exist if the cost of producing outputs jointly is less than the total cost of producing the same outputs separately. The degree of economies of scope can be defined following Willig (1979):

$$SC = \frac{TC(Q_1, 0) + TC(0, Q_2) - TC(Q_1, Q_2)}{TC(Q_1, Q_2)} , \tag{16}$$

[15] In the conventional translog cost function system, we can calculate ε_{TCQ_1} in the following way.

$$\because \ln TC = a + b_1 \ln Q_1 + b_2 \ln Q_2 + \ldots ,$$

$$\therefore \Rightarrow \varepsilon_{TCQ_1} = \frac{\partial TC / TC}{\partial Q_1 / Q_1} = \frac{\partial \ln TC}{\partial \ln Q_1} = b_1 .$$

However, in the hybrid translog cost function system, the relationship is changed to:

where

two kinds of outputs: Q_1 and Q_2, and

two separate cost functions: $TC(Q)_1$ and $TC(Q_2)$.

Positive values indicate that overall economies of scope exist, while negative values suggest the opposite.

2. *Expansion path sub-additivity*

Previous studies (Molyneux, Altunbas, and Gardener 1997; Noulas, Miller, and Ray 1993; Berger, Hunter, and Timme 1993) argue that expansion path sub-additivity is a more appropriate method than traditional scope economy measures for examining the cost structure of banking markets. The reason is that cost sub-additivity can measure the relative efficiency of large and small firms and consider both scale and scope economies simultaneously. If the mix of outputs of an industry can be produced at a lower cost by a single monopoly firm than by any combination of smaller firms, this industry will be a natural monopoly.

Following Berger, Hanweck, and Humphrey's (1987) definition, expansion path sub-additivity is explained as whether a large-size bank can produce a combination of outputs more effectively than two smaller banks producing the same combination of outputs. Expansion path sub-additivity can be measured as follows:

$$EPSUB\,(Q^A) = \frac{TC\,(Q^B) + TC\,(Q^C) - TC\,(Q)^A}{TC\,(Q^A)}\ , \tag{17}$$

where

two kinds of output: Q_1 and Q_2,

two smaller banks: bank B and bank C,

one large bank: bank A, and

$EPSUB(Q^A)$: indicates the cost changes resulting from breaking large bank A into two smaller banks B and C.

If the value of the expansion path sub-additivity is positive, breaking up a large bank into smaller ones will not bring about lower costs. Negative values indicate the opposite situation. We observe that the overall economies of scope is a special case of expansion path sub-additivity, and both can provide us with different economic information. Expansion path sub-additivity shows whether cost-effective multiproduct firms should become larger or smaller. Economies of scope indicate whether or not the firms should specialize or diversify in production.

$\because \ln TC = a + b_1 \cdot \left(\frac{Q_1^{\mu} - 1}{\mu}\right) + b_2 \cdot \left(\frac{Q_2^{\mu} - 1}{\mu}\right) + \ldots,$

$\therefore \Rightarrow \frac{\partial \ln TC}{\partial Q_1 / Q_1} = \frac{\partial \ln TC}{\partial Q_1} \cdot Q_1 = b_1 \cdot \frac{Q_1^{\mu}}{Q_1} \cdot Q_1 = b_1 \cdot Q_1^{\mu}$

$\varepsilon_{TC_{Q_1}}$ can be inferred as $b_1 \cdot Q_1^{\mu}$ and then we can obtain the new estimation formula for the product-specific economies of scale.

C. *Looking beyond the Tests of the Market-Power and Efficient-Structure Hypotheses*

Berger (1995) suggests that research may benefit from looking beyond the current version of the ES and MP hypotheses for explanations of observed variations in bank profitability. In this study, we modify the model suggested by Berger (1995) by including one more factor, risk, into the model of the profit-structure relationship. In the first procedure, we apply a model[16] similar to Berger's (1995) to study the extent to which the ES and MP hypotheses can explain the Taiwanese banking market, and still add direct measures of both *X*-efficiency and scale efficiency to the empirical analysis. Although accounting ratios in banking are typically used to obtain a "partial measure" of banking productivity, these measures are problematic.[17] The basic model is explained as follows, and definitions for all variables are summarized in Table I:

TABLE I

DEFINITIONS FOR ALL VARIABLES IN THE PROFIT-STRUCTURE RELATIONSHIP MODEL

Symbol	Definitions
ROE	Ratio of net before-tax income to equity
CONC	Herfindahl index of concentration of deposit market
MS	Bank *i*'s share of total market deposit
Relative cost efficiency	Ratio of the smallest $(n-1)$-year average residual of all banks to the bank's $(n-1)$-year average residual (current year's data excluded). The smallest and largest 1 per cent are set equal to the 1st and 99th percentiles, respectively.
SEFF	Scale efficiency can be obtained from the previous case of scale economies; there are two situations
(1) *SEFFE*	Scale economy efficiency: equals *SEFF* if bank is below efficient scale; otherwise equals 1.
(2) *SEFFD*	Scale diseconomies efficiency: equals *SEFF* if bank is above efficient scale; otherwise equals 1.
MGTH	Real growth of the deposit market
Dummy variables	Dummies for $(n-1)$ different bank groups

Source: Tabulated by the author.

[16] Like Berger (1995), we apply the "distribution-free" method on the same banking data rather than imposing predetermined distributions on the *X*-efficiencies and random error.

[17] For example, if we increase labor productivity by replacing people with machines, labor productivity will rise, but the cost of the machines is not included in the measure.

$$ROE = f_1 (CONC, MS, \text{relative cost efficiency}, SEFF, MGTH, \text{dummy variables}) + \varepsilon , \quad (18)$$

$$CONC = f_2 (\text{relative cost efficiency}, SEFF, MGTH, \text{dummy variables}) + \varepsilon , \quad (19)$$

$$MS = f_3 (\text{relative cost efficiency}, SEFF, MGTH, \text{dummy variables}) + \varepsilon . \quad (20)$$

This model is flexible since all four hypotheses, the structural-conduct-performance hypothesis, the relative-market-power hypothesis, the *X*-efficiency version of the efficient-structure hypothesis, and the scale-efficiency version of the efficient-structure hypothesis, can be represented by different variables. The positive profit-concentration relationship occurs because concentration (*CONC*) affects price and price affects profit. On the other hand, under the relative-market-power hypothesis, market share (*MS*) becomes the key exogenous variable, since banks with large market shares have well-differentiated products and are able to exercise market power when pricing these products. In brief, under MP hypotheses, the appropriate market structure variables, concentration (*CONC*), and market share (*MS*) have a positive coefficient, while the other variables are simply irrelevant. For instance, if only the relative-market-power hypothesis holds, concentration (*CON*C) will have a zero coefficient because it is only spuriously related to profit through its correlation with *MS*.

