USING A THREE STAGE SUPER-SBM MODEL TO ANALYZE THE INFLUENCE OF BANK'S INTERNATIONALIZATION AND RISK ON THE OPERATIONAL EFFICIENCY

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Abstract

This study applies the three stage Super-SBM model, which combines the approaches of Fried et al. (2002) and Tone (2002), to analyze the influence of banks' internationalization and risk on efficiency. Most former works focused on the effects of risk, but they seldom emphasize the impact of internationalization. Therefore, in addition to the modification of the empirical model, this study also considers internationalization as an external factor into the efficiency measurement. The results show Taiwan's commercial banks could increase its degree of internationalization to improve efficiency, whether by using the strategy of foreign direct investment or increasing foreign shareholding. This study also evidences that several banks

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have a fine management capacity, but they are easily affected by external factors to be defined as inefficient units.

I.   *Introduction*

After Taiwan became a member of the World Trade Organization (WTO) in the 1990s, the government continuously promoted the liberalization and deregulation of financial business. Many emerging local commercial banks were established during the period. In addition, international banks also had begun to expand its branches into Taiwan. However, the demand for loanable funds did not increase as quickly as supply. As a result, commercial banks today are confronting a much more competitive market environment. In order to survive and prosper amidst such competition, internationalization has become an important approach in most Taiwanese commercial banks.

Strategies for internationalization in Taiwanese commercial banks include two patterns. One is extending business in overseas markets and the other is boosting foreign ownership. Commercial banks can enlarge the size of its business through asset allocation by extending business overseas. Boosting foreign ownership is beneficial to improving corporate governance and in sharing foreign knowledge. Through International enterprise, banks can employ their domestic advantages in overseas markets, such as scale of capital, management expertise, credit disciplines and practices, product design, brand and reputation. Banks are also subject to less regulation abroad (Yamori, 1997). In addition, banks may be able to obtain the benefit of scale economies by entering into foreign markets (Mahajan et al., 1996). The experience obtained through prior entry to foreign markets is also considered as a competitive advantage for exploring new markets (Ball and Tschoegl, 1982). According to different viewpoints in literature, internationalization is not an absolute approach for effectively improving performance in Taiwan's commercial banks. Some studies express the advantage in banking internationalization as equivocal. The study of Degryse and Ongena (2005) emphasized multinational enterprises as having higher information cost. Bush et al. (2011) describe some domestic banks as being productive, whereas other banks that have internationalized as being entirely unproductive.

After the financial deregulation in 1991, Taiwanese commercial banks started to establish branches abroad to enlarge their markets. Foreign subsidiaries established by local bankers grew to almost 300 branches. Those branches were mainly distributed across North America and Asia Pacific. In order to prepare for the implementation of Basel II and to develop human resources for the domestic financial market, the government introduced the " Program of Promoting Regional Financial Services Center" in 2004 to encourage local commercial banks to increase foreign ownership from 21.5% in 2003 to 44% in 2009. Unfortunately, the policy was not effective, and the proportion of foreign ownership reached only 31% by 2009. When the Lehman shocks occurred in 2008, local commercial banks determined their risk exposure to be 10 billion NT$, which accounted for 0.1% of total assets. While the Lehman event did shock the Taiwanese stock market, it ultimately did not do significant harm to the commercial banks.

Since 2009, these commercial banks and the government have concentrated their attention towards financial risk management and diversified asset allocation. This focus on internationalization also started to shift toward Mainland China as well in recent years.

