Chapter 5

MEASURING EFFICIENCY OF COMMERCIAL BANKS' OPERATIONS

5.1 Introduction

Commercial banks play a major role in the development of the financial system throughout the world. The evidence in the preceding chapter confirms the strong support for the positive relationship between the commercial banks' credit and the economic development in Thailand. Thus, the banking system is important in the sense that it is one mechanism that increases the growth of the economy. If we can prove that the operational efficiency of the Thai commercial banks has been increasing through time, this higher efficiency, if there is any, should lead to benefits of the economic unit and enhance the growth of the economy. The higher efficiency would also be especially notable if it occurred during a time when there were many changes in both the economic structure of the country and in the banking industry, especially the changes brought on by the financial reform policies that have been implemented since 1989.

The efficiency of financial institutions has been extensively studied with the main focus on scale and scope efficiencies. Most researchers in this field work with the data from the US markets where one can easily define a perfect competitive market environment and pursue the commonly used translog cost function. However, Gilbert (1984) states that normally most banks are operating in oligopolistic markets rather than perfect competition and the market structure that implies the exogenous output of the banks should be included in the analysis of the operational efficiency of the banking business. Therefore, the following study will bring this point into consideration and the model used here is one that accounts for the conjectural variations, that is, the firms' expectations about the reaction of other firms to an increase in quantity uniquely occurring in an oligopoly market.

An earlier empirical study in this field (Iwata 1974) proposes a method for measuring the numeric value of the conjectural variation in the Japanese flat glass industry. Although the results of his study are not statistically significant, his approach can generally be used in further empirical analyses. Gollop and Roberts (1979) extend his work by decomposing the conjectures with respect to rival's size. Hence, they are able to characterize the pattern of interdependency in the US coffee industry where they empirically tested their model. The recent paper by Berg and Kim (1994) picks up the idea and modifies Gollop and Roberts' model to measure the scale efficiency in the Norwegian banking sector.

Our study in this chapter is related to the methodologies from these studies. Section 2 of this chapter describes the analytical framework; the variables are defined in Section 3. Section 4 describes the research methodology and the estimation technique. Empirical results are presented in Section 5. Section 6 is the analyses and the last section provides the conclusion.

5.2 *The analytical framework*

The study covers the period from 1985 to 1996, chosen because this period accounts for the change in the exchange rate system. In November 1984, the fixed exchange rate system was officially replaced by a flexible rate system. The Thai baht is tied to a certain basket of currencies throughout the period of investigation. This time span also allows us to test for any structural change in banking efficiencies due to the effect of the financial liberalization that began in late 1989. All 15 Thai banks are included in the analysis. The foreign bank branches are excluded due to the differences in the nature of operations and also because the market share of the foreign banks is very small (according to Table 5.1, the total assets of all of the foreign banks is less than one-tenth of the combined total assets of Thai banks).

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The 15 Thai banks are divided into 3 groups--large, medium, and small according to their share of total output (deposits and credit This criterion differs from other Thai banks studies which classified banks by their total assets. We prefer dividing the sample by size because output is the main decision variable in the conjectural variations model. Therefore, the output position of each bank is a crucial factor in our model. Three bank groups are as follows:

Group 1 -- Large banks:

The Bangkok Bank (BBL), Krung Thai Bank (KTB), Thai Farmers Bank (TFB).

Group 2 -- Medium banks:

Siam Commercial Bank (SCB), Bank of Ayudhaya (BAY), The Thai Military Bank (TMB), First Bangkok City Bank (FBCB), Siam City Bank (SCIB), The Bangkok Bank of Commerce (BBC), and Bangkok Metropolitan Bank (BMB).

Group 3 -- Small banks:

The Bank of Asia (BOA), Thai Dhanu Bank (TDB), The Union Bank (UB), Nakornthon Bank (NTB), and Laem Thong Bank (LTB).

In the first group, large banks consist of the 3 largest banks. Each has an average market share of output between 13 to 25 percent. The second group consists of 7 medium size banks with the average market share between 3 to 7 percent and the third group is the 5 small banks with the average market share less than 3 percent. It should be noted that the combined output of

Following Berg and Kim (1994), 3 benchmark banks are selected. BBL and LTB have to be included in the model since they are the largest and smallest banks. The third one is SCB, representing the medium banks. These three benchmark banks have individual market shares of 25, 7 and 0.5 percent respectively. In order to satisfy the requirement of the model, all three benchmark banks have to remain in the same rank throughout the entire period. Table 5.2 shows the consistency of the data from 1985 to 1996.

The study will start by analyzing the market structure of the banking industry. Three models of bank productions will be tested. The first model is the Cournot model which is one of the classical oligopoly theories. In Cournot equilibrium, each bank makes production decisions without taking account of any possible reactions from its rivals. In other words, there is no conjectural variations between firms. The second model assumes homogeneous conjectures across size classes. This equality hypotheses suggests that each benchmark bank has the same expectation regarding the relative responses by its rivals when changes in output occur. The rejection of the first two models should lead to the suggestion that there exists heterogeneity of these conjectural variations across size classes for each benchmark bank. After identifying the pattern of interdependence in the banking industry, the most appropriate model is selected and scale efficiency before and after the liberalization is estimated.

The estimation model is derived in the framework relating to Gollop and Roberts (1979) and Berg and Kim (1994) which assumes that all 15 Thai banks in the system are producing a single output. The three general inputs of the banks' production function are labor, materials, and fixed assets. We add the fourth input, foreign borrowing, not only to capture the effect of capital control liberalization but foreign borrowing is also one of the most important inputs in banking operations. Thai banks rely heavily on this external source of funds as table 5.3 reveals that foreign borrowing accounts for over 55 percent of the total inputs.