By contrast, if ES hypotheses are accepted, the coefficients of the appropriate efficiency variables will be positive and the coefficients of all the other key variables will be either relatively small or zero. An important limitation of the reduced-form profit equation in (18) is that it tests only one of the three necessary conditions of the ES hypotheses. More precisely, in order to rigorously explain the profit-structure relationship, two more conditions (equations (19) and (20)) should be met, since both profits and the market structure variables must be positively related to efficiency. For instance, one of the conditions is that in equation (20), more efficient firms must have greater market shares. This requirement can be explained since more efficient banks obtain greater market share through price competition or through the acquisition of less efficient banks.

However, banking firms are not like normal financial companies. Both efficiency and safety are essential to them. Therefore, we choose three kinds of indicators to represent the risk factors and look at how risk can affect the profit-structure relationship. These three kinds of risk are the default risk, leverage risk, and portfolio risk. Our tests are performed by regressing profits against measures of concentration, market share, relative cost efficiency, scale efficiency, real growth of the deposit market, the three kinds of risk indicators, and some control variables. We apply two measures of profitability; the rate of return on assets and the rate of return

on equity (*ROE*). The results from the use of the former were found to be statistically inferior to those reported here, which are based on the *ROE* measure.[18] The three equations used to test the Taiwanese banking industry are described as follows:

$$ROE = f_1\,(CONC,\ MS,\ \textit{relative cost efficiency},\ SEFF,\ MGTH,\ \textit{portfolio risk},\ \textit{financial leverage risk},\ \textit{default risk},\ \textit{dummy variables}) + \varepsilon\,, \tag{21}$$

$$CONC = f_2\,(\textit{relative cost efficiency},\ SEFF,\ MGTH,\ \textit{portfolio risk},\ \textit{financial leverage risk},\ \textit{default risk},\ \textit{dummy variables}) + \varepsilon\,, \tag{22}$$

$$MS = f_3\,(\textit{relative cost efficiency},\ SEFF,\ MGTH,\ \textit{portfolio risk},\ \textit{financial leverage risk},\ \textit{default risk},\ \textit{dummy variables}) + \varepsilon\,. \tag{23}$$

Where portfolio risk is defined as the standard error of the *ROA* (return on assets). Financial leverage risk can be estimated as the ratio of net value to total assets. Default risk is defined as the ratio of nonperforming loans to total loans. Dummy variables are for the $n-1$ subgroups of banks.[19]

III. EMPIRICAL RESULTS

The Taiwanese banking industry was heavily regulated until the beginning of the 1990s. As part of this regulation, entry into this industry was restricted. In this paper, a pre- and post-analysis of the changes and an assessment of their impact on the banking sector are conducted. We report on our evaluation of the MP and ES hypotheses for the Taiwanese banking sector.

A. *Data Resources and Definitions of Variables*

In this study, the major data resources were banks' balance sheets and income statements obtained from the Central Bank of China.[20] The data on "number of branches" for Taiwanese banks were also gathered from the Central Bank of China.[21] Other relevant information not available in the Central Bank of China was obtained from the following sources. "Personnel expenses" were obtained from the Bureau of Monetary Affairs.[22] The "general index of consumer price in Taiwan

[18] Smirlock (1985) argued that the rate of return on equity is the most appropriate measure of profitability as it is more consistent with the notion that ownership will aim to maximize profits.

[19] For more details, see the definitions of other variables in Appendix.

[20] Accounting data were available from "Jinrong jigou zhongyao yewu tongjibiao" [Important businesses of Taiwanese financial institutions], from 1985 to 1998, by the Central Bank of China.

[21] The data on "number of branches" for Taiwanese domestic banks was gathered from *Financial Statistics Monthly, Taiwan District, the Republic of China*, from 1985 to 1998 published by Economic Research Department, the Central Bank of China.

[22] "Personnel expenses" were obtained from *Financial Statistics Abstract* from 1994 to 1997, published by the Bureau of Monetary Affairs.

area" for each year was available from the Directorate-General of Budget, Accounting and Statistics, Executive Yuan.[23] The number of total employees for each bank was obtained from the international bank database, BankScope.

The sample period in this study is the thirteen years from 1985 to 1997. Considering the financial reforms around 1991 to 1992, we separate the whole sample period into two observable stages. The first stage comprises the seven years from 1985 to 1991. Before 1991, the Taiwanese government imposed many restrictions on the banking market, and there were only twenty-four domestic banks in the market. The second stage contains the following five years, from 1993 to 1997. From 1991 to 1992, the Taiwanese government relaxed some of the financial restrictions imposed on the banking market, and sixteen new banks were established during these two years. We do not consider the data for the new banks in 1992, because some of them lacked sufficient data for the whole year, 1992. Nineteen ninety-eight was excluded because some public banks were privatized in order to improve their competitive ability. Hence, it can be inferred that from 1998, the structure of the Taiwanese banking market likely changed again.

Because the observable periods for some new banks are short, the final sample includes thirty-eight banks. Foreign banks are excluded from our sample because they are placed under different restrictions compared with domestic banks. Furthermore, based on the bank asset size and business similarities, we can divide the whole sample into four different subgroups: government-owned banks, local banks, old private banks, and new private banks. In this paper, the empirical results of scale and scope economies will be compared between these four groups. Finally, the four groups of banks are listed in Appendix Table.

In this study, bank multi-outputs are measured by the intermediation approach. In our view, banks are more accurately described as intermediators of financial services rather than producers of loan and deposit account services, the view taken by the production approach. The latter usually defines bank output as the number of deposit of loan accounts or the number of transactions performed on these accounts. Kolari and Zardkoohi (1987) argue that the intermediation approach has crucial advantages over the production approach. In their view, banks compete via nominal amounts, not the number of accounts. Furthermore, dollar amounts constitute a common denominator for the many kinds of services banks provide. Therefore, the intermediation approach seems to be more appropriate in a competitive, asset-side driven banking market. Given this choice of approach, we use two categories of outputs,[24]

[23] A suitable "construction cost index in Taiwan area" was not available before 1991. Because of this, we chose "general index of consumer price in Taiwan area" to replace the "construction cost index." "General index of consumer price in Taiwan area" was available from *Commodity-Price Statistics Monthly in Taiwan Area of the Republic of China* published by the Directorate-General of Budget, Accounting and Statistics, Executive Yuan.

[24] In this paper, because the sample of Taiwanese banks is small in size, we cannot consider too many variables in the hybrid translog cost function system. In the future, if we can expand our data size,

three kinds of input variables and one control variable in our models. All variables in this study are measured in million NT dollars. Data from income statements are gathered from the 1st of January to 31st of December for each year. Data from balance sheets and other official reports are obtained on the 31st of December for each year. Finally, each variable is deflated by the general index of consumer price in Taiwan for each year. All variables in this paper are defined in Appendix.

