Joint Production in Banking Industry

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INTRODUCTION

Financial liberalization and de-regulation are conducted for the purposes of increasing competitiveness and reducing production costs. Under severe competition, financial institutions with lesser scales may experience higher average production costs (Lin and Lui, 2000). Taiwan's banking market, however, is characterized by a majority of small-scaled institutions that have gained sufficient market share after much effort that are overly-diversified at the same time (Chou and Chen, 2007). Government-controlled banks remain the largest institutions and dominate the domestic financial market (Huang, 2004). Several phases of banking industry -entrance barrier lifting, encouraging the establishment of privately-held commercial banks and financial holding companies caused the problem of over-banking (Wang and Huang, 2005; Huang, 2004). Bank efficiencies are staggered by the recent economic downturns, non-performing loans, and insider ownerships (Hsu et al., 2006; Huang, 2004).

This study aims at examining the relationship between selected input and output variables to identify key operation activities affecting cost savings of banks. Effects of bank organization structure are discussed to analyze the impact of organization transformation. Substitution between input variables is conducted to identify the possibility of replacing inputs to reduce production costs. Optimal single production activity and production pairs of various bank activities are also identified to provide a reference for cost saving and enhanced scope economies.

This study contributes by identifying key operation activities affecting cost savings of banks. Cost structure analysis of individual banks, rarely evidenced by previous researches, is conducted to identify the strength and weakness of banks. We identify optimal operation activities and suggest more appropriate forms of organization structure. Feasible suggestions and solutions are provided to improve bank operations and strategies.

Results indicate scale economies for small and large-sized banks and scope economies for all banks. The establishment of a financial holding company appears to benefit largely those banks affiliated with market-leading insurance conglomerates. These results suggest active diversification should focus on deposits and lending while promoting lending jointly with deposits and investments.

LITERATURE REVIEW

The study of cost economies in the banking industry is characterized by cost structure analysis for research into scale and scope economies. Scale economies search for constant return to scale during the banking production process where cost subadditivity should exist. Scope economies focus on the multiple production characteristics represented by cost complementarity. Both scale and scope economies aim to reduce bank production costs to obtain efficient firm size and optimal product mix. A banking firm is considered as a multiple production organization, bank output measures remain an area of question for most studies. Rezvanian and Mehdian's (2002) result of non-parametric technique for 70 banks in Singapore indicate an overall efficiency of 57%. This indicates, on average, these banks could reduce costs by 43% from daily operations. Sources of overall inefficiency include allocative inefficiency and technical inefficiency.

Flow measure and stock measure are widely used output measures. The flow measure method measures outputs by deposit and lending transaction volumes, whereas the stock measure method measures outputs by deposit and lending dollar amounts and account numbers (Wang, 1995). Bank output may also be measured by several other methods, including treating individual activities, such as deposits, as output variables (Huang & Tsai, 1986). Deposits are included in banking output to show "moneyness" where money stock with the necessary flow dimension through the continuous activity (costs) incurred by the bank to support the ever changing hands of such capital flow (Kim, 1986), though Sealy and Lindley (1977) suggest deposits and operating costs should be viewed as inputs.

The selection of bank output should consider multiple production characteristics as well as the interdependence of various activities, including a diversity of deposit and lending activities (Chu & Chang, 1993). Even so, inputs and outputs of depository institutions are difficult to identify. Demand and time deposits can be considered as inputs used to finance loans, but banks are devoted to servicing these accounts, which, in turn means that they can also be considered as outputs. Deposit fees and minimum deposit balance requirement are examples of how depository

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1977), others restrict output measures to activities of banks that incur operating expenses (Benston et al., 1982). Bank production characteristics are thus a central factor in determining which output measures should be applied. The single output measure, including total assets or total deposits, is closest to representing the multiple production characteristics of banking firms where cost subadditivity and cost complementarity should be obtained to reduce production costs. Alhadeff (1954), Horvitz (1962), Schweiger and McGee (1961) represent some of the classical studies that applied the single output measure using earning assets or total assets. Recent studies using the single output measure, are also divided into those using total assets and those using total deposits. For weighted output index, Benston et al. (1982) adopted the Divisia multilateral index as an example. Cayseele and Wuypts (2007) use number of clients of the central security depository as output variable that could represent a cost driver.

In determining efficient firm size, most studies show that the theory of constant returns to scale seems not to apply. Often, researchers find that large banks experience diseconomies of scale. In some cases, these large banks also experience diseconomies of scope. While most banks in the European market obtain economies of both scale and scope, some of the largest banks experience diseconomies of scale and scope as a result of specialization. The majority of U.S. studies have found that scale economies are easily exhausted when a bank is too large in deposit size. Previous researches evidence, when measured by asset sizes, larger banks tend to be more cost efficient than smaller banks. (Murray and White, 1983; Hunter and Timme, 1986; Mahajan et al., 1996; Flannery, 1983). For largest banks, scale economies may diminish as banks increase in size (Hunter et al., 1990; Gilligan and Smirlock, 1984; Gropper, 1991; Wang, 1996). In particular, branch banks seem to experience scale economies while unit banks generally face diseconomies of scale (Besnton et al., 1982; Berger et al., 1987). Other studies, (Gilligan and Smirlock, 1984; Gilligan et al., 1984; Berger et al., 1987; Noulas et al., 1990; Gropper, 1991) have found that when one bank surpasses a certain level of assets or does not produce sufficient quantities of certain financial products, scale economies are not easy to obtain. However, Gilligan and Smirlock (1984) found that small banks obtained better scale economy than larger banks when measured by deposit size. European studies, on the contrary, confirm smaller size banks enjoy constant return to scale (Drake, 1992; Zardkoohi and Kolari, 1994; Altunbas and Molyneux, 1996A and 1996B; Lang and Welzel, 1996; Ashton, 2001). For the search of optimal product mix, studies have also attempted to examine the scope economies between two and three outputs. Studies show optimal product mix involves often deposits, lending and investments. A combination of product investments and lending seems to create diseconomies of scope, and the existence of scope economies is less evident. Wang (1996) found only cooperative banks could enjoy scope economy or cost complementarity. Gilligan et al. (1984) found evidence of scope economies between traditional bank activities such as deposits and lending in his study of 714 commercial banks. Murray and White (1983) found strong evidence of cost complementarity or jointness in production between mortgage and other lending activities in the full cost system regression. Le Compte and Smith (1990) found existence of fully exploited economies in association with joint production of mortgages and other assets. As for consumer loans and investments, these researchers evidence nonexistence of exploited economies. Lui (1992) found evidence of scale economy for banks. Specific scope economy is evidenced for joint production between investment and guaranteed loans regardless of overall diseconomies of scope.