Table 5.1 Comparative Total Assets as at December 31, 1996 (000,000)

	Total Assets	*(%)*
Banks Incorporated in Thailand		
1. Bangkok Bank Public Company Ltd.	1,155,109	21%
2. Krung Thai Bank Public Company Ltd.	715,995	13%
3. Thai Farmers Bank Public Company Ltd.	646,007	12%
4. The Siam Commercial Bank Public Company Ltd.	541,417	10%
5. Bank of Ayudhaya Public Company Ltd.	414,879	7%
6. The Thai Military Bank Public Company Ltd.	333,994	6%
7. First Bangkok City Bank Public Company Ltd.	252,146	5%
8. Siam City Bank Public Company Ltd.	234,145	4%
9. Bangkok Metropolitan Bank Public Company Ltd.	191,550	3%
10. The Bangkok Bank of Commerce Public Company Ltd.	185,575	3%
11. Bank of Asia Public Company Ltd.	126,508	2%
12. The Thai Dhanu Bank Public Company Ltd.	119,598	2%
13. The Union Bank of Bangkok Public Company Ltd.	64,610	1%
14. Nakornthon Bank Public Company Ltd.	64,471	1%
15. The Laem Thong Bank Public Company Ltd.	41,117	1%
Sub-Total	5,087,121	92%
Banks Incorporated Abroad		
1. The Bank of Tokyo-Mitsubishi Ltd.	122,419	2%
2. The Sakura Bank Ltd.	83,569	2%
3. Citibank N.A.	61,099	1%
4. The Hongkong and Shanghai Banking Corp. Ltd.	47,025	1%
5. Standard Chartered Bank	32,468	1%
6. Deutsche Bank AG.	26,692	0%
7. Bank of America N.T. & S.A.	25,650	0%
8. The Chase Manhattan Bank, N.A.	23,322	0%
9. Banque Indosuez	21,019	0%
10. ABN-AMRO Bank N.V.	15,228	0%
11. Overseas-Chinese Banking Corporation Ltd.	5,542	0%
12. The International Commercial Bank of China	4,885	0%
13. Sime Bank Berhad	1,497	0%
14. Bharat Overseas Bank Ltd.	1,495	0%
Sub-Total	471,910	8%
Total	5,559,031	100%

Source : Commercial Banks in Thailand 1997, published by Bangkok Bank Public Co, Ltd.

Table 5.2: Percentage of Market Share for Each Bank

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
BBL	33.62	31.84	29.76	29.70	28.35	27.42	25.94	24.94	24.46	23.28	22.63	21.99
KTB	12.83	12.74	14.71	14.91	15.12	14.64	15.79	14.97	14.67	15.72	14.64	14.80
TFB	14.28	14.52	14.05	13.55	14.11	14.53	14.05	14.23	14.40	14.03	13.56	13.34
Subtotal	60.73	59.10	58.53	58.17	57.57	56.59	55.78	54.13	53.53	53.04	50.82	50.13
SCB	8.82	9.20	9.33	8.90	9.37	9.87	10.03	10.47	10.44	9.67	10.02	10.47
BAY	5.07	5.31	5.53	5.90	6.49	7.22	6.90	7.05	6.78	8.10	8.82	8.64
TMB	4.77	5.30	5.74	6.02	5.94	5.77	5.89	6.15	6.26	6.24	6.39	6.66
FBCB	2.64	2.72	3.34	3.35	3.21	3.49	4.27	4.81	4.87	4.90	4.87	5.09
SCIB	3.76	3.76	3.47	3.65	3.55	3.49	3.52	3.70	3.94	4.30	4.37	4.47
BBC	4.21	4.24	3.68	3.42	3.38	3.53	3.62	3.89	3.96	3.76	3.85	2.98
BMB	3.93	4.01	3.75	3.60	3.48	3.20	3.12	3.24	3.63	3.48	3.69	3.80
Subtotal	33.20	34.53	34.85	34.84	35.42	36.58	37.33	39.30	39.88	40.45	42.01	42.11
BOA	2.13	2.23	2.35	2.47	2.34	2.26	2.29	2.00	2.01	2.02	2.33	2.34
TDB	1.06	1.15	1.36	1.59	1.78	1.51	1.55	1.57	1.61	1.69	1.83	2.20
UB	1.70	1.72	1.68	1.64	1.55	1.61	1.48	1.34	1.28	1.15	1.12	1.20
NTB	0.70	0.79	0.81	0.90	0.97	1.06	1.09	1.12	1.10	1.05	1.21	1.24
LTB	0.47	0.48	0.42	0.39	0.38	0.38	0.47	0.55	0.60	0.61	0.67	0.78
Subtotal	6.07	6.37	6.63	6.99	7.01	6.82	6.89	6.57	6.59	6.51	7.16	7.76
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Calculated from annual reports of each bank.

Table 3.1: Major Financial Institutions Total Assets

unit : million baht

	1989	%	*1990*	%	*1991*	%	*1992*	%	*1993*	%	*1994*	%	*1995*	%
Commercial Banks	1,4263.67	73.7	1,806.56	74.2	2,169.91	73.5	2,555.62	71.2	3,204.64	70.3	4,065.06	70.1	5,045.08	69.4
Finance and Securities	281.7	14.5	365.6	15.0	481.0	16.3	689.86	19.2	931.34	20.4	1,223.46	21.1	1,588.13	21.8
Government Savings bank	125.7	6.5	132.81	5.4	140.16	4.8	150.86	4.2	165.48	3.6	183.90	3.2	210.49	2.9
Bank for Agriculture and agricultural Co-operatives	45.0	2.4	54.80	2.2	67.23	2.3	76.94	2.2	105.74	2.4	122.68	2.1	159.96	2.2
Government Housing Bank	27.81	1.4	35.78	1.5	45.39	1.5	57.07	1.6	78.26	1.7	111.80	1.9	154.06	2.1
Industrial Finance Corporation of Thailand	29.60	1.5	37.90	1.6	47.85	1.6	57.14	1.6	70.40	1.6	90.19	1.6	118.12	1.6
Total	1,936.48		2,433.54		2,951.54		3,587.49		4,555.86		5,797.09		7,275.84	

Source : Computed from various issues of the Annual Report of the Bank of Thailand

The model development starts by expressing the demand function as:

$$P_t = D(Y_t)$$

where P_t is market price which is the interest margins of the banking sector during 1985-1996 and Y_t is the summation of output of each bank in the market ($\sum_j y_j$; j = 1,.....,15) with the following production function:

$$y_j = f(x_{kj})$$

where x_{kj} (k=1, 2, 3, 4 ...) are inputs and the profit function of the j^{th} firm as:

$$\pi_j = Py_j - \sum_k w_k x_{kj} \; ; j=1 , ... , 15$$

where w_k are the input prices.