B. *Empirical Results for Scale Economies*

1. *Estimation of the hybrid translog cost function system*

We estimate all coefficients of the hybrid translog cost function system using the following estimation procedures. The first step is to search for the optimal μ. In the hybrid translog cost function system, we have an unknown parameter, μ. If this can be estimated, the model becomes linear again and the minimum square nonlinear estimators become easy to calculate.[25] Although the minimum square value of μ is expected to be between –1 and 1 in most instances, in this study, we assume that μ is strictly positive.[26] Once the Box-Cox transformation is solved as shown above, an estimation of the hybrid translog cost function can be obtained through the seemingly unrelated regression estimation technique.

We summarize all the coefficients derived from the hybrid translog cost function system in the following Table II. In brief, our empirical results are similar to the findings of the banking studies reviewed earlier (Mester 1987; Molyneux, Altunbas, and Gardener 1997) since all the coefficients of input prices are found to be statistically significant. We also find that before the financial reform, labor played the most influential role in determining total cost. This result is similar to those obtained for the Italian banking system (Molyneux, Altunbas, and Gardener 1997). High labor costs can be explained by the fact that prior to deregulation, Taiwanese banks operated in a uncompetitive marketplace, and therefore labor costs before financial reform could not be controlled efficiently by the banks. The results after the financial reform suggest that the cost of "interest inputs" becomes much more expensive than the other two kinds of inputs, since the coefficients of interest costs and labor costs are both significant but the magnitude of the interest costs is bigger.

2. *Empirical results of overall economies of scale*

We summarize the empirical results of overall economies of scale for the Taiwanese banking industry in Table III. The average value of overall economies of

we will be able to consider cost factors in more detail. For example, this could include differentiating between housing loans and car loans.

[25] Greene (1997) found that μ can be searched in increments of 0.1 and the optimal value of μ can provide the minimum sum of the squares. If the lowest sum of the squares is found, the optimal value of μ can make up the nonlinear least squares (and, with normality of the disturbance, maximum likelihood) estimates of the parameters.

[26] In this study, we make the assumption proposed by Rodriguez, Alvarez, and Gomez (1993).

TABLE II

EMPIRICAL RESULTS OF THE HYBRID TRANSLOG COST FUNCTION SYSTEM

Coefficient	Model		Coefficient	Model	
	1985–91	1993–97		1985–91	1993–97
	$\mu = 0.1$	$\mu = 0.5$		$\mu = 0.1$	$\mu = 0.5$
Constant	3.0675***	6.1665***	$\ln p_2 \ln p_3$	−0.0037	−0.0181***
	(0.3383)	(0.1915)		(0.0056)	(0.0030)
Q_1^*	0.2197***	0.0048***	$\ln B \ln B$	0.0227	0.1054
	(0.0786)	(0.0005)		(0.1842)	(0.0817)
Q_2^*	0.0150	0.0031***	$\ln p_1 Q_1^*$	0.0603***	−7.87E–05***
	(0.0555)	(0.0009)		(0.0054)	(2.83E–05)
$\ln p_1$	0.1906***	0.4790***	$\ln p_2 Q_1^*$	−0.0137***	−2.46E–05**
	(0.0619)	(0.0403)		(0.0024)	(1.02E–05)
$\ln p_2$	1.2106***	0.2180***	$\ln p_1 Q_2^*$	−0.0324***	0.0001**
	(0.1112)	(0.0270)		(0.0048)	(6.45E–05)
$\ln B$	0.3961**	0.7037***	$\ln p_2 Q_2^*$	−0.0096***	4.33E–05*
	(0.1960)	(0.1699)		(0.0016)	(2.56E–05)
$Q_1^* Q_1^*$	0.0308**	−2.70E–07	$\ln B Q_1^*$	−0.0536*	−0.0007***
	(0.0123)	(5.97E–07)		(0.0306)	(0.0002)
$Q_1^* Q_2^*$	−0.0209**	6.63E–07	$\ln B Q_2^*$	0.0488***	−0.0008**
	(0.0084)	(8.70E–07)		(0.0067)	(0.0003)
$Q_2^* Q_2^*$	0.0156**	−4.75E–07	$\ln B \ln p_1$	−0.0238	0.1444***
	(0.0082)	(2.16E–06)		(0.0147)	(0.0064)
$\ln p_1 \ln p_2$	−0.0616***	−0.0204***	$\ln B \ln p_2$	−0.2502***	−0.0683***
	(0.0047)	(0.0036)		(0.0353)	(0.0075)
$\ln p_1 \ln p_3$	0.0645***	0.0363***	Adjusted R^2 of the hybrid translog cost function	0.9968	0.9992
	(0.0086)	(0.0069)			

Note: Approximate standard errors are in parentheses.
* Significantly different from zero at the 10 per cent level.
** Significantly different from zero at the 5 per cent level.
*** Significantly different from zero at the 1 per cent level.

scale obtained from the hybrid translog cost function system is around 0.3470. This means that Taiwanese banks were able to obtain benefits from overall economies of scale before financial reform. This value is similar to those for Spain, where the value of overall economies of scale is equal to roughly 0.3695 (Molyneux, Altunbas, and Gardener 1997).

In Table III, we indicate that after 1992, overall economies of scale still exist in the Taiwanese banking market, but the value reported has fallen dramatically, to roughly 0.0030. The decline in the value, it should be noted, indicates an increase in overall economies of scale, as the total cost of producing one more unit of output is smaller than one, and decreasing. Compared with the results shown in Table III and Table IV, we argue that the specification of the hybrid translog cost function and two-stage estimation procedure may cause problems for overall economies of scale esti-

TABLE III

EMPIRICAL RESULTS OF OVERALL ECONOMIES OF SCALE FOR THE TAIWANESE BANKING INDUSTRY FROM 1985 to 1997

	Model I of the Hybrid Translog Cost Function System	Conventional Translog Cost Function System
1985–91	0.3470***	0.5629***
	(0.0420)	(0.0855)
1993–97	0.0030***	0.7017***
	(0.0011)	(0.0568)

Note: Approximate standard errors are in parentheses.
* Significantly different from one at the 10 per cent level.
** Significantly different from one at the 5 per cent level.
*** Significantly different from one at the 1 per cent level.

TABLE IV

OVERALL ECONOMIES OF SCALE USING THE HYBRID TRANSLOG COST FUNCTION

	France	Germany	Italy	Spain
All banks	0.6323*	0.7052***	0.7421	0.3695*
	(0.1350)	(0.1783)	(0.2308)	(0.3072)

Source: Molyneux, Altunbas, and Gardener (1997, p. 214).
Note: Approximate standard errors are in parentheses.
* Significantly different from one at the 10 per cent level.
** Significantly different from one at the 5 per cent level.
*** Significantly different from one at the 1 per cent level.

mates. It might be useful to reestimate overall economies of scale using the conventional translog cost function system. Finally, in Table III we show these results estimated using the conventional translog cost function system. The values for overall economies of scale obtained from the conventional translog cost function system are much larger than those estimated by the hybrid translog cost function system, but their values are still smaller than one and indicate that overall economies of scale exist in the Taiwanese banking market after financial reform.