TAIWAN BANKING MARKET

The Taiwan banking industry is characterized by a branch banking system where banks are allowed to set up branches in various geographical locations, with a central headquarter retaining control. In Taiwan, the government has long monopolized the banking industry, beginning in 1946, after the KMT[1] government occupied Taiwan in the fall of 1945. The establishment of banking institutions has been, for the most part, a transfer of operations from China. For almost half a century the banking industry of Taiwan has been composed of 15 banking institutions[2] totaling at 556 branches in 1983 as an extremely closed market. (Liang and Ho, 1984 part I). Public banks carry on far more depository and lending activities than private banks, whose establishment was not permitted until the banking laws were revised in 1991. Under the revisions, the establishment of fifteen "new banks"[3] was allowed. In 1992, an additional private bank was allowed (Chen and Wang, 1995). The new rules also allowed various banking institutions to convert to commercial banks.[4]

[1] KMT stands for Kuomintang, the Chinese Nationalist Party. Chinese nationalist forces occupied Taiwan in 1945, moving completely to Taiwan in 1949 with the defeat of Chiang Kai-shek in the Chinese Civil War.

[2] These are the Taiwan Bank, Bank of Chao-Tung, Farmers Bank, Central Trust, Land Bank of Taiwan, Cooperative Bank of Taiwan, Taipei Bank, First Commercial Bank, Hwa Nan Commercial Bank, Chang Hwa Commercial Bank, ICBC, Overseas Chinese Bank, Shanghai Commercial and Savings Bank, United Bank and Kaohsiung Bank.

[3] These are called "new banks" in order to distinguish them from those originating in China ,which transfered their complete operations to Taiwan in 1949.

[4] Three SME (small and medium enterprise) banks were converted in 1998. Seven cooperative banks were converted between 1997 and 1999. Four investment trust companies were converted between 1992 and 1999.

Financial holding companies were later allowed to be established in 2001 under the Financial Holding Company Act. Banking activities have also long been characterized by the traditional depository and lending activities. Only in recent years, with the deregulation trend, have banks been allowed to conduct investment and security related services, as well as insurance related services. Public banks and newly-privatized public banks take up 52.33% of the market share by assets with a mere 8.40% of income before tax market share as of end of 2005 according to the Executive Yuan. Market share of top 5 domestic banks accounts for only 37%, indicating an over-banking problem. Such market share is represented by an overly growing number of financial institutions and a majority of small-scaled institutions. Return of equity for public banks is about 7.32% in comparison with that of private banks at 7.77%. For financial holding companies, average return on equity and return on assets are 13.89% and 1.11% respectively.

METHODOLOGY

We adopt the Transcendental Logarithmic Cost Function ("Translog" for short) to identify the relationships between different inputs and outputs and the total cost of a given banking firm. The intermediation approach is applied to explain more precisely, the relationships between different bank production factors under a multiple set of inputs and outputs. The translog cost function allows the entering of various outputs as separate variables, and does not require treating homogeneity and constant elasticity of substitution as maintained hypotheses. The Translog cost functions stress the multiplication of outputs (Burgess, 1974; Diewert, 1974). In its most general forms, the translog function provides a second order approximation to any twice-differentiable function. The linear relationship of the Translog cost function between its inputs and outputs under second-order Taylor series expansion, quadratic in logarithms, and unknown parameters gives it an advantage over other types of cost functions in studies of banking scale and scope economies. Gropper (1991) points out that the translog cost function is essentially a second-order expansion in input prices and output quantities, and thus provides a second-order approximation to an arbitrary cost function. The Translog cost function C(w, q) with input prices w and outputs q is computed as:

$$\ln(C(w, q)) = \ln(a_0) + a_q \ln(q) + \sum_{i=1}^{n} a_i \ln(w_i) + \tfrac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij} \ln(w_i) \ln(w_j) + \sum_{i=1}^{n} a_{qi} \ln(q) \ln(w_i) + a_{qq} [\ln(q)]^2 \quad (1)$$

SAMPLE SELECTION PROCEDURE AND DATA

Thirty-six Taiwanese banks with complete statistics during the period between 1997 and 2002 were selected as our sample group and sample time. Sample selection period between 1997 and 2002 is chosen to analyze the effects of organization structure transformation on scale and scope economies. In particular, we are interested in identifying the existence of scale and scope economies of banks that transformed to other organization structure such as the establishment of holding company from commercial banks. Since the banking market in Taiwan is undergoing a series of transformations, we suggest the period of 1997 and 2002 may be one of the reference periods to identify the effects of organization structure on banks. These 36 banks are the leading commercial banks, and include government-held commercial banks, private banks and other financial institutions recently converted to commercial banks. The selected banks have all participated in the financial reform of the Taiwan banking industry and are a good representation of the evolution of the domestic banking market.

Sample statistics are taken principally from "Important Activity Statistics of Financial Institutions" published by Central Bank of China (Taiwan), annual reports and requests from individual banks for additional data.

VARIABLE DEFINITIONS AND DESCRIPTIVE STATISTICS

Four major groups of variables were included in our empirical study on the Taiwan banking industry. These are (a) total cost - comprising personnel costs, capital values and interest expenses, (b) output variables - consisting of the price of labor, the price of capital, and the price of interest, (c) input variables - composed of deposits, lending and investments, and (d) controlling variables - comprising of branch numbers and technology level. For multi-product firms like banks, the addition of branches would increase marginal costs and result in increase of total costs. Technological progress is considered as one of the major expenditures and initiatives that permit the same level of output at lower costs and alter bank cost structure (Schmiedel et al., 2006; Tadesse, 2006). Therefore, changes in cost structure are widely measured by technological advancements and number of branches (Hsu et al., 2006; Lin and Liu, 2000; Lang and Welzel, 1996; Mahajan et al., 1996; Lui, 1992; Flannery, 1983). Technological changes are measured indirectly through time (Hsu et al., 2006; Schmiedel et al., 2006; Glass and

McKillop, 1992). Table 1 shows the variables applied and their explanations. Table 2 shows the result of descriptive statistics.