The first order conditions of profit maximization for the j^{th} firm are:

$$\frac{\partial \pi_j}{\partial x k_j} = Pf_k \left[1-(y_j/Y\,\varepsilon) - (y_j/Y\varepsilon) \sum_{i \neq j} \frac{\partial y_i}{\partial y_j}\right] - w_k = 0$$

where F_k is the marginal product, ε is the market demand and assumed to be constant, and $\sum_{i \neq j} \frac{\partial y_i}{\partial y_j}$ is the conjectural variations of the j^{th} firm.

The 15 Thai banks are divided into 3 groups with 3 banks in group 1 (large), 7 banks in group 2 (medium) and another 5 banks in group 3 (small). Three banks-- BBL (largest), SCB (medium) and LTB (smallest) are selected as benchmark banks. In Berg and Kim (1994), the behavioral equations are transformed to include conjectures expressed in both the relative term due to the rivals' respond as follows:

$$\frac{\partial \pi_j}{\partial x_{kj}} = Pf_k\,[1-(y_j/Y\varepsilon) - (y_j/Y\varepsilon) \sum_r \left(\sum_{i\in r, i\neq j} y_i\right) CVS_{jr}] - w_k = 0$$

where $CVS_{jr} = \partial ln\left(\sum_{i\in r, i\neq j} y_i\right) / \partial y_j$ is the j^{th} bank's conjectural variation with respect to the relative response of the banks in the r size class (r = 1, 2, 3) expressed in semi-logarithmic form. The conjectures are also expressed in logarithmic form, like elasticities, as:

$$\frac{\partial \pi_j}{\partial x_{kj}} = Pf_k\,[1-(y_j/Y\varepsilon) - (y_j/Y\varepsilon) \sum_r \left(\sum_{i\in r, i\neq j} y_i / y_i\right) CV_{jr}] - w_k = 0$$

where $CV_{jr} = \partial ln\left(\sum_{i\in r, i\neq j} y_i\right) / \partial ln\, y_j$.

Both sets of equations will then be expressed in terms of conjectures of neighboring benchmark banks depending on the size position of any particular bank. The weight (ϕ) will be assigned to reflect the distance of the output of that bank that falls between the 2 nearest benchmark banks, b_t and b_{t+1} :

$$\frac{\partial \pi_j}{\partial x_{kj}} = PF_k\,[1-(y_j/Y\varepsilon) - (y_j/Y\varepsilon) \sum_r \left(\sum_{i\in r, i\neq j} y_i\right) \times (\phi_t CVS_{tr} + \phi_{t+1} CVS_{t+1,r})] - w_k = 0$$

and

$$\frac{\partial \pi_j}{\partial x_{kj}} = PF_k\,[1-(y_j/Y\varepsilon) - (y_j/Y\varepsilon)\sum_r \left(\sum_{i\in r, i\neq j} y_i / y_j\right) \times (\phi_t CV_{tr} + \phi_{t+1} CV_{t+1,r})] - w_k = 0$$

where bank j is located between benchmark banks b_t and b_{t+1} and ϕs are determined by the output distances from bank j to benchmark banks b_t and b_{t+1} ; $\phi_t = (y_t - y_j)/(y_t - y_{t+1})$ and $\phi_{t+1} = (y_j - y_{t+1})/(y_t - y_{t+1})$, thus, sum of the weights $(\phi_t + \phi_{t+1}) = 1$.

However, after conducting the full information maximum likelihood (FIML) estimation on the entire data set (1985-1996), we find that the second model (the logarithmic conjectural variations) is preferred over the semilogarithmic one. The preference test has been done with Akaike's Information Criterion (AIC): AIC = -2log L(R) + 2n, where L(R) is the likelihood function, the AIC for semilogarithmic model is 5,128 and for the logarithmic model is 4,568. Thus, the latter model with the smaller AIC is chosen for further analysis.

5.3 *Definition of the variables*

As indicated before, the bank production function consists of four inputs: labor, materials, fixed assets, and foreign borrowing. The value of labor input is defined as the personnel expenses taken from the income statement of each bank. The value of materials input is defined as the operating cost minus personnel expenses also taken from the income statement of each bank. The value of fixed assets is the book value of net fixed assets of each bank taken from the balance sheet. The value of foreign borrowing is defined as the amount of foreign borrowing multiplied by the average Euro-dollar rate in the corresponding year.

On the output side, this paper follows the value-added approach which is consistent with Berger and Humphry (1991a and 1991b) and also used in Berg and Kim (1994). This method of defining the output utilizes the information on operating cost by regressing the operating cost on the disaggregated values of credits and deposits. These two primary outputs are aggregated into one variable according to their weights relative to the operating costs. The weighting method is described in the next section. Both variables are taken from the balance sheet of each bank.