The empirical results on overall economies of scale demonstrate that overall economies of scale actually exist in Taiwanese banking industry. However, there are two ways for banks to obtain the benefit of scale economies: (1) they can achieve overall economies of scale by increasing their branches independently; or (2) they can increase their size through mergers. To examine which method offers greater benefit for the Taiwanese banking sector, we examine expansion path sub-additivity in the following part.

3. *Empirical results of product-specific economies of scale*

Product-specific economies of scale for pre- and post-analyses can be obtained

TABLE V

PRODUCT-SPECIFIC ECONOMIES OF SCALE FOR ALL BANKS

	1985–91		1994–97	
	Total Loans	Other Investments	Total Loans	Other Investments
Model	1.2314***	0.4888***	0.4419***	0.3056***
	(0.0728)	(0.1699)	(0.0280)	(0.0268)

Notes: 1. Product-specific economies of scale for all banks are estimated using the mean data level of output, number of branches, and overall mean levels of input prices for all banks in each year.
2. Approximate standard errors are in parentheses.
* Significantly different from one at the 10 per cent level.
** Significantly different from one at the 5 per cent level.
*** Significantly different from one at the 1 per cent level.

TABLE VI

PRODUCT-SPECIFIC ECONOMIES OF SCALE FOR THE HYBRID TRANSLOG COST FUNCTION

	1985–91		1993–97	
	Loans	Investment	Loans	Investment
Government-owned banks (GOB)	1.1636***	0.4893***	0.2979***	0.8324***
	(0.0307)	(0.1021)	(0.0710)	(0.1987)
Local banks (LB)	1.3094***	0.5471***	0.5764***	0.8297***
	(0.0181)	(0.1679)	(0.1596)	(0.1798)
Old private banks (OPB)	1.2618***	0.4267***	0.4627***	0.9436***
	(0.0248)	(0.1185)	(0.0538)	(0.0630)
New private banks (NPB)			0.6789***	1.2515***
			(0.0337)	(0.0642)

Note: Approximate standard errors are in parentheses.
* Significantly different from one at the 10 per cent level.
** Significantly different from one at the 5 per cent level.
*** Significantly different from one at the 1 per cent level.

for each Taiwanese bank using the mean data level of output, number of branches, and overall mean levels of input prices. The empirical results are shown in Table V.

We can see that before financial reform, the value of product-specific economies of scale for total loans was larger than one, while the value of product-specific economies of scale for total investments is smaller than one. This seems to imply that before financial reform, Taiwanese banks could have gained, from a cost standpoint, by increasing "total loans" rather than by making additional "total investments." However, after banking deregulation, the values of product-specific economies of scale for total investments and for total loans are both less than one.

In order to obtain more details, we divide the whole sample into four subgroups: government-owned banks (GOB), local banks (LB), old private banks (OPB), and new private banks (NPB), and compare behavior by the type of bank. However from

TABLE VII
OVERALL ECONOMIES OF SCOPE

	1985–91	1993–97
Government-owned banks (GOB)	0.0716**	−0.0403
	(0.1391)	(0.1764)
Local banks (LB)	0.0338***	0.2579***
	(0.0427)	(0.0708)
Old private banks (OPB)	0.1858***	0.0151
	(0.0489)	(0.0970)
New private banks (NPB)		0.0634***
		(0.0268)

Note: Approximate standard errors are in parentheses.
* Significantly different from zero at the 10 per cent level.
** Significantly different from zero at the 5 per cent level.
*** Significantly different from zero at the 1 per cent level.

Table VI, for all four groups of banks in 1993–97, returns to product-specific economies of scale for total loans decrease dramatically and the values are smaller than one. Product-specific economies of scale exist only for total investments in new private banks (NPB). This suggests that for NPB alone, there are increasing returns to scale specific to total investment. For the three other groups, there are significant diseconomies of scale for two kinds of outputs. Our results for the period 1985–91 are consistent with Molyneux, Altunbas, and Gardener (1997), who show that there are increasing returns to total loans for Italian banks, but decreasing returns to total investment. Glass and McKillop (1992) also find evidence for increasing returns to scale for specific loans for Irish banks.

C. *Empirical Results for Scope Economies*

1. *Estimation of overall economies of scope*

In Table VII, we find that there is a wide range of values of overall economies of scope for the post-analysis. For instance, the values of overall economies of scope for LB and NPB are significant different from zero, suggesting they can gain from diversified banking businesses. However, the result for GOB is the reverse and the OPB do not have significant economies of scope, although before financial reform, both groups had significant economies of scope. Moreover, of all the groups, LB have the highest degree of economies of scope in these two sample periods.

2. *Estimation of expansion path sub-additivity*

We can use equation (17) to estimate expansion path sub-additivity and divide the representative banks into two smaller groups, by taking the mean value of outputs. In our case, we use the average output prices for the whole group to divide the whole

TABLE VIII

EXPANSION PATH SUB-ADDITIVITY FROM 1985 to 1997

(%)

	Model I
1985	1.2312
1986	1.2356
1987	1.2371
1988	1.2365
1989	1.2548
1990	1.2794
1991	1.3093
The financial environment of the Taiwanese banking market changed dramatically around 1992.	
1993	1.5923
1994	1.5901
1995	1.5880
1996	1.5839
1997	1.5803

sample into two subsamples. We can estimate the expansion path sub-additivity for each observed year by calculating the mean data level of output, the mean number of branches, and overall mean level of input prices. We list the empirical results of expansion path sub-additivity in Table VIII.

In Table VIII, our estimated values of expansion path sub-additivity are always positive. Looking at previous studies, Noulas, Miller, and Ray (1993) also find positive values of expansion path sub-additivity for medium-sized U.S. banks, and Molyneux, Altunbas, and Gardener (1997) also find that the French, German, and Italian banking markets are natural monopolies, and there is a tendency for banks to become large. Hunter, Timme, and Yang (1990) also indicate that banks with U.S.$2 to 25 billion in assets have positive values of expansion path sub-additivity.

We can deal with the question described in Section III-B-2, based on the empirical results of expansion path sub-additivity and overall economies of scale. Having found, by examining expansion path sub-additivity, that the Taiwanese banking market is a natural monopoly, we can infer that the total cost of the same mix of output produced by a big bank can be less than by any combination of small banks. Based on this empirical result, we show that it is better for the Taiwanese banking industry to have fewer banks in the market. Therefore, if Taiwanese banks want to obtain the benefits of overall economies of scale, they should choose to merge with other banks rather than to expand their networks (opening more branches).