Table 1 : List of Variables

Variable	Symbol	Unit (NT$)	Explanations and Calculations
Total Cost	*TC*	Million	= (Pl x L) + (Pk x K) + (Pr x R)
Deposits	*Yd*[1]	Index	= corresponding values – average value
Lending	*Yp*[2]	Index	= corresponding values – average value
Investments	*Yt*[3]	Index	= corresponding values – average value
Personnel Charges	*L*	Million	includes personnel fees, payroll expenses, taxes, rents, layoff fees and mobility fees.
Capital charges	*K*	Million	includes general charges on development, equipment fees, property charges, depreciations, etc.
Interest Charges	*R*	Million	= interests paid to deposit account of depositors
Price of labor	*Pl*	million/ personnel	= L / employee number
Price of capital	*Pk*	million / capital	= K / fixed capital
Price of interest	*Pr*	million / (deposits + lending)	= R / (deposits + lending)
Branches	*Branch*	Unit	Branch number of each individual bank studied provided by banks
Time	*T*	virtual variable	1997=1, 1998=2, 1999=3, 2000=4, 2001=5, 2002=6

Note: [1] include inter-bank deposits and deposits received by banks from its depositors.
[2] include discounts, advances on imports, short-term loans, medium and long term loans, overdrafts, advances on exports and other loans minus bad debt reserves.
[3] include government bonds investments and other investments minus investment losses reserves.

Table 2 : Descriptive Statistics

Variable	*Mean*	Variance	Minimum	Maximum
TC	23550833	4.578E+14	642000	93362000
L	8955944.4	8.731E+13	121000	63141000
K	1977851.9	4.354E+12	255000	19413000
R	12617037	1.604E+14	171000	65516000
Yd	280742347	7.568E+16	30113000	1.218E+09
Yp	339369796	1.152E+17	46143000	1.656E+09
Yt	47201287	2.223E+15	3161000	239649000
Pl	0.9990	0.451	0.01	4.46
Pk	6.760E-03	5.780E-05	0.00	0.08
Pr	3.936E-02	1.164E-04	0.00	0.06
EMP	2506.5648	3384445.5	594	7079

TC: Total costs; L: Labor costs; K: capital costs; R: Interest costs; Yd: Deposits; Yp: Lending; Yt: Investments; Pl: Price of labor; Pk: Price of capital; Pr: Price of Interests; EMP: Number of employees.

PRELIMINARY TEST

A preliminary examination on the possible changes in cost structure is often required to assure the constituency of statistical data. A Chow Test structural changes analysis is performed with the following formula:

$$F = (SSE / k1) / [(SSE1 + SSE2)/ k2] \quad (2)$$

where SSE represents the error sum of squared residual of our pooled data, SSE1 represents the error sum of squared residual of our first group of sample data, and SSE2 represents the error sum of squared residual of our second group of sample data.

This preliminary analysis shows that there are changes in the cost structure of the banks during study sample period. We follow Lang and Welzel (1996) and divide sample banks into two subsamples according to asset sizes. Group 1 includes banks with larger asset sizes between NT$182.8 million and NT$25.6 million. Group 2 includes banks with smaller asset sizes between NT$22.0 million and NT$5 million. The Chow Test values of Group 1 at 2.0452 and Group 1 & 2 at 1.6638 are less than F (0.05; 18, 18) at 2.2000, accepting the null hypothesis of identical cost structure at 5% confidence level. Chow test value of Group 2 at 2.6265, however, is greater than F (0.05; 18, 18) at 2.2000, rejecting the null hypothesis of identical cost structure at 5% confidence level. Further examination of cost structure at 10% confidence level rejects the null hypothesis of identical parameters in both sub-samples. Chow test values of Group 1 at 2.0452 and Group 2 at 2.6265 are both greater than the critical value F (0.10; 18, 18) at 1.8500, indicating cost structure changes between two sample groups. Evidence show Chow test value of Group 1 and 2 at 1.6638 is less than F (0.10; 18, 18) at 1.8500, thus accepting the null hypothesis of identical cost structure. We then add controlling variables to adjust our current cost structure and obtain better multi-variant regression results. Prior studies (Lui, 1992; Lang and Welzel, 1996; Lin and Liu, 2000) conclude that cost structure changes in banking industry

are mostly the result of technological advancements. Additional variables such as technological changes and branch number were then estimated jointly with the full sample. We assume that the changes in the cost structure of our sample are either technology changes or branch number changes. These controlling factors are already explained in the previous section. Our results are presented in Table 3.

Table 3 : CHOW Test Results

Group	Chow Test Value
Group 1	2.0452
Group 2	2.6265
Group 1 & 2	1.6638

F (0.05; 18, 18) □ 2.2000 F (0.10; 18, 18) □ 1.8500

TRANSLOG COST FUNCTION

Our cost function for the empirical study on local banking industry in Taiwan market is structured according to the following formula:

$$\begin{aligned}\ln TC = {} & \alpha 0 + \alpha 1 \ln Yd + \alpha 2 \ln Yp + \alpha 3 \ln Yt + \beta 1 \ln Pl + \beta 2 \ln Pk + \beta 3 \ln Pr \\ & + 1/2\, \delta 11 (\ln Yd)^2 + 1/2\, \delta 22 (\ln Yp)^2 + 1/2\, \delta 33 (\ln Yt)^2 + \delta 12 \ln Yd \ln Yp \\ & + \delta 13 \ln Yd \ln Yt + \delta 23 \ln Yp \ln Yt - 1/2\, \gamma 11 (\ln Pl)^2 - 1/2\, \gamma 22 (\ln Pk)^2 \\ & - 1/2\, \gamma 33 (\ln Pr)^2 + \gamma 12 \ln Pl \ln Pk + \gamma 13 \ln Pl \ln Pr + \gamma 23 \ln Pk \ln Pr \\ & - \rho 11 \ln Yd \ln Pl + \rho 12 \ln Yd \ln Pk + \rho 13 \ln Yd \ln Pr - \rho 21 \ln Yp \ln Pl \\ & + \rho 22 \ln Yp \ln Pk + \rho 23 \ln Yp \ln Pr - \rho 31 \ln Yt \ln Pl + \rho 32 \ln Yt \ln Pk \\ & + \rho 33 \ln Yt \ln Pr + \varepsilon 1 \end{aligned} \quad (3)$$