However, the first step is to estimate the demand elasticity which is found by forming a log-linear regression between the dependent variable--aggregated output of the banks--and the independent variables, the average interest margin and manufactured output of the country. The output is an aggregation of the loans and deposits of the bank. The aggregation will be done by setting the "price" of the loan equal to 1, and the relative price of the deposits as equal to the ratio of the average interest paid on deposits divided by the average interest collected on loans. The average interest margin which represents the price of the banking sector output is found by subtracting the deposit rate from the lending rate. The lending rate is the average of loans and overdrafts rates for the priority sectors and others while the deposits rate is the average between the savings rate and time deposits rate. All rates are taken from Table 22--Structure of Interest Rates taken from various issues of BOT monthly reports. The manufacturing output is chosen because the largest share of bank credit is granted to the manufacturing sector (see Table 4.24). This variable is collected from National Account Division, NESDB.

5.4 Research methodology and estimation technique

5.4.1 Estimate demand by OLS

The estimation of the demand elasticity (ε) is done by using the OLS. The banks' output (OUTPUT) is set as the dependent variable and interest margin (INTMAR) and manufacturing output (MANU) are the explanatory variables. The annual data are collected from 1977-1995, resulting in 19 observations.

After correcting for serial correlation in the error term by using the first-order autoregressive correction, the regression outputs are:

$$\log(\text{OUTPUT}) = \underset{(0.77998)}{3.37222} - \underset{(-3.65527)}{0.48193}\log(\text{INTMAR}) + \underset{(2.06960)}{0.43197}\log(\text{MANU})$$

The adjusted R-squared is 0.994. The Durbin-Watson statistic is 1.52 which shows no evidence of positive serial correlation at the 99 percent level of confidence. The negative sign of the demand elasticity is according to our expectation since output and price should reveal an inverse relationship. Therefore, the estimated demand elasticity of -0.48193 will be used in further analysis.

5.4.2 Specify input quantities

Labor is measured by the number of employees of each bank, taken from commercial bank statistics published annually by Bangkok Bank; materials are measured by operating expenses divided by the manufacturing price index, and fixed assets are the net book value divided by the housing index. All indices are acquired from the Department of Business Economics, Ministry of Commerce. Since most of the banks have changed the method of recording their fixed assets value from the historical cost basis to the market value basis since 1993, the adjustments have been made to get back to the book value method for every bank for data consistency. The foreign borrowing data is taken directly from the balance sheet.

5.4.3 Specify the output aggregation

The regression equation has been set up, with operating costs as the dependent variable and the two outputs, deposits and credit, as the explanatory variables. The resulting regression coefficients are computed as weights for each output to be combined. This process results in the weight for 'credit' equal to 0.2990 and the weight for 'deposit' equal to 0.7010.

The result suggests banks have been spending more in producing deposits than in granting loans. This finding is supported by the fact that the largest type of depositor is private individuals, which account for 70.2 percent of deposits compared to 12.5 percent from the business sector. The highest number of deposit accounts is in the category of less than 100,000.00 baht per account. At the end of 1996, there were 42,820,609 accounts (93 percent of total number of accounts) with deposits totaling 333,732 million baht resulting in an average of 7,793.72 baht per account. However, when we examine the total deposits in the banking industry (3,661,715 million baht in 1996) and divide by the total number of accounts (46,078,529 accounts), the average size of a deposit account is 79,466.84 baht. In contrast, the largest portion of credit is extended to the business sector (61.4 percent compared to 34.0 percent extended to private individuals).

5.4.4 Estimating the price 'P'

The interest margin representing the price of the output is calculated from the average loans and overdrafts rate and discount rates of commercial banks minus the average of the saving and time deposits rates during 1985-1996. All the rates are taken annually from Table 22, Structure of Interest Rates, drawn from various issues of the Bank of Thailand's monthly bulletin.

5.4.5 Estimating methodology

The behavioral equations expressed in Section 5.4.3 are constrained by the production function:

$$y_j = F(x_j).$$

This equation is approximated by the second-order Taylor series expansion around the point (x) = 1 and represented by the translog functional form:

$$\ln(y_j) = \alpha 0 + \sum_k \alpha k \; ln(x_{kj}) + \tfrac{1}{2} \sum_k \sum_s \delta_{ks} \, ln(x_{kj}) \, ln(x_{sj})$$

The marginal products F_k in the behavioral equations are presented in their logarithmic form as:

$$M_{kj} = \partial \ln(y_j)/\partial \ln(x_{kj}) = \alpha k + \sum \delta ks \; ln(x_{sj}), \quad \begin{matrix} j = 1,\ldots\ldots,n. \\ k = 1,\ldots\ldots,m. \end{matrix}$$

The behavioral equations to be estimated together with the production function are the four cost-shared equations in the elasticities forms:

$$(w_k x_{kj})/(P y_j) = M_{kj} \; \{1-(y_j/Y\varepsilon) - (y_j/Y\varepsilon) \times \sum_r [(\sum_{i \in r, i \neq j} y_i / y_j)(\phi_t CV_{tr} + \phi_{t+1} CV_{t+1,r})]$$

Since the system of equations is highly non-linear, we will apply the full information maximum likelihood (FIML) method and for estimation purposes, the value of all variables are normalized around the mean values. The SAS statistical package is used in the estimation process.

5.5 Estimation results

The parameter estimates of the full (unrestricted) model are presented in Table 5.4. The sign of coefficients of each input variable ($\alpha 1$-$\alpha 4$) are consistent with the expectations of the production function and their 't' values are all satisfactory. The first hypothesis is the testing for the Cournot model which is done by setting the restrictions on the nine conjectures variables (CV_{11}-CV_{33}) to be equal to zero. The results of the restricted estimation are reported in Table 5.5. The Cournot hypothesis:

$$H_O: CV_{11}= CV_{12} = CV_{13} = CV_{21} = CV_{22} = CV_{23} = CV_{31} = CV_{32} = CV_{33} = 0$$

is tested against the unrestricted model. The likelihood ratio statistic:

$$LR = -2(\ln L_r - \ln L_u)$$

is 1634 relative the critical $\chi^2(9)$ value of 21.67, where $\ln L_r$ is log likelihood of the restricted model estimation and $\ln L_u$ is log likelihood of the unrestricted model estimation. Thus, we reject the hypothesis at the one percent significance level. This strong rejection implies that at least some of the banks take account of their rivals' expected reactions regarding the output change and incorporate them into their decision process. However, in order to have more information about this rejection, we break the analysis and estimate the Cournot hypotheses with respect to the expectation across size classes and within each size class. This method is earlier used in Gollop and Roberts (1979). The six independent tests of Cournot restrictions are: testing the conjectures across size classes for each benchmark bank--