Risk management practice is defined as an important process in strengthening capital structure and improving operational performance in Taiwan's bank industry. Commercial banks provide financial products and services while taking risks involved with liquidity, capital adequacy, credit, interest and foreign exchange rates, operating risks, etc. Bessis (1998) defined banks as "risk machines." Consequentially, risks have a potential impact on the operational performance of commercial banks. Establishing a system of risk-monitoring has become a trend in banking reform, which supports managers' decision making and hence profitability (Emel et al., 2003). After the financial deregulation, a more competitive market environment prompted banks to increase small-business lending and high-risk loans in order to boost market share. Enhanced risk management practices are positively related to financial capital quality (Hsiao et al., 2010). However, strict risk management practices can inhibit banks from holding high-risk loans, which is disadvantageous for profits. Some researches include these factors of risk into banks' efficiency measurement in an attempt to establish relationships between risk and efficiency, e.g., Pastor (2002), Altunbas et al. (2000), Hughes et al. (2001), and Girardone et al. (2004).

Risk management is considered an important business in banking and its influence on bank efficiency has been investigated in present studies. The internationalization of risk management is also regarded as having a significant impact on bank performance. However, the effectiveness of internationalization is rarely discussed in previous analyses on bank efficiency. Whether the internationalized enterprise has a positive or negative effect on a bank's efficiency has not been evidenced in previous works. The main aim of this study is to evaluate the influences of risk and internationalization on banks' efficiency in Taiwan. We utilize a three-stage data envelopment analysis (DEA) approach, which refer to Chiu and Chen (2009) to treat risk and internationalization indicators as external impact on efficiency in the DEA model. In addition to identifying the relationship between external impact and efficiency, the three-stage DEA is able to discover the pure efficiency in which the effects of external impacts are excluded. The differences between this study and previous works contain two aspects. Firstly, we investigate simultaneously the influences of risk and internationalization in the empirical model. Most of the previous works discussed the effects of risk on banks' efficiency in Taiwan but seldom emphasize the role of internationalization. Secondly, in order to enhance the discrimination for decision making units (DMUs) that place on the efficiency frontier, we further modify the three-stage DEA with the concept of super efficiency developed from Tone (2002). In this study we call the three stage Super-SBM model. Hopefully, the empirical results of this study can provide useful information for banks and government agencies to do decision-making about the improvement of operational efficiency.

The reminders of this study are structured as follows: Section II illustrates the presented works on banks' efficiency. Section III introduces the empirical model. Empirical results and analysis are expressed in Section IV. Finally, the conclusions are offered in Section V.

II.   *Literature*

In early bank's efficiency studies, researchers used basic DEA models to evaluate the performance of the banking industry with indicators of technical, cost, profit, scale, allocated efficiencies, such as Ferrier and Lovell (1990), Aly et al. (1990) Berger and Humphrey (1991) McAllister and McMauus (1993), Grabowski et al. (1993), etc. Following the extension of DEA models, productivity was included into the bank's performance indicators. Chou et al. (2002), Chan and Liu (2006) evaluated banks' efficiency and productivity in the periods before and after deregulation. Mukherjee et al. (2001) assessed the performance of US and European commercial banks, respectively, by using efficiency and productivity indicators.

The comparison between different ownership types was assessed in the bank's efficiency. Chen (1998) and Chen and Yen (2000) found that privately-owned banks performed more efficiently. Isik (2007) and Ray and Das (2010) discovered an opposite result - that state-owned banks displayed higher productivity, especially during the post-deregulation period. Isik and Hassan (2002) claimed that private and foreign banks were more efficient than publicly-owned banks.

Considering the trend of establishing or joining financial holding groups, the consequences of financial holding management were included in the analyses. Stiroh (2000) measured the efficiencies of financial holding companies. Many researchers were interested in the difference between financial-holding and independent bank types and made comparisons in efficiency and productivity for the two types, such as Benston (1994), Saunders and Walter (1994), Grabowski et al. (1993), Vennet (2002), and Yamori et al. (2003).