Formula 3 consists of output deposits (*Yd*), lending (*Yp*) and investments (*Yt*). Inputs are the price of labor (*Pl*), the price of capital (*Pk*) and the price of interest (*Pr*). Certain conditions are necessary to compute our cost function. They are: 1) $\beta 1 + \beta 2 + \beta 3 = 1$, 2) $\gamma 11 + \gamma 21 + \gamma 31 = 0$, 3) $\gamma 12 + \gamma 23 + \gamma 32 = 0$, 4) $\gamma 13 + \gamma 23 + \gamma 33 = 0$, 5) $\rho 11 + \rho 12 + \rho 13 = 0$, 6) $\rho 21 + \rho 22 + \rho 23 = 0$, and 7) $\rho 31 + \rho 32 + \rho 33 = 0$. Coefficient values are obtained from the multi-variant regression analysis.

ELASTICITY OF SUBSTITUTION

The application of Allen elasticity of substitution, also known as the partial elasticity of substitution (PES), proposed by Allen in 1938, is a widely adopted method of elucidating the substitution or complementary relationships between different input factors. Researchers such as Thompson (1997), Wang (1996), Chu and Chang (1993), Kuo (1997) have all applied Allen elasticity of substitution as a way of identifying substitution possibilities between input factors. The Allen elasticity of substitution is defined as:

$$\sigma^a ij = ((\sum i\, fixi)/xixj)(|Bij|/|B|) \quad (4)$$

where xi and xj are the quantities of inputs, *fi* and *fj* are input marginal products, $|B|$ is the determination of bordered Hessian and $|Bij|$ is the cofactor of *fij*.

Allen elasticity of substitution is computed with PES to represent partial elasticity of substitution as follows:

$$\sigma ji = (\gamma ji + SjSi)/(SjSi) \quad (5)$$

and

$$\sigma jj = (\gamma ji + Sj(Sj-1)/(Sj)^2 \quad (6)$$

where $j \neq i$, γji represent inputs factors

Own-price elasticity *ejj* and cross-price elasticity $\in ji$ uses the σji and σjj values obtained from Formula (6) and Formula (7) to derive the following formula:

$$\in ji = \sigma ji\, Si \quad (7)$$

where $j \neq i$ and $\in jj = \sigma jj\, Sj$

The input cost-share equations (Sj) obtained via Shepard's lemma, where Sj is the share of the jth input in the total variable cost, are:

$$Sj = \beta j + \sum i \gamma ij \ln \rho i + \sum j \delta ij \ln \alpha j \quad (8)$$

RESULTS

ESTIMATION OF THE TRANSLOG COST FUNCTION

The translog cost function is estimated jointly with its input cost-share equations using the iterative seemingly unrelated regression (SUR) estimation technique. The iterative Zellner estimation procedure was used to obtain

estimates. Based on the R^2 -adjusted at 0.98 and standard error statistics, the fit of the equations appears to be extremely good. The majority of the parameter estimates are statistically significant at the 5% and 10% level based on a two-tailed t-test; 17 out of 30 coefficients.

The coefficients for two outputs have the appropriate signs, while the estimated output coefficient for lending (LnQ2) has a negative sign but is not significant. The jointness of outputs between deposits and lending ((LnQ1)(LnQ2)) and between lending and investment ((LnQ2)(LnQ3)) have negative values and are statistically significant. This indicates the joint production of deposits, lending, and investment would bring cost saving benefits to institutions that offer such products. Especially, an institution that offers product pair composed of deposits and lending would create the most synergy in cost reduction. Also, the joint production between deposits and investments ((LnQ1)(LnQ3)) is significantly positive, indicating such product pair increases costs. Table 4 presents the estimated coefficient values.

Table 4 : Coefficient Values

Variables	Estimated Coefficie	Symbol	Estimated Coefficient Values (T value)
Intercept	Constant	$\alpha 0$	19.094 (41.333)*
Outputs	LnQ1	$\alpha 1$	1.132 (1.069)
	LnQ2	$\alpha 2$	-0.302 (-0.642)
	LnQ3	$\alpha 3$	0.671 (1.811)*
Inputs	LnPl	$\beta 1$	0.126 (1.828)*
	LnPk	$\beta 2$	0.331 (3.760)**
	LnPr	$\beta 3$	0.004215 (0.171)
Squared	$(LnQ1)^2$	$\delta 11$	0.313 (1.364)
terms of	$(LnQ2)^2$	$\delta 22$	1.432 (5.627)**
outputs	$(LnQ3)^2$	$\delta 33$	0.0007561 (0.211)
Jointness	(LnQ1)(LnQ2)	$\delta 12$	-1.767 (-4.317)**
of	(LnQ1)(LnQ3)	$\delta 13$	0.944 (4.366)**
outputs	(LnQ2)(LnQ3)	$\delta 23$	-0.984 (-4.002)**
Squared	$(LnPl)^2$	$\gamma 11$	0.006964 (7.331)**
terms of	$(LnPk)^2$	$\gamma 22$	0.005257 (3.527)**
inputs	$(LnPi)^2$	$\gamma 33$	0.003049 (0.697)
Jointness	(LnPl)(LnPk)	$\gamma 12$	0.004164 (3.220)**
of	(LnPl)(LnPi)	$\gamma 13$	-0.009640 (-4.739)**
inputs	(LnPk)(LnPi)	$\gamma 23$	-0.119 (-2.847)**
Jointness	(LnQ1)(LnPl)	$\rho 11$	-0.005043 (-0.787)
between	(LnQ1)(LnPk)	$\rho 12$	-0.148 (-2.466)**
inputs	(LnQ1)(LnPi)	$\rho 13$	0.303 (3.073)**
and	(LnQ2)(LnPl)	$\rho 21$	0.002173 (0.311)
outputs	(LnQ2)(LnPk)	$\rho 22$	0.0003874 (0.328)
	(LnQ2)(LnPi)	$\rho 23$	-0.424 (-3.098)**
	(LnQ3)(LnPl)	$\rho 31$	-0.001 (-0.493)
	(LnQ3)(LnPk)	$\rho 32$	0.009065 (1.861)*
	(LnQ3)(LnPi)	$\rho 33$	0.005349 (0.926)
Controlling	Branch	Branch	0.00007979 (1.526)
variable	Time	T	-0.001979 (-1.458)