$CV_{11} = CV_{12} = CV_{13} = 0,$

$CV_{21} = CV_{22} = CV_{23} = 0,$

$CV_{31} = CV_{32} = CV_{33} = 0;$

and testing the conjectures of the benchmark bank with respect to the expectations of banks in each size subset--

$CV_{11} = CV_{21} = CV_{31} = 0,$

$CV_{12} = CV_{22} = CV_{32} = 0,$

$CV_{13} = CV_{23} = CV_{33} = 0.$

Each set of restrictions is tested against the original unrestricted model (Table 5.4). The likelihood ratios of each restricted model are reported in Table 5.6. All hypotheses are rejected when compared with the $\chi^2(3) = 11.34$ at the one percent significance level. These results suggest that there is no evidence supporting the Cournot assumption for both an individual bank's expectation across size classes and each size group's expectation toward the behavior of the market.

Table 5.4 Estimated coefficients of the full model

Production parameters	*Estimate*	't' *Ratio*	*Conjective Variations*	*Estimate*	't' *Ratio*
α_0	0.079978	3.26	CV_{11}	134.147215	1.56
α_m	0.268768	14.34	CV_{12}	30.455790	1.12
α_l	0.275845	18.63	CV_{13}	-15.094875	-0.39
α_k	0.267512	20.08	CV_{21}	13.862383	1.12
α_f	0.285886	23.98	CV_{22}	9.211836	1.86
δ_{mm}	0.180597	3.31	CV_{23}	20.002365	2.88
δ_{ml}	0.006892	0.23	CV_{31}	-171.616289	-4.20
δ_{mk}	-0.124175	-5.23	CV_{32}	73.423206	5.60
δ_{mf}	-0.030577	-2.05	CV_{33}	76.998212	4.47
δ_{ll}	0.038868	1.61			
δ_{lk}	0.013451	0.75			
δ_{lf}	-0.022217	-2.63			
δ_{kk}	0.222515	10.65			
δ_{kf}	-0.040695	-5.78			
δ_{ff}	0.087249	7.84			

Log Likelihood *-2104*

Symbols: m = materials,
l = labor,
k = fixed assets,
f = foreign borrowing.

Table 5.5 **Estimated coefficients of the Cournot model**

Production parameters	*Estimate*	*'T' Ratio*
α_0	-3.813639	-1.31
α_m	7.245979	4.32
α_l	11.220382	25.11
α_k	6.984760	12.43
α_f	3.298219	3.36
δ_{mm}	8.038189	2.03
δ_{ml}	-1.512303	-1.53
δ_{mk}	-5.699168	-6.01
δ_{mf}	-1.540222	-2.15
δ_{ll}	0.274700	0.23
δ_{lk}	0.051488	0.05
δ_{lf}	-0.410841	-1.53
δ_{kk}	10.234432	9.89
δ_{kf}	-2.307267	-6.27
δ_{ff}	4.022712	7.32

Log Likelihood *-2921*

Symbols: m = materials,
l = labor,
k = fixed assets,
f = foreign borrowing.

Table 5.6 **Summarized Cournot Hypotheses Testing against $\chi^2(3) = 11.34$**

Hypotheses	Likelihood Ratios
$CV_{11} = CV_{12} = CV_{13} = 0$	394
$CV_{21} = CV_{22} = CV_{23} = 0$	1466
$CV_{31} = CV_{32} = CV_{33} = 0$	1642
$CV_{11} = CV_{21} = CV_{31} = 0$	52
$CV_{12} = CV_{22} = CV_{32} = 0$	34
$CV_{13} = CV_{23} = CV_{33} = 0$	60

The next set of hypotheses are for testing for the homogeneous conjectures across size classes and within each size subset. Another six restrictions are imposed one by one. The first set of the hypotheses are:

$CV_{11} = CV_{12} = CV_{13},$

$CV_{21} = CV_{22} = CV_{23},$

$CV_{31} = CV_{32} = CV_{33},$

and the second set are:

$CV_{11} = CV_{21} = CV_{31},$

$CV_{12} = CV_{22} = CV_{32},$

$CV_{13} = CV_{23} = CV_{33}.$

The summary of the hypothesis testings are reported in Table 5.7. Each restricted model is also tested against the original unrestricted model. The results show that for the first set, the likelihood ratios for the first two hypotheses are smaller than the critical χ^2 (2) = 9.21 and leads to the fact that we cannot reject that there exists the homogeneity of conjectures of banks in all size classes with respect to the output change initiated by large and medium benchmark banks. The last hypothesis in the first set has the likelihood ratios greater than the critical value 9.21, leading to the rejection of the homogeneous conjectures at one percent significant level. Thus, the benchmark bank of the small group does not expect any homogeneous response from all other banks in different size classes. On the second set, the tests reject all three hypotheses, showing that all the benchmark banks are not expected to identically respond to the change in market supply.

Table 5.7 **Summarized Homogeneous Hypotheses Testing against $\chi^2(2) = 9.21$**

Hypotheses	Likelihood Ratios
$CV_{11} = CV_{12} = CV_{13}$	4
$CV_{21} = CV_{22} = CV_{23}$	0
$CV_{31} = CV_{32} = CV_{33}$	38
$CV_{11} = CV_{21} = CV_{31}$	30
$CV_{12} = CV_{22} = CV_{32}$	34
$CV_{13} = CV_{23} = CV_{33}$	52

Although the results of the tests are mixed, most of the tests are rejected. These rejections of almost all of the hypotheses lead to the conclusion that even though the Thai banking industry is characterized by the homogeneity of the output and the whole market is highly regulated (the number of the Thai banks is fixed throughout the entire period of the analysis), we can not expect to see that all of the banks will have the same expectation regarding the reactions from their rivals, whether from different or similar size classes when they change their output level.