D. *Test of the Market-Power and Efficient-Structure Hypotheses*

The theoretical models are applied to the same data set used in the cases of scale and scope economies in this study. The use of separate samples allows us to conduct

TABLE IX

EMPIRICAL RESULTS OF THE BASIC THEORETICAL MODEL, 1986–91 (BEFORE FINANCIAL REFORM)

Variable	*ROE* (Equation 18)	*CONC* (Equation 19)	*MS* (Equation 20)
Constant	0.9495*	0.0806***	0.3142***
	(0.4850)	(0.0216)	(0.0654)
Concentration rate (*CONC*)	–5.0050***		
	(1.3871)		
Market share (*MS*)	1.3975		
	(0.8716)		
Relative cost efficiency	0.3409	0.0490***	–0.0025
	(0.2578)	(0.0125)	(0.0452)
Scale economy efficiency (*SEFFE*)	–0.4412**	–0.0097	–0.0593**
	(0.2018)	(0.0123)	(0.0272)
Scale diseconomy efficiency (*SEFFD*)	–0.3391	–0.0223*	–0.2318***
	(0.2614)	(0.0113)	(0.0352)
Real growth of the deposit market (*MGTH*)	–0.0551	0.0351***	–0.0423**
	(0.1889)	(0.0054)	(0.0179)
Adjusted R^2	0.2438	0.1557	0.9100

Notes: 1. The sample banks within the period of 1986–91 are estimated by the FGLS procedures.
2. Originally, the sample period was 1985–91. However, since the explained variable *MGTH* is estimated by the real growth of the Taiwanese deposit market, 1985 was dropped from the sample.
3. Approximate standard errors are in parentheses.

* Significantly different from zero at the 10 per cent level.
** Significantly different from zero at the 5 per cent level.
*** Significantly different from zero at the 1 per cent level.

a comprehensive treatment of the banking industry and determine whether the results are stable over time and across environments.[27] In this subsection, the entire data set is divided into five subgroups: the government-owned specialized banks, the government-owned commercial banks, local banks, old private banks, and new private banks. The panel data indicates that the sample for each subgroup is homogeneous so that the degree of pooling is valid. From this, we can conclude that the parameters in our model are constant, and stable in the estimated relationship.

First, we present the empirical results of the basic model and investigate the market-power (MP) and efficient-structure (ES) hypotheses as potential explanations for the observed variation in bank profitability. Then, we add one more factor, risk, into the basic model and find that risk indicators also play an important role as explanations of the observed variation in bank profitability.

Basic theoretical model. The empirical results of the basic theoretical model are described in Table IX and Table X.

Modified theoretical model. We add other factors which help us look beyond the

[27] It is important to test if the banking sector is homogeneous to ensure that the degree of pooling is valid.

TABLE X

EMPIRICAL RESULTS OF THE BASIC THEORETICAL MODEL, 1993–97 (AFTER FINANCIAL REFORM)

Variable	*ROE* (Equation 18)	*CONC* (Equation 19)	*MS* (Equation 20)
Constant	0.3382***	0.0242***	0.1431***
	(0.0744)	(0.0016)	(0.0248)
Concentration rate (*CONC*)	–1.2954		
	(2.4342)		
Market share (*MS*)	1.1115***		
	(0.2809)		
Relative cost efficiency	–0.1305**	0.0022**	–0.0607***
	(0.0591)	(0.0011)	(0.0164)
Scale economy efficiency (*SEFFE*)	–0.3086***	0.0055***	–0.0790***
	(0.0969)	(0.0019)	(0.0283)
Real growth of the deposit market (*MGTH*)	1.1094**	0.2740***	0.1553**
	(0.5429)	(0.0049)	(0.0754)
Adjusted R^2	0.5348	0.9603	0.6508

Notes: 1. The sample banks within the period of 1993–97 are estimated by the FGLS procedures.
2. In this model, *MGTH* is considered the explained variable and obtained by the real growth of the Taiwanese deposit market. Since we have data for the Taiwanese deposit market in 1992, the sample period 1993–97 is not reduced.
3. Approximate standard errors are in parentheses.

* Significantly different from zero at the 10 per cent level.
** Significantly different from zero at the 5 per cent level.
*** Significantly different from zero at the 1 per cent level.

MP and ES hypotheses and also explain variations in profit. We modify the model described above by including three kinds of risk indicators: portfolio risk, leverage risk, and default risk. Three new equations (21), (22), and (23) are generated, and the empirical results of the modified theoretical model are described in Table XI and Table XII.

For the sample banks in the period 1987–91, the empirical results are similar to those from the previous model, but the coefficients of concentration (*CONC*) and scale efficiency (*SEFFE*) become statistically insignificant in the major equation (21). However, we find that the coefficients of default risk and leverage risk in the major equation (21) are negatively related to profit (*ROE*) at a statistically significant level. In particular, financial leverage risk can bring more negative effects on *ROE* than default risk.

Our findings in the modified theoretical model are that, for the Taiwanese banking industry in 1994–97 (Table XII), the relative-market-power hypothesis can determine the profit-structure relationship. These results suggest that if Taiwanese banks have large market shares and well-differentiated products, they can exercise market power in pricing these products and earn supernormal profits.

Moreover, in the analysis of 1994–97 (Table XII), both the concentration

TABLE XI

EMPIRICAL RESULTS OF THE MODIFIED THEORETICAL MODEL, 1987–91 (BEFORE FINANCIAL REFORM)

Variable	*ROE* (Equation 21)	*CONC* (Equation 22)	*MS* (Equation 23)
Constant	0.6558	0.1141***	0.2937***
	(0.6620)	(0.0142)	(0.0462)
Concentration rate (*CONC*)	–1.9333		
	(2.0710)		
Market share (*MS*)	0.7474		
	(1.0393)		
Relative cost efficiency	0.0917	0.0407***	–0.0067
	(0.1867)	(0.0104)	(0.0284)
Scale economy efficiency (*SEFFE*)	–0.2284	–0.0302***	–0.0441*
	(0.2134)	(0.0086)	(0.0261)
Scale diseconomy efficiency (*SEFFD*)	–0.1861	–0.0377***	–0.2146***
	(0.3227)	(0.0086)	(0.0247)
Real growth of the deposit market (*MGTH*)	–0.1367	0.0221***	–0.0384
	(0.1820)	(0.0039)	(0.0239)
Portfolio risk	5.8120	–0.4185***	0.0275
	(3.5479)	(0.1199)	(0.4028)
Financial leverage risk	–1.2597***	0.0155	–0.0630
	(0.2496)	(0.0161)	(0.0391)
Default risk	–0.2352*	0.0389***	–0.0284
	(0.1399)	(0.0148)	(0.0403)
Adjusted R^2	0.3680	0.3445	0.9136

Notes: 1. Since in our modified model we consider one more factor, portfolio risk, our sample period is reduced to 1986–91. The portfolio risk is defined as the standard error of the *ROA* (return on assets). For example, the portfolio risk for the *k*th period is obtained from the standard error of *ROA* for the k, $k-1$, and $k-2$ periods. 1985 and 1986 are dropped from the sample.

2. Approximate standard errors are in parentheses.

* Significantly different from zero at the 10 per cent level.