$R^2 = 0.982$ Adjusted $R^2 = 0.980$

"**" = significant level ≥5%; T (0.025, 186) ≥1.96

"*" = significant level ≥10%; T (0.05, 186) ≥ 1.69

ECONOMIES OF SCALE

All bank observations are sorted by asset sizes in descending order from the largest bank (C1) to the smallest bank (C36) and listed in Table 5. The level of scale economy varies between institutions. There seems to be a larger cost saving potential for the largest (C1 and C2) and smallest (C35 and C36) banks. The former institutions are public-owned and the later ones are privately-owned. These observations indicate public banks outperform private banks in respect to asset size which assist in obtaining larger economies of scale. Banks affiliated with financial holding companies also appear to receive limited benefits in cost savings from scale economies.

Table 5 : Scale Economy Values

Bank	1997	1998	1999	2000	2001	2002	Bank	1997	1998	1999	2000	2001	2002
C1[P]	0.688	0.674	0.697	0.663	0.677	0.750	C19[Pv]	0.581	0.560	0.548	0.547	0.607	0.700
C2[P]	0.679	0.673	0.697	0.684	0.703	0.756	C20[Pv]	0.646	0.630	0.666	0.658	0.626	0.683
C3[Pv,H]	0.599	0.577	0.565	0.595	0.609	0.684	C21[Pv]	0.610	0.595	0.579	0.601	0.639	0.682
C4[Pv,H]	0.554	0.542	0.554	0.571	0.598	0.661	C22[Pv]	0.641	0.651	0.642	0.677	0.699	0.756
C5[Pv]	0.553	0.543	0.561	0.580	0.627	0.695	C23[Pv]	0.596	0.566	0.610	0.636	0.637	0.679
C6[Pv]	0.610	0.572	0.602	0.617	0.618	0.703	C24[Pv]	0.667	0.663	0.708	0.637	0.592	0.667
C7[P]	0.551	0.534	0.567	0.590	0.625	0.687	C25[Pv,H]	0.414	0.604	0.650	0.610	0.681	0.774
C8[Pv,H]	0.353	0.581	0.590	0.601	0.596	0.645	C26[P]	0.614	0.612	0.641	0.694	0.713	0.672
C9[Pv]	0.636	0.658	0.674	0.698	0.713	0.760	C27[Pv]	0.616	0.731	0.705	0.700	0.687	0.741
C10[P]	0.602	0.565	0.600	0.575	0.607	0.634	C28[Pv]	0.676	0.659	0.651	0.613	0.634	0.705
C11[Pv,H]	0.342	0.351	0.385	0.500	0.468	0.537	C29[Pv]	0.733	0.711	0.645	0.619	0.631	0.665
C12[Pv,H]	0.690	0.666	0.623	0.641	0.625	0.676	C30[Pv,H]	0.709	0.678	0.699	0.699	0.723	0.762
C13[Pv]	0.511	0.484	0.566	0.574	0.575	0.650	C31[Pv]	0.271	0.581	0.629	0.644	0.660	0.724
C14[Pv]	0.622	0.608	0.619	0.624	0.635	0.694	C32[Pv,H]	0.325	0.564	0.597	0.548	0.576	0.611
C15[Pv,H]	0.671	0.642	0.602	0.625	0.623	0.651	C33[P]	0.563	0.533	0.555	0.529	0.541	0.576
C16[Pv,H]	0.634	0.643	0.633	0.622	0.631	0.700	C34[Pv]	0.462	0.601	0.616	0.618	0.608	0.677
C17[Pv,H]	0.690	0.668	0.700	0.728	0.731	0.753	C35[Pv]	0.823	0.674	0.659	0.653	0.659	0.729
C18[Pv]	0.656	0.599	0.604	0.572	0.604	0.635	C36[Pv]	1.011	0.618	0.585	0.568	0.579	0.607

"P" : public banks; "Pv" : private banks; "H" : financial holding companies

ECONOMIES OF SCOPE

Results in Table 6 evidence scope economies for banks in all asset sizes. The largest banks (C1 and C2) and smallest banks (C35 and C36) seem to produce the largest economies of scope. This result is identical to our result for economies of scale where public banks outperform private banks. For example, Bank C36 obtained scope economies estimates in 2002 at -6.4742. This indicates joint production of outputs including deposits, loans, and investments are less costly than producing each output independently. Banks C7 to C14, however, experience the none-existence of scope economies where the estimates are not significantly different from zero. For such banks, no scope economies or diseconomies exist between deposits, loans, and investments, and joint production is no more costly than producing these outputs separately. Hence, a majority of banks in our sample can reduce production costs through product diversification. Additionally, changes in scope economies over the period under study show an increase over time for the majority of banks.

The effect of scope economies for banks which have adopted the financial holding company structure is limited to 5 out of 12 banks. Banks C3, C4, C8, C11, and C12 were the only banks which experience economies of scope under the financial holding company structure. While the other banks including bank C15-17, C25, and C30-31 experience scope economies significantly; no different from zero at the end of 2002.