The strong rejections of Cournot model suggests that there exists a pattern of interdependency in the market structure of Thai commercial banks. However, the mixed results of the homogeneous conjectures models suggest that the pattern of interdependency in the market structure of the Thai banking sector should be described as having a mixture of hetero- and homogeneous conjectures both within and across size classes. The two hypotheses that we cannot reject ($CV_{11} = CV_{12} = CV_{13}$ and $CV_{21} = CV_{22} = CV_{23}$) are consistent with the pattern of dominant firm leadership in the sense that when changing output level, the large and medium benchmark banks can expect the same response from all other banks in different size classes while we cannot find the same expectation for small benchmark banks.

However, since the objective of this part of the study is to find the most appropriate model describing the behavior of Thai banks, this best model should be the one that incorporates the two restrictions of homogeneous conjectures which cannot be rejected in the earlier tests. For this purpose, we combine the two restrictions and test the joint hypothesis of:

H_O: $CV_{11} = CV_{12} = CV_{13}$, and

$CV_{21} = CV_{22} = CV_{23}$

The likelihood ratio of the test against the original model is 10 which is smaller than the critical χ^2 (4) = 13.28, significant at the one percent level, hence, we cannot reject the hypothesis. The estimation of this best described model is reported in Table 5.8 where CV1 reflects $CV_{11} = CV_{12} = CV_{13}$ and CV2 reflects $CV_{21} = CV_{22} = CV_{23}$.

The results from the estimation lead to the interpretation as follows. Four conjecture variables are significantly positive at the 95 percent level (CV1, CV2, CV_{32} and CV_{33}). The strong positive CV1 and CV2 suggest that all banks are expected to match their output when the large and medium benchmark banks change their output level. The same expectations for medium and small banks occur when the small benchmark bank increases its output (CV_{32} and CV_{33} are positive).

On the other hand, the highly significant negative value of CV_{31} which is much smaller than -1 might prove counterintuitive. Iwata (1974) states that the conjectural variation in his approach must be larger than -1 in order to satisfy the second order condition of the profit maximization function. However, this is not the case in our study. In general, Iwata measures the aggregate conjecture, $\partial(\Sigma_{i\neq j} q_i)/\partial q_j$, meaning his study evaluates the aggregate output response of the n-1 firms anticipated by firm j, where "n" is the number of firms in the industry. Therefore, in his approach, the value of conjecture larger than -1 must hold.

More specifically, as our objective is to be able to identify the pattern of interdependency in the Thai banking sector, we follow Gollop and Roberts (1979) and decompose the conjectures with respect to rival's size and measure conjectures of only three benchmark banks representing three size classes, large, medium and small. Each bank's conjectures are an average of CVs of the three size classes with fixed weights. Hence, our conjectures are not bound by the same rule as Iwata (1974). Moreover, similar evidence of negative CVs is also reported in Gollop and Roberts (1979). The highly significant negative value of CV_{31} suggests that when a small benchmark bank makes a production decision, it expects an accommodating reaction from banks in the large group.

Table 5.8 Estimated coefficients of Ho: $CV_{11} = CV_{12} = CV_{13}$ and $CV_{21} = CV_{22} = CV_{23}$

Production parameters	***Estimate***	**'t' Ratio**	***Conjective Variations***	***Estimate***	**'t' Ratio**
α_0	0.097330	4.02	*CV1*	28.462378	14.42
α_m	0.273421	14.14	*CV2*	13.593007	14.98
α_l	0.279696	17.88	CV_{31}	-169.400585	-5.55
α_k	0.271487	18.75	CV_{32}	79.213806	7.69
α_f	0.282478	22.21	CV_{33}	66.524855	5.78
δ_{mm}	0.178779	3.33			
δ_{ml}	0.005393	0.18			
δ_{mk}	-0.128560	-5.43			
δ_{mf}	-0.027881	-1.93			
δ_{ll}	0.040657	1.72			
δ_{lk}	0.009494	0.52			
δ_{lf}	-0.020435	-2.32			
δ_{kk}	0.223364	10.85			
δ_{kf}	-0.038599	-5.35			
δ_{ff}	0.082313	7.19			

Log Likelihood *-2109*

The results from this best described model produce the estimate of scale elasticity equal to 1.107082 which is significantly greater than one at the one percent significant level with the likelihood ratio of 8 against the critical value of χ^2 (1) = 6.63. This increasing return to scale when compared to the result obtained from the Cournot model (28.74934, which is abnormally high), suggests that the model does not account for the interdependence among firms in an oligopolistic environment, leading to biased results when firms operate in this type of market. This very high number is drastically reduced when we take into account the conjectures among banks appearing in this study.

The next tests are tests for any structural shift resulting from the financial liberalization since late 1989. Most of the studies in this field conduct the test by including dummy variables in the model. Jagtiani and Khanthavit (1996) add dummy variables to the translog cost function to check on the regulatory effects--risk-based capital requirement (RBC)--in large US banks during 1984-1991. Their results suggest that the cost structure of these large US banks are significantly different before and after the application of the RBC.

Ideally, the dummy variable should be added to the coefficient of all variables in the model. However, this involves a trade off with the model's degrees of freedom. Hence, we have to separately test for the structural shift for each set of variables. The first test is for the efficiency of the banking operation.

The dummy variable, D, is added to the coefficients of four inputs (all αs) of the best described model where D is equal to 1 from 1990-1996 and equal to 0 before that period. The dummy model is treated as the unrestricted model and the best described model (without the dummy variable) is the restricted one. The likelihood ratio test of 868 is much greater than the critical $\chi^2(3) = 11.34$, thus the hypothesis that $\beta_m = \beta_l = \beta_k = \beta_f = 0$ is rejected. This finding reveals that the efficiency of the banking operation is significantly different after liberalization. The results of the estimation are reported in Table 5.9.