** Significantly different from zero at the 5 per cent level.

*** Significantly different from zero at the 1 per cent level.

coefficient (*CONC*) and the scale-efficiency coefficient (*SEFFE*) are negative and significant at the 10 per cent critical level in the major equation (21). We may conclude that the scale-efficiency version of the ES hypothesis and the structural-conduct-performance hypothesis may contradict the profit-structure relationship of the Taiwanese banking market after financial reform. One explanation for the contradiction with the scale-efficiency version of the ES hypothesis is that when banks try to make higher profits by exploiting economies of scale, the benefit is depreciated by invisible costs, such as changes in management strategies after the bank size increases or changes in relative cost efficiency following mergers.

Our empirical results show that for both the pre- and post-analyses, risk indicators play an important role in explaining the observed variations in bank profitability. The adjusted R^2 are increased by 12 per cent for 1987–91 (Table IX vs. Table XI)

TABLE XII

EMPIRICAL RESULTS OF THE MODIFIED THEORETICAL MODEL, 1994–97 (AFTER FINANCIAL REFORM)

Variable	*ROE* (Equation 21)	*CONC* (Equation 22)	*MS* (Equation 23)
Constant	0.4036***	0.0226***	0.1182
	(0.0886)	(0.0022)	(0.0940)
Concentration rate (*CONC*)	–3.7084*		
	(1.9741)		
Market share (*MS*)	0.7576***		
	(0.2347)		
Relative cost efficiency	–0.0617	0.0030**	–0.0448
	(0.0667)	(0.0013)	(0.0499)
Scale economy efficiency (*SEFFE*)	–0.1880*	0.0085***	–0.0435
	(0.0986)	(0.0020)	(0.0818)
Real growth of the deposit market (*MGTH*)	1.3037***	0.2670***	0.0910
	(0.4763)	(0.0047)	(0.1394)
Portfolio risk	–7.9765	–0.1591	–1.5069
	(6.1319)	(0.1125)	(1.1074)
Financial leverage risk	–0.5254***	–0.0046**	–0.1061*
	(0.1928)	(0.0023)	(0.0635)
Default risk	–0.8010***	0.0011	0.0278
	(0.2431)	(0.0043)	(0.0825)
Adjusted R^2	0.6462	0.8962	0.6541

Notes: 1. One further factor, the portfolio risk is considered in this part. The portfolio risk is defined as the standard error of the *ROA* (return on assets) and the portfolio risk for the *k*th period is gained from the standard error of *ROA* for the *k*, *k*–1, and *k*–2 periods. Since we have the data for the *ROA* in 1992, the sample period is only reduced from 1993–97 to 1994–97.

2. Approximate standard errors are in parentheses.

* Significantly different from zero at the 10 per cent level.

** Significantly different from zero at the 5 per cent level.

*** Significantly different from zero at the 1 per cent level.

and 11 per cent for 1994–97 (Table X vs. Table XII). Based on the results of the pre- and post-analyses, we find that default risk and leverage risk have negative effects on the profits of banking (*ROE*), but the effect of portfolio risk is uncertain. Thus, we conclude that there is a significant negative relationship between default risk and profit, a result that is consistent with evidence in the post-deregulation period.

In the basic as well as the modified theoretical model, the coefficient of market share (*MS*) is much more significant (at the 1 per cent level) than the other variables. Hence, we may conclude that the profit-structure relationship of the Taiwanese banking market after financial reform can be better explained by the relative-market-power hypothesis. Furthermore, we find that after we consider three risk factors, the structural-conduct-performance hypothesis significantly contradicts the observed profit-structure relationship in the Taiwanese banking industry after financial reform. Although the structural-conduct-performance hypothesis and the relative-market-power hypothesis are related in the sense that they link market power with

profitability, there is a fine but crucial difference between the two. While in the relative-market-power hypothesis, market power is said to stem from innovative and well-differentiated products (hence the attribute "relative"), the structural-conduct-performance hypothesis states that high concentration itself is the source of market power. If the structural-conduct-performance hypothesis was accepted and the other three rejected for Taiwan, this would have substantially weakened the normative case for further consolidation. It would mean that banks already use their oligopolistic power to charge unfavorable prices to consumers, with other sources of higher profitability, such as scale, technical efficiency, or high relative market share being ruled out. Consequently, based on the relative-market-power hypothesis, which was the sole one to be accepted, we conclude that mergers in the Taiwanese banking industry will not necessarily decrease the social benefit for Taiwanese consumers.

IV. CONCLUSIONS

Since overall economies of scale exist and expansion path sub-additivity indicates that the Taiwanese banking sector is a natural monopoly, there might be large increases in profits following mergers. However, consolidation should be carried out cautiously so as not upset the balance between bank profits on the one hand and the interests of Taiwanese bank customers on the other. To examine the relationship between these issues, we investigated the profit-structure relationship of the Taiwanese banking industry to determine the source of the benefits of Taiwanese banks. From the rejection of the structural-conduct-performance hypothesis and the acceptance of the relative-market-power hypothesis, it can be inferred that mergers in the Taiwanese banking industry will not necessarily decrease the social benefit for Taiwanese consumers. The relative-market-power hypothesis asserts that Taiwanese banks are able to exercise market power in pricing their products and earn supernormal profit by producing well-differentiated products to obtain large market shares. However, if the consolidation trend in Taiwan were explainable by the structural-conduct-performance hypothesis, this would weaken the social benefit for Taiwanese consumers since banks already use their oligopolistic power to charge unfavorable prices to them.

Based on our findings on product-specific economies of scale and overall economies of scope, we are unable to recommend whether Taiwanese banks should develop as specialized banks or diversified banks. However, we find that new private banks (NPB) are able to enjoy joint production of total loans and total investments at less cost (existence of economies of scope) and gain, from a cost standpoint, by increasing their output of total investment after financial reform (existence of increasing return to scale specific to total investment).

In order to investigate further the profit-structure relationship, we have attempted to look beyond the MP and ES hypotheses. Risk indicators are found to play an im-

portant role in explaining the observed variation in bank profitability. The adjusted R^2 are increased by 12 per cent for 1987–91 and 11 per cent for 1994–97. Based on the results of our pre- and post-analyses, we find that default risk and leverage risk have negative effects on the profits of banking (*ROE*), but that the effect of portfolio risk is uncertain.

REFERENCES

Avery, Robert B. 1977. "Error Components and Seemingly Unrelated Regressions." *Econometrica* 45, no. 1: 199–209.

Baumol, William J.; John C. Panzar; and Robert D. Willig. 1988. *Contestable Markets and the Theory of Industry Structure*. Rev. ed. New York: Harcourt Brace Jovanovich.

Benston, George J.; Allen N. Berger; G. Hanweck; and D. Humphrey. 1982. "Operating Costs in Commercial Banking." *Federal Reserve Bank of Atlanta Economic Review* 67, no. 1: 6–21.

Berger, Allen N. 1995. "The Profit-Structure Relationship in Banking—Tests of Market-Power and Efficient-Structure Hypotheses." *Journal of Money, Credit, and Banking* 27, no. 2: 404–31.