Table 6 : Scope Economy Value

Bank	1997	1998	1999	2000	2001	2002	Bank	1997	1998	1999	2000	2001	2002
C1[P]	-3.591	-3.298	-3.718	-3.872	-4.017	-4.093	C19[Pv]	-0.409	-0.313	-0.516	-0.514	-0.175	0.255
C2[P]	-2.431	-2.488	-2.860	-3.542	-3.563	-3.485	C20[Pv]	-1.838	-0.926	-0.356	-0.182	-0.140	-0.129
C3[Pv,H]	-1.300	-1.377	-1.460	-1.878	-2.018	-2.011	C21[Pv]	-1.672	-1.219	-0.942	-0.709	-0.298	-0.259
C4[Pv,H]	-1.168	-1.217	-1.366	-1.747	-1.904	-1.902	C22[Pv]	-1.475	-0.829	-0.642	-0.357	-0.137	-0.202
C5[Pv]	-1.037	-1.163	-1.342	-1.695	-2.048	-1.898	C23[Pv]	-1.682	-1.060	-0.735	-0.422	-0.368	-0.467
C6[Pv]	-0.911	-0.731	-0.941	-1.237	-1.167	-1.426	C24[Pv]	-2.346	-1.462	-1.042	-0.708	-0.857	-0.741
C7[P]	0.000	-0.023	-0.059	-0.156	-0.232	-0.367	C25[Pv,H]	-1.558	-1.267	-0.713	-1.169	-0.294	-0.083
C8[Pv,H]	-0.098	-0.161	-0.254	-0.454	-0.587	-0.653	C26[P]	-1.781	-1.591	-1.059	-0.402	-0.196	-1.002
C9[Pv]	-0.072	-0.170	-0.180	-0.243	-0.350	-0.363	C27[Pv]	-1.984	-0.947	-0.692	-0.512	-0.538	-0.510
C10[P]	-0.154	-0.193	-0.406	-0.378	-0.549	-0.351	C28[Pv]	-1.550	-0.853	-0.769	-0.839	-0.855	-0.969
C11[Pv,H]	-0.003	0.276	0.275	-0.050	-0.203	0.236	C29[Pv]	-1.323	-0.301	-0.769	-0.849	-0.684	-0.831
C12[Pv,H]	-0.951	-0.466	-0.393	-0.262	-0.248	-0.035	C30[Pv,H]	-2.450	-1.888	-1.649	-1.448	-0.842	-0.946
C13[Pv]	0.010	0.060	-0.053	-0.085	-0.085	-0.089	C31[Pv]	-3.730	-2.025	-0.940	-0.632	-0.730	-0.764
C14[Pv]	-0.272	-0.281	-0.261	-0.187	-0.190	-0.232	C32[Pv,H]	-1.375	-0.963	-0.639	-0.897	-0.854	-0.970
C15[Pv,H]	-1.264	-1.048	-0.928	-0.555	-0.478	-0.631	C33[P]	-1.730	-1.363	-1.155	-1.151	2.341	-1.158
C16[Pv,H]	-1.239	-0.790	-0.443	-0.332	-0.336	-0.451	C34[Pv]	-4.152	-3.965	-3.120	-2.223	-2.144	-1.500
C17[Pv,H]	-1.342	-0.831	-0.767	-0.153	-0.394	-0.666	C35[Pv]	-5.273	-4.234	-3.843	-3.770	-3.628	-4.085
C18[Pv]	-0.056	-0.026	-0.131	-0.160	-0.356	-0.392	C36[Pv]	-4.979	-5.977	-6.446	-6.281	-6.557	-6.472

"P" : public banks; "Pv" : private banks; "H" : financial holding companies

ELASTICITY OF SUBSTITUTION

Table 7 reports the Allen partial elasticity of substitution. All inputs are substitutes. They indicate labor and capital have a low substitutability (0.999), which may reflect extremely inflexible personnel organizations, especially in public banks. Substitutability between deposits and capital is found greater than substitutability between deposits and labor at 1.019 against 0.998 in empirical study.

Table 7 : Elasticity of Substitution

Input	Labor	Capital	Deposits
Labor	0.853		
Capital	0.999	1.135	
Deposits	0.998	1.019	-0.163

Table 8 reports the own - and cross-price elasticities of demand. Most own-price elasticities are negative in accordance with theory, except for input demand labor. Moreover, since own-price elasticities are greater than one in absolute value, most input demands are elastic. The exception is own-price elasticities for input demand deposits with values of less than 1. This result suggests an overly excessive labor force with own-price elasticity at 5.803, creating high bank production costs.

Table 8 : Elasticity of Input Demand

Input	Labor	Capital	Deposits
Labor	5.803		
Capital	6.798	-8.379	
Deposits	0.855	-7.524	-0.139

SPECIFIC SCOPE ECONOMY

Three joint production sets will be discussed including (1) between deposits and lending activities, (2) between deposit and investment activities and (3) between lending and investment activities. Our data suggest that the economies associated with the joint production of deposits and investments were fully exploited for all bank sizes during the study period. Cost complementarity is absent for joint production between deposits and investments where the pairwise parameter is greater than zero. Joint production between deposits and lending and between lending and investments showed cost complementarity with a pairwise parameter of less than zero, at -1.16 and -0.75, respectively. The negative estimates values exhibit cost complementarity for such production combinations. Banks C1 to C5 remain the best-performing asset group for these two different types of joint products. The level of specific scope economy obtained is between -1.2410 to -4.9526 for joint production of deposits and lending. Product-specific scope economy estimates between lending and investment are between -0.4929 and -3.0847. Banks C35 and C36 comprise a better performing asset group that obtains specific scope economies through diversification into different joint production sets. The obtained specific scope economy values for joint production between deposits and lending are at minimum -5.1469 and maximum -9.1068. For the joint production between deposits and investments, the obtained specific scope economy values are between -1.4115 and -6.2547.

On the contrary, joint production between deposits and investments exhibits diseconomies of specific scope for a majority of studied banks. Instead of reducing costs, banks experience an increase in production costs for joint production of deposits and investments. One possible reason may be that deposits and investments are similar in nature; both are savings activities. A few banks, however, managed to reduce costs through joint production of deposit and investment activities, banks in the second and third asset size groups. Only one bank was able to consistently reduce costs throughout the entire empirical study period with a minimum and maximum specific scope economy values at -0.0953 and -0.2184 respectively.