We also conduct the test on the structural change of the conjectures. The same dummy variable, D, is added to the conjecture variables in the best described model and the same procedure is repeated. The results of the estimation, as shown in Table 5.10, indicate that there is also significant change in the structure of the conjectures. The likelihood ratio of 62 is greater than the critical value of 11.34. Therefore, we reject the null hypothesis that $\theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = 0$.

Since both models are significant, we again apply the preference test with Akaike's Information Criterion (AIC) and found that the AIC for the efficiency test is 3,710 which is smaller than the AIC for the conjectures test (4,516). Hence, we prefer the first model and our discussion in the next section is based only on this model[1].

[1] We also selectively add dummy variables to both sets of variables. Dummy variables are added to all CVs and α_f since only the dummy variable of α_f is statistically significant. The results, not reported here, are qualitatively identical. However, the AIC is larger than the model with only dummy variables attached to αs.

Table 5.9 Dummy Model (Efficiency Test)

Production parameters	*Estimate*	'T' *Ratio*	*Conjective Variations*	*Estimate*	'T' *Ratio*
α_0	0.056247	2.26	$CV1$	30.352675	16.48
α_m	0.244411	13.95	$CV2$	14.841144	17.95
α_l	0.253797	12.63	CV_{31}	-44.272842	-1.17
α_k	0.259538	12.55	CV_{32}	43.139297	4.15
α_f	0.327629	15.93	CV_{33}	48.533687	3.11
β_m	0.014900	0.56			
β_l	0.032698	1.06			
β_k	0.006432	0.21			
β_f	-0.087008	-2.85			
δ_{mm}	0.162708	12.43			
δ_{ml}	-0.004445	-0.31			
δ_{mk}	-0.091923	-7.76			
δ_{mf}	-0.026216	-4.18			
δ_{ll}	0.004473	0.22			
δ_{lk}	-0.014654	-1.11			
δ_{lf}	-0.007592	-1.01			
δ_{kk}	0.172004	11.13			
δ_{kf}	-0.027701	-3.91			
δ_{ff}	0.107308	9.46			

Log Likelihood *-1675*

<u>Table 5.10</u> Dummy Model (Conjectures Test)

Production parameters	*Estimate*	*'T' Ratio*	*Conjective Variations*	*Estimate*	*'T' Ratio*
α_0	-0.010222	-0.43	*CV1*	31.167773	13.42
α_m	0.267806	15.93	*CV2*	14.415515	13.31
α_l	0.266694	20.87	CV_{31}	-294.741708	-2.57
α_k	0.268532	23.20	CV_{32}	142.420012	4.71
α_f	0.282375	24.42	CV_{33}	50.975098	1.24
δ_{mm}	0.172343	3.67	θ_1	-2.362568	-1.00
δ_{ml}	0.011996	0.43	θ_2	-0.346910	-0.38
δ_{mk}	-0.111983	-5.50	θ_3	472.63141	3.56
δ_{mf}	-0.015040	-1.22	θ_4	-155.746164	-4.23
δ_{ll}	0.054355	2.37	θ_5	-61.774724	-1.35
δ_{lk}	0.019934	1.21			
δ_{lf}	-0.013436	-1.50			
δ_{kk}	0.205004	12.43			
δ_{kf}	-0.024519	-3.31			
δ_{ff}	0.087686	9.02			

Log Likelihood *-2078*

5.6 *The analyses*

The first part of the analyses in this chapter suggests that the general translog cost function that works well under the perfect competitive assumption should not be applied when investigating the performance of firms that operate in an oligopolistic market environment. The estimating model in this study is related to the Gollop and Roberts (1979) and Berg and Kim (1994) models which take into account firm interdependence in oligopolistic markets. The main difference between their models and the models in this study is the fact that their studies were cross-sectional while this study is a pooled time series cross-section sample. This kind of data allows us to examine any changes in both banks' efficiency and conjecture variables that might occur due to the financial liberalization after 1989.

With the small number of operating firms and the highly unequal distribution of output, the market structure of Thai commercial banks are clearly identified as an oligopoly, however, we would like to give more insight into the specific pattern of interdependency among banks.

In an industrial organization study, we can broadly classify two types of oligopolistic markets: a tight oligopoly and a loose oligopoly. The first case is where we can find explicit collusion among firms. The higher the degree of concentration, the higher the chance that collusion will persist with success. In a loose oligopoly, the market structures range from moderate collusion to almost pure competition, hence the degree of the interdependence can vary. Normally, we can expect to find that firms in a loose oligopoly can accommodate, retaliate, or simply ignore each other's reaction.

What we find in the study of the Thai banking industry reveals that the Thai banking market should be classified as a loose oligopoly. We strongly reject the Cournot assumption from both within and across size classes and conclude that the market structure of Thai banks should be describe as having a mixture of hetero- and homogeneous conjectures. Two equality tests that can not be rejected are partly consistent with assumptions underlying the dominant firms leadership model. In light of this support, we find that all banks are expected to have identical responses with respect to changes originated by the large and medium benchmark banks while we cannot find the same evidence for small banks' expectations.

These findings are confirmed by the fact that the Thai banking industry consists of 15 banks and according to Table 5.2 the largest bank (BBL) captures about 22 percent of total aggregate output in 1996 which has deteriorated from 35 percent in 1985. Two other large banks (KTB and TFB) each sustained a market share of roughly 14 percent throughout 1985-1996. The performances of the medium size banks are somewhat impressive; the first three banks (SCB, BAY and TMB) were able to increase their market share throughout the same period while the rest of the medium banks maintained their position. Moreover, the combined market share of each category shows that medium banks increased their share from 33.20 percent in 1985 to 42.11 percent in 1996; small banks also were able to increase their share from 6.07 to 7.76 percent. These increases were at the expense of large banks or, to be more specific, the largest bank and support the finding of negative conjecture of large banks with respect to the production decision of the small benchmark bank (CV_{31}).