Berger, Allen N.; Gerald A. Hanweck; and David B. Humphrey. 1987. "Competitive Viability in Banking: Scale, Scope, and Product Mix Economies." *Journal of Monetary Economics* 20, no. 3: 501–20.

Berger, Allen N.; William C. Hunter; and Stephen G. Timme. 1993. "The Efficiency of Financial Institutions: A Review and Preview of Research Past, Present and Future." *Journal of Banking and Finance* 17, nos. 2–3: 221–49.

Berndt, E. R.; B. E. Hall; and J. A. Hausman. 1974. "Estimation and Inference in Nonlinear Structural Models." *Annals of Economic and Social Measurement* 3, no. 4: 653–65.

Box, G., and D. Cox. 1964. "An Analysis of Transformation." *Journal of the Royal Statistical Society*, Series B26: 211–64.

Caves, Douglas W.; Laurits R. Christensen; and Michael W. Tretheway. 1980. "Flexible Cost Functions for Multiproduct Firms." *Review of Economics and Statistics* 62, no. 3: 477–81.

Christensen, Laurits R., and William H. Greene. 1976. "Economies of Scale in U.S. Electric Power Generation." *Journal of Political Economy* 84, no. 4, part 1: 655–76.

Christensen, Laurits R.; Dale W. Jorgenson; and Lawrence J. Lau. 1973. "Transcendental Logarithmic Production Frontiers." *Review of Economics and Statistics* 55, no. 1: 28–45.

Demsetz, Harold. 1973. "Industry Structure, Market Rivalry, and Public Policy." *Journal of Law and Economics* 16, no. 1: 1–9.

———. 1974. "Two Systems of Belief about Monopoly." In *Industrial Concentration: The New Learning*, ed. Harvey J. Goldschmid, H. Michael Mann, and J. Fred Weston. Boston: Little, Brown and Company.

Diewert, W. E. 1974. "Applications of Duality Theory." In *Frontiers of Quantitative Economics*, vol. 2, ed. Michael D. Intriligator and David A. Kendrick. Amsterdam: North-Holland.

Glass, J. C., and D. G. McKillop. 1992. "An Empirical Analysis of Scale and Scope Economies and Technical Change in an Irish Multiproduct Banking Firm." *Journal of Banking and Finance* 16, no. 2: 423–37.

Greene, William H. 1997. *Econometric Analysis*. Upper Saddle River, N.J.: Prentice Hall.
Hunter, William C.; Stephen G. Timme; and Won Keun Yang. 1990. "An Examination of Cost Subadditivity and Multiproduct Production in Large U.S. Banks." *Journal of Money, Credit, and Banking* 22, no. 4: 504–25.
Kolari, James, and Asghar Zardkoohi. 1987. *Bank Costs, Structure, and Performance*. Lexington, Mass.: Lexington Books.
Lambson, Val Eugene. 1987. "Is the Concentration-Profit Correlation Partly an Artifact of Lumpy Technology?" *American Economic Review* 77, no. 4: 731–33.
McAllister, Patrick H., and Douglas McManus. 1993. "Resolving the Scale Efficiency Puzzle in Banking." *Journal of Banking and Finance* 17, nos. 2–3: 389–405.
Mester, Lolletta J. 1987. "A Multiproduct Cost Study of Savings and Loans." *Journal of Finance* 42, no. 2: 423–45.
———. 1990. "Traditional and Nontraditional Banking: An Information-Theoretic Approach." Paper presented at the Conference on Bank Structure and Competition, held by Federal Reserve Bank of Chicago, May 1990, Chicago.
Molyneux, Philip; Yener Altunbas; and Edward Gardener. 1997. *Efficiency in European Banking*. New York: John Wiley & Sons.
Murray, John D., and Robert W. White. 1983. "Economies of Scale and Economies of Scope in Multiproduct Financial Institutions: A Study of British Columbia Credit Unions." *Journal of Finance* 38, no. 3: 887–902.
Noulas, Athanasios G.; Stephen M. Miller; and Subhash C. Ray. 1993. "Regularity Conditions and Scope Estimates: The Case of Large-Sized U.S. Banks." *Journal of Financial Services Research* 7, no. 3: 235–48.
Noulas, Athanasios G.; Subhash C. Ray; and Stephen M. Miller. 1990. "Returns to Scale and Input Substitution for Large U.S. Banks." *Journal of Money, Credit, and Banking* 22, no. 1: 94–108.
Panzar, John C., and Robert D. Willig. 1975. *Economies of Scale and Economies of Scope in Multi-output Production*. Bell Laboratories Economic Discussion Paper no. 33. Murray Hill, N.J.: Bell Laboratories.
———. 1981. "Economies of Scope." *American Economic Review* 71, no. 2: 268–72.
Peltzman, Samuel. 1977. "The Gains and Losses from Industrial Concentration." *Journal of Law and Economics* 20, no. 2: 229–63.
Rodriguez, J. R. O.; A. A. Alvarez; and P. P. Gomez. 1993. *Scale and Scope Economies in Banking: A Study of Savings Banks in Spain*. Institute of European Finance Research Papers in Banking and Finance no. RP93/07. Bangor: Institute of European Finance.
Shephard, Ronald W. 1953. *Cost and Production Functions*. Princeton, N.J.: Princeton University Press.
———. 1970. *Theory of Cost and Production Functions*. Princeton, N.J.: Princeton University Press.
Shepherd, William G. 1982. "Economies of Scale and Monopoly Profits." In *Industrial Organization, Antitrust, and Public Policy*, ed. John. V. Craven. Boston: Kluwer Nijhoff.
Smirlock, Michael. 1985. "Evidence on the (Non) Relationship between Concentration and Profitability in Banking." *Journal of Money, Credit, and Banking* 17, no. 1: 69–83.
Varian, Hal R. 1992. *Microeconomic Analysis*. 3d ed. New York: W. W. Norton & Company.
Willig, Robert D. 1979. "Multiproduct Technology and Market Structure." *American Economic Review* 69, no. 2: 346–51.

Zellner, Arnold. 1962. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias." *Journal of the American Statistical Association* 57: 348–68.

APPENDIX

DEFINITION OF VARIABLES

A. *Definition of Input Variables*

Since we assume that Taiwanese domestic banks are in a competitive market, we can consider input prices as exogenous variables.

1. P_1, *the average price of the interest rate*

P_1 is the average interest cost per dollar of interest-bearing total deposits[a] and total borrowed funds.

$$\text{Interest cost} = P_1 \cdot R,$$

where R = (total deposits) + (borrowed funds).

However, if banks hold government deposits, they do not have to pay interest expenses. According to this reason, if "government deposits" are *eliminated* from total deposits, we can determine interest costs more accurately.