The establishment of a financial holding company seems beneficial to certain private banks that currently operate under such a bank organization structure. Private financial holding banks were found to reduce costs only through one set of joint production. Two banks without any affiliations with a financial holding company reduced costs through all three sets of joint production. As observed, the establishment of a financial holding company contributes little in specific scope economies for private banks. Bank asset sizes seem not to be important criteria in determining potential cost reductions. Rather, strong parent company support is the key criteria to reduce costs for private banks affiliated with a financial holding company. This is particularly true in the case of bank C17 and bank C36, affiliated with market-leading insurance-based conglomerates. Table 9 presents estimates of product-specific economies of scope for joint production of deposits, lending and investments.

Table 9. Specific Scope Economy on Deposits, Lending, and Investments

	Deposits / Lending						Deposits / Investments						Lending / Investments					
Bank	1997	1998	1999	2000	2001	2002	1997	1998	1999	2000	2001	2002	1997	1998	1999	2000	2001	2002
C1[P]	-3.77	-3.80	-4.27	-4.62	-4.89	-4.95	0.67	2.19	2.41	2.66	3.56	3.94	-0.49	-1.69	-1.86	-1.91	-2.68	-3.08
C2[P]	-2.86	-3.17	-3.62	-4.06	-4.15	-4.10	1.28	2.26	2.72	1.67	2.12	2.37	-0.85	-1.58	-1.95	-1.14	-1.53	-1.76
C3[Pv,H]	-1.52	-1.76	-1.98	-2.25	-2.47	-2.44	0.71	1.27	1.72	1.30	1.68	1.97	-0.49	-0.88	-1.20	-0.92	-1.22	-1.54
C4[Pv,H]	-1.42	-1.62	-1.86	-2.19	-2.32	-2.40	0.81	1.44	1.74	1.47	1.67	2.60	-0.55	-1.04	-1.24	-1.02	-1.25	-2.10
C5[Pv]	-1.24	-1.44	-1.74	-2.02	-2.22	-2.10	0.62	0.89	1.28	1.04	0.63	0.93	-0.42	-0.61	-0.88	-0.71	-0.46	-0.728
C6[Pv]	-1.01	-1.00	-1.28	-1.46	-1.52	-1.56	0.25	0.71	0.92	0.61	1.08	0.44	-0.15	-0.44	-0.58	-0.38	-0.72	-0.30
C7[P]	0.00	-0.01	-0.06	-0.16	-0.13	-0.22	0.00	0.02	0.08	0.21	0.19	0.42	0.00	-0.03	-0.07	-0.20	-0.29	-0.57
C8[Pv,H]	-0.05	-0.14	-0.25	-0.48	-0.61	-0.74	0.06	0.15	0.18	0.32	0.75	0.80	-0.10	-0.17	-0.18	-0.29	-0.72	-0.70
C9[Pv]	-0.06	-0.09	-0.19	-0.21	-0.34	-0.22	0.15	0.22	0.36	0.30	0.60	0.51	-0.15	-0.30	-0.34	-0.33	-0.60	-0.65
C10[P]	-0.01	-0.08	-0.20	-0.37	-0.44	-0.27	0.03	0.18	0.41	0.56	0.70	0.42	-0.17	-0.29	-0.61	-0.56	-0.80	-0.50
C11[Pv,H]	0.22	0.28	0.22	0.10	0.16	0.09	-0.05	-0.00	0.02	-0.11	-0.24	0.09	-0.17	-0.01	0.02	-0.04	-0.12	0.04
C12[Pv,H]	-1.34	-0.61	-0.52	-0.33	-0.25	-0.04	1.32	0.40	0.52	0.20	0.01	0.03	-0.93	-0.25	-0.39	-0.13	-0.01	-0.02
C13[Pv]	-0.01	-0.04	-0.08	-0.08	-0.10	-0.08	0.03	0.16	0.12	0.01	0.08	-0.04	-0.01	-0.05	-0.09	-0.01	-0.06	0.03
C14[Pv]	-0.38	-0.29	-0.21	-0.14	-0.13	-0.09	0.32	0.04	-0.09	-0.09	-0.10	-0.21	-0.21	-0.02	0.05	0.04	0.04	0.08
C15[Pv,H]	-1.78	-1.37	-1.20	-0.75	-0.55	-0.38	1.52	0.77	0.74	0.44	0.16	-0.50	-1.00	-0.44	-0.47	-0.24	-0.08	0.26
C16[Pv,H]	-1.73	-1.03	-0.75	-0.58	-0.46	-0.53	1.78	0.64	0.86	0.68	0.27	0.16	-1.28	-0.39	-0.55	-0.43	-0.15	-0.07
C17[Pv,H]	-1.71	-1.11	-0.83	-0.47	-0.56	-0.63	1.28	0.77	0.14	0.57	0.27	-0.04	-0.91	-0.49	-0.07	-0.25	-0.10	0.02
C18[Pv]	-0.62	-0.26	-0.24	-0.41	-0.50	-0.49	1.69	0.82	0.27	0.72	0.28	0.20	-1.12	-0.58	-0.16	-0.47	-0.13	-0.10
C19[Pv]	-0.52	-0.48	-0.69	-0.72	-0.60	-0.56	0.33	0.50	0.47	0.62	1.01	1.80	-0.21	-0.32	-0.29	-0.41	-0.57	-0.98
C20[Pv]	-2.38	-1.23	-0.83	-0.58	-0.59	-0.77	1.86	1.07	1.95	1.54	1.62	1.67	-1.31	-0.75	-1.48	-1.14	-1.16	-1.02
C21[Pv]	-2.25	-1.75	-1.27	-1.03	-0.91	-0.86	2.46	1.75	1.37	1.04	1.70	1.81	-1.87	-1.21	-1.04	-0.71	-1.09	-1.21
C22[Pv]	-2.04	-1.17	-1.05	-1.19	-0.91	-0.78	2.36	1.00	1.30	2.33	2.03	1.19	-1.80	-0.66	-0.88	-1.49	-1.25	-0.61
C23[Pv]	-2.11	-1.45	-1.03	-0.90	-1.07	-1.09	1.77	1.65	1.16	1.40	1.87	1.84	-1.34	-1.25	-0.86	-0.92	-1.16	-1.21
C24[Pv]	-2.91	-1.85	-1.67	-1.50	-1.24	-1.23	1.99	1.24	1.65	2.39	1.54	1.41	-1.42	-0.84	-1.02	-1.60	-1.15	-0.92
C25[Pv,H]	-2.22	-1.62	-1.31	-1.61	-1.07	-0.82	2.21	1.21	2.27	1.50	2.34	2.12	-1.55	-0.86	-1.67	-1.06	-1.55	-1.37
C26[P]	-2.44	-2.18	-1.50	-0.96	-0.73	-1.30	2.74	1.95	1.50	2.07	1.61	1.21	-2.07	-1.36	-1.05	-1.51	-1.07	-0.91
C27[Pv]	-2.63	-1.38	-0.95	-0.84	-0.88	-0.99	2.67	1.44	1.17	1.23	1.19	1.70	-2.03	-1.01	-0.90	-0.89	-0.84	-1.21
C28[Pv]	-2.02	-1.19	-1.04	-1.12	-1.25	-1.64	1.91	1.39	0.99	1.01	1.01	1.55	-1.43	-1.05	-0.71	-0.73	-0.61	-0.87
C29[Pv]	-1.80	-1.39	-1.33	-1.40	-1.25	-1.41	1.64	3.27	1.77	1.86	1.70	1.79	-1.15	-2.17	-1.23	-1.31	-1.13	-1.20
C30[Pv,H]	-3.04	-2.31	-1.94	-1.86	-1.71	-1.57	1.89	1.29	0.75	1.04	2.29	1.56	-1.30	-0.86	-0.46	-0.62	-1.42	-0.94
C31[Pv]	-5.35	-3.03	-2.16	-1.81	-1.46	-1.67	4.68	2.95	3.49	3.41	1.77	2.00	-3.06	-1.94	-2.27	-2.23	-1.03	-1.09
C32[Pv,H]	-1.88	-1.45	-1.23	-1.61	-1.75	-2.09	1.74	1.52	1.61	2.36	2.39	3.00	-1.23	-1.02	-1.02	-1.65	-1.49	-1.88
C33[P]	-2.17	-2.09	-2.29	-2.41	-2.28	-2.26	1.10	1.91	2.87	3.78	3.84	3.49	-0.66	-1.19	-1.73	-2.51	0.77	-2.38
C34[Pv]	-6.19	-5.10	-4.46	-3.72	-2.91	-2.10	5.39	3.10	3.59	4.39	2.03	1.68	-3.34	-1.96	-2.24	-2.89	-1.26	-1.07
C35[Pv]	-7.26	-5.85	-5.20	-5.01	-4.77	-5.14	5.16	4.20	3.52	3.20	2.94	2.47	-3.16	-2.58	-2.16	-1.95	-1.79	-1.41
C36[Pv]	-9.10	-8.51	-8.55	-8.42	-8.63	-8.69	10.38	6.76	5.65	6.04	5.62	6.29	-6.25	-4.21	-3.54	-3.90	-3.53	-4.07