The estimated coefficient of input factors from the best described model generate the significance scale efficiency of 1.107082. Although this finding coincides with other studies of Thai banks, we argue that our method (to consider the bank's output as an exogenous variable) produces more accurate results. The nature of oligopolistic markets requires that each firm's production decision depends on the expectation of its rivals' reactions to its actions, hence, ignoring this crucial fact may lead to biased estimates. The findings of significant conjectures which are mostly positive (except CV31) in our study indicate that retaliation among Thai banks does indeed exist and these retaliatory reactions increase a bank's output in order to maintain its market share. Thus, leaving this effect out from the model may lead to some biased results, as appears in the estimation of the Cournot model.

The test for any change in bank efficiency before and after the liberalization reveals that the efficiency structure is significantly different after the liberalization takes place (since 1990). When combined, the estimated coefficients of α_s and β_s produce the result of 1.052497 which is significantly less than before liberalization. This lower increasing return to scale indicates that the banking operations are moving toward the minimum efficiency scale (MES) located at the lowest point of the average U-shaped cost curve (where the production of the firm reaches constant returns to scale). If the long run average cost curve is unchanged, this result would suggest that, on average, the banking sector has improved its efficiency after the liberalization in the sense that it is operating at the point closer to the MES of its own average cost curve. However, this MES might not be the same as before the liberalization (because the cost curve may be changed) so we cannot conclude that the Thai banking sector has achieved a higher level of efficiency after the liberalization.

Despite the inconclusive results, the finding of the structure shift in banking operations is solely the effect of the increase in foreign borrowing since we find the significant negative coefficient of the dummy variable attached to this input. The negative value is the result of the dramatic increase of low cost foreign funds (in terms of both interest rates and transaction costs). Table 5.11 reveals the comparative growth rate of each input and output. The sharp increase of the growth rate of foreign borrowing was not matched by the growth rate of output. In fact output growth slowed after 1990.

This improvement in efficiency is consistent with the results reported in Okuda and Mieno (1996) which takes account of the effect of financial liberalization by extending the period of the analysis until 1993. The results from their study show that medium and small banks (classified by total assets) have higher economies of scale after the liberalization while for large banks the result is not clearly observed. However, despite the different method of estimation, their inputs do not include external financing as in our study and for us, we find that this variable contains some crucial facts when analyzing the effect of the deregulation. Taking out the negative effect of the foreign borrowings will increase the number to 1.139405 meaning the backward movement on the average cost curve which widens the distance to the MES.

We cannot define any structural shift in the pattern of interdependency due to the limitation of the model's degree of freedom. However, we attempt to define some theoretical index regarding the degree of monopoly power during 1985-1996 in the Thai banking sector. In a monopoly, price is above marginal cost and this effect was labeled the Lerner index of the degree of monopoly. It is the following ratio:

$$\text{Lerner index} = \frac{\text{price} - \text{marginal cost}}{\text{price}}$$

This ratio can be restated using the definition of marginal cost = $\frac{\text{input price}}{\text{marginal product}}$ which in our notation is w_k/F_k. We apply this method to capture the degree of monopoly power in our case of the Thai banking group over the investigation period:

$$\text{Lerner index}_t = \frac{P_t - \sum_j \frac{w_{kt}}{F_{kt}} \cdot \frac{y_{jt}}{Y_t}}{P_t}$$

where $\sum_j \frac{w_{kt}}{F_{kt}} \cdot \frac{y_{jt}}{Y_t}$ is the average marginal cost across all banks.

These indices are computed for each factor input for each year from 1985-1996. Figure 5.1 shows the trend of each index. In general, all of them reveal the higher degree of monopoly through time and the most obvious index is the fourth one, foreign borrowing, where the trend shifts in 1992 and remains at that high level thereafter. This higher concentration indicates the failure of the deregulation to increase the competitive environment in the bank market. Thai banks seem to enjoy higher profits after the liberalization and better efficiency does not come from more competitiveness as we expected.

5.7 Conclusion

Unlike the earlier studies that assumed a perfect competitive market environment, this chapter attempts to measure the scale efficiency in Thai banking operations by incorporating into the analysis some conjecture variables which uniquely occur in an oligopolistic market. We are able to describe the Thai banking industry as loose oligopoly and the more realistic results show significant increasing returns to scale. This scale efficiency is significantly different after the liberalization. On average, if the cost curve is unchanged, the Thai banking sector has been able to achieve higher efficiency as a result of the deregulation. The Lerner indices indicate the higher degree of monopoly power. Thus, our findings indicate that the implementation of financial reform policies might lead to structural changes in the efficiency of the Thai banking sector but not a more competitive market structure.

Table 5.11

Comparative growth rate of inputs and output

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
INPUT														
Operating cost	14.89	14.89	16.69	5.02	15.25	19.12	23.80	35.55	20.81	12.84	14.59	20.02	23.31	18.68
Personal expenses	9.80	11.94	9.87	6.27	9.32	13.66	14.15	23.52	19.43	24.66	17.81	20.23	18.65	8.31
Fixed assets	9.59	11.58	15.97	12.19	7.77	5.56	11.52	28.54	30.60	24.11	22.90	24.24	27.03	20.18
Foreign borrowings	46.12	30.13	8.95	20.76	7.24	17.87	20.51	66.95	12.55	26.91	7.17	24.08	4.59	5.35
OUTPUT														
Deposits and Credit	26.90	20.82	9.86	8.03	19.89	20.37	26.34	28.70	20.87	16.92	19.71	17.26	19.89	15.18

Source : Calculated from annual reports of commercial banks

Figure 5.1 LEARNER INDEX OF EACH INPUT