The average price of the interest rate can be calculated by the equation below:

$$P_1 = (\text{interest cost}) / (\text{total deposits} + \text{borrowed funds}).$$

2. P_2, *the average price of labor*

$$P_2 = (\text{personnel expenses for year}) / (\text{average employee number per branch} \times \text{number of branches}).$$

Subsequently, it is difficult to differentiate between *labor expenses* and *capital expenses*, because these two specific items are included in a larger item: *selling and administrative expenses*.[b] We cannot gather more details for labor expenses and capital expenses. To overcome this difficulty, in this study they are measured in the following way:

Personnel expenses include wages, overtime pay, reward, pensions, bonuses, and so on. But because of the previous difficulty, we use the *personnel expenses* from *Financial Statistics Abstract* published by the Bureau of Monetary Affairs from

[a] Total deposits include: (1) those due to the Central Bank of China (CBC) and other banks, (2) checking deposits, (3) demand deposits, (4) time deposits, (5) saving deposits, (6) foreign deposits, and (7) government deposits.

[b] Following the income statements from the CBC, we just can obtain the larger item, "selling and administrative expenses," which include two specific items, labor expenses and capital expenses.

1994 to 1998. By observing that the ratios of personnel expenses divided by selling and administrative expenses are almost constant from year to year, we can calculate the average ratio for each bank using the available data. Since we use the average ratio times selling and administrative expenses, the personnel expenses for each bank in every year can be inferred. Finally, following the equation, the average price of labor can be obtained.

3. P_3, *the average price of capital*

The average price of capital is calculated by the following equation:

$$P_3 = \text{(aggregate capital expenses) / (net fixed assets)}$$
$$= \text{(aggregate capital expenses) / (fixed assets – accumulated depreciation).}$$

Many studies on the structure of costs in banking define capital equipment as the sum of concepts such as rent, depreciation, furniture, and equipment (Mester 1987; Murray and White 1983). In this study, we assume capital expenses to include four specific items: (1) depreciation for fixed assets and all equipment, (2) rental expenses, (3) expenses for maintenance and repair, and (4) insurance costs.

Because of the same difficulty, we cannot obtain capital expenses directly from balance sheets and income statements. The only data we can obtain are selling and administrative expenses. By using the relationship described below,

$$\text{Capital expenses} = \text{(selling and administrative expenses – personnel expenses).}$$

Capital expenses can be inferred for each bank for each year. Since selling and administrative expenses include not only personnel expenses and capital expenses but also the expenses for water supply, electricity, and advertising, the only disadvantage is that capital expenses are slightly overestimated.

B. *Definitions of Two Categories of Outputs*

The empirical approach to "output" definition in this study is supported theoretically by Molyneux, Altunbas, and Gardener's (1997) model of scale and scope economies in European banking markets. The definitions of outputs in this study are similar to the definition in Kolari and Zardkoohi (1987) and most other European studies.

In this study, we define two categories of outputs as "total investments" and "total loans."

1. Q_1, *total loans*

In our models, total loans comprise:

$$Q_1 = \text{(discounts) + (bills purchased-net) + (overdrafts) + (short-term loans)} + \text{(middle-long-term-loans) + (other loans) – (reserve for loan loss).}$$

2. Q_2, *total investments*

Total investments include:

Q_2 = (investments in government bonds and securities)
+ (other investments) – (allowance for unrealized loss).

C. *Definitions of Other Variables*

1. *TC*, *total cost*

Total cost as a dependent variable comprises interest expenses, labor expenses, and capital expenses. Their relationship can be explained as follows:

$$TC = P_1 \cdot R + P_2 \cdot L + P_3 \cdot K$$
= (interest cost) + (selling and administrative expenses),

where

$P_1 \cdot R$: interest expenses,
$P_2 \cdot L$: labor expenses, and
$P_3 \cdot K$: capital expenses.

2. *ROE*

The value of *ROE* is the ratio of net before-tax income to equity.

3. *CONC*

We choose to measure the degree of concentration in the Taiwanese banking industry using banking deposits and the Herfindahl index.

4. *MS*

MS is defined as the bank's share of the deposits market.

5. *Relative cost efficiency*

We define relative cost efficiency as being comprised of *X*-efficiency and allocation efficiency. In this study, we apply the "distribution-free" method to estimate relative cost efficiency. It is the ratio of the smallest *n*-year average multiplicative cost function residual of banks to the bank's *n*-year average residual (the current year's data is excluded).

6. *SEFFE, scale economy efficiency*

We use the value obtained from the estimation of overall economies of scale. If a bank is located on the left-hand side of the bottom of the average cost (*AC*) curve for the whole banking industry during that year, *SEFFE* equals the value of overall economies of scale; otherwise it equals one.

7. *SEFFD*

On the other hand, if a bank is located on the right-hand side of the bottom of the average cost (*AC*) curve for the whole banking industry during that year, *SEFFD*

equals the value of overall diseconomies of scale; otherwise it equals one.

8. *MGTH, market growth*
MGTH is estimated by the real growth of the Taiwanese deposit market.

9. *Indicator of the portfolio risk*
The portfolio risk is defined as the standard error of *ROA* (return on assets). For example, the portfolio risk for the kth period is obtained from the standard error of *ROA* for the k, $k-1$, and $k-2$ periods.

10. *Indicator of the financial leverage risk*
The financial leverage risk can be estimated as the ratio of net value to total assets.

11. *Indicator of the default risk*
The default risk is defined as the ratio of nonperforming loans to total loans.

APPENDIX TABLE I

LIST OF BANKS

Government-owned bank	A:	Chiao Tung Bank Co., Ltd.
	B:	The Farmers Bank of China
	C:	Bank of Taiwan
	D:	TAIPEIBANK Co., Ltd.
	E:	Land Bank of Taiwan
	F:	Taiwan Cooperative Bank
	G:	First Commercial Bank
	H:	Hua Nan Commercial Bank, Ltd.
	I:	Chang Hwa Commercial Bank, Ltd.
	N:	Taiwan Business Bank
	YQ:	Chinatrust Commercial Bank
Local banks	O:	Taipei Business Bank
	P:	Taichung Business Bank
	Q:	Hsinchu Bank
	R:	Tainan Business Bank
	S:	Kaoshang Business Bank
	T:	Hwalain Business Bank
	U:	Taidon Business Bank
Old private banks	J:	The International Commercial Bank of China
	K:	United World Chinese Commercial Bank
	L:	The Shanghai Commercial & Savings Bank., Ltd.
	M:	Overseas Chinese Commercial Banking Corporation
New private banks	YA:	Grand Commercial Bank
	YB:	Dah An Commercial Bank
	YC:	Union Bank of Taiwan
	YD:	The Chinese Bank
	YE:	Far Eastern International Bank
	YF:	Asia Pacific Bank
	YG:	Bank SinoPao
	YH:	E. Sun Commercial Bank., Ltd.
	YI:	Cosmos Bank, Taiwan
	YJ:	Pan Asia Bank
	YK:	Chung Shing Commercial Bank
	YL:	Taishin International Bank
	YM:	Fubon Commercial Bank
	YN:	Ta Chong Bank Ltd.
	YO:	BaoDao Commercial Bank Ltd.
	YP:	Entie Pacific Bank