"[P]" : public banks; "[Pv]" : private banks; "[H]" : financial holding companies

CONCLUSIONS AND SUGGESTIONS

This empirical study uses an econometric analysis based on the transcendental logarithmic cost function to search for deregulation effects on the cost structure of 36 local banks in Taiwan for the period 1997 to 2002. Three banking activities, deposits, lending and investments, were selected as the targets of an analysis of joint production of banking activities in obtaining specific scope economies. The Chow Test was performed to identify possible cost structural changes of our sample banks. This study used an intermediation approach. We further examine various substitution possibilities to increase scale economy via the application of Allen's elasticity of substitution. A thorough examination on the obtained coefficient values was also conducted.

The promotion of lending activities seems to be a feasible way to obtain better cost effectiveness when jointly produced with deposits or investments. Technological advancements and branch establishments did not significantly affect the bank cost reduction process. Particular cost increases are evidenced for joint production of deposits and investments. It seems diversification into investment activities may not present the best option for cost reduction. It is also advisable to avoid obtaining tangible goods as capital assets. An alternative would be to employ more staff for daily operations.

There exists low substitutability between labor and capital due to extremely inflexible personnel organizations, especially in public banks. Substitutability between deposits and capital was found to be greater than that of deposits and labor. Own-price elasticity analysis shows that high bank production costs also derive from excessive labor forces.

The results suggest that the average cost curve for the Taiwanese banking industry is U shaped and that there are economies of scale for small and large banks. The findings further indicate that there are economies of scope for banks of all sizes. This means that joint production of outputs is less costly than producing each output separately. A variety of economies of scope estimates have been made. These broadly indicate that diseconomies of scope exist in the joint production of deposits and investments.

We found large banks seem to reach economies of scale and economies of scope easier than smaller banks and obtain an optimal size. Smaller banks with extremely few assets may also succeed in obtaining scale economies and scope economies. Such achievements may be of the experienced knowledge in handling various loans and deposits to create custom-tailored financing. In all, largest and smallest banks could achieve cost reductions via joint production of diversified bank production activities.

Results indicate that public banks appear to be more effective than private banks in reducing production costs in scale, scope and specific scope economies. This empirical result contradicts the results of previous studies conducted by Chu and Chang (1993), Chu et al. (2001) and Karim (2001), which found that private banks are more efficient than public banks. Further, public banks seem to benefit more than private banks from deregulation effects in this empirical study. These banks have benefited from government support which has assisted them in gaining market leading positions accompanied by high market penetration rates. Private banks are also able to achieve certain less important levels of scale, scope and specific scope economies.

The establishment of financial holding companies, however, has very restricted effect on the levels of scale and scope economies obtained. All public banks in our empirical study have maintained their original organizational structure. Private banks that have adopted a financial holding company organizational structure appear to reduce costs solely in specific scope economies; joint production of deposits and lending and of lending and investments. We observed that private financial holding company type banks with strong parent company support are best suited for such activity diversification. This is especially true of bank C17 and bank C32, both of which are affiliated with market-leading insurance-based conglomerates.

We may conclude that during our study period, the deregulation of banking industry in Taiwan has had only limited effects on bank cost economies. In terms of market power and economic profit, public banks seem unaffected. Private banks, however, are struggling to compete in cost savings and market position. One source of the problem may be the homogeneous product offerings and service content that diminishes differences between banking institutions.

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