Some researchers established the frameworks of the value-chain and network in DEA models to discuss the bank's performance. Seiford and Zhu (1999) evaluated the profitability and marketability efficiencies of the banks via a two-process DEA. Lo and Lu (2006) further explored the influence on the bank's profitability and marketability. Chen and Zhu (2004) measured information technology's indirect impact on the bank's operation with a two-process frame. Cooper et al. (2000) used a multi-component efficiency model to distinguish between sales and service divisions. Manandhar and Tang (2002) developed a network model to assess service quality, operational efficiency, and profitability. With this in mind, the framework of the network measures the bank's performance from multiple perspectives. It was applied frequently in the following studies, such as Wu et al. (2006), Matthews (2013), etc.

An increasing number of researchers tried to find the sources of inefficiency which are caused by external factors rather than internal factors such as excess input utilization and output deficits. The external influences on efficiency were introduced in the DEA studies conducted by Favero and Papi (1995), DeYoung and Hasan (1998), Chang (1999), Li, et al. (2004), Lieu et al. (2005), Huang et al. (2012), etc. The types of external factors include overdue loan ratio, governmental shareholding, market share, degree of diversification, degree of automatic service, operating age, etc. Risk is also involved in the bank's enterprise. Some studies assumed risk to be an input factor, such as Hughes et al. (2001), Altunbas et al. (2000), Drake and Hall (2003), Girardone et al. (2004), Chiu et al. (2008). Risk is also defined as an important external impact on bank efficiency in researches by Berger and DeYoung (1997), Emel et al., (2003), Ataullah et al. (2004), Chang and Chiu (2006), Hsiao et al. (2010), Matthews (2013), etc.

As mentioned above, risk is defined as an influential factor on efficiency and is evaluated in a bank's efficiency. Internationalization of the banking industry also has a significant effect on bank performance (Mahajan et al., 1996; Bush et al., 2011; Yamori, 1997), but was rarely discussed in bank efficiency studies. This study introduces both risk and internationalization as external factors to measure the bank's efficiency.

III.   *Methodology*

Multiple-stage DEA is structured with the basic DEA model and regression model to evaluate efficiency and estimate the significance of external influences on efficiency. Fried et al. (1993) and Pastor (1999) proposed using the two-stage models, which computes efficiency scores in the first stage and estimates parameters for external influences in the second stage. Fried et al. (1999, 2002) modified previous models into a three-stage framework, which evaluates further pure efficiency in the third stage. The efficiency performed from firms operating without the effect of external factors is able to be revealed through the third stage. The empirical model of this study modified the process of Fried et al. (2002), in which the Super Slacks Based Model (Super-SBM) is used instead of the basic DEA model in both the first and third stages, i.e. the three stage Super-SBM model. The numbers of observations used in the empirical evaluation are the 19 banks, and there are 5 to 7 units that are evaluated each year as being efficient and have the same efficiency score in the two stages. In order to increase discrimination for the difference, we used the three stage Super-SBM model, which further rank the banks located on the efficiency frontier.

1.   The First Stage

Farrell (1957) developed primitively the concept of production frontier. The principle was extended for use on the measurement of efficiency by most researchers. Charnes et al. (1978) and Banker et al. (1984) proposed the basic radial DEA models. Following studies, including Banker and Gifford, (1988), Banker et al. (1989), and Andersen and Petersen (1993), established the super efficiency DEA model, which is able to discriminate the difference between efficient DMUs. Some studies developed non-radial DEA models and used slacks, which contain excess inputs utilization and output deficits, to calculate efficiency indicators, such as Färe and Lovell (1978), Charnes et al. (1985), Ali et al. (1995), Thrall (1996), and Sharp et al. (2007).

Tone (2002) combined the principles of super efficiency and non-radial measurement and presented Super Slacks Based Model (Super-SBM). Suppose there is an N dimension DMU set denoted as n and $DMU_n \in N$. The input and output are labeled as $x \in R_+^M$ and $y \in R_+^R$, respectively. The symbol, ρ, means the efficiency score computed through following mathematical planning programme.

$$Min \; \rho = \frac{\dfrac{1}{M}\sum_{m=1}^{M} \dfrac{\bar{x}_m}{x_{m0}}}{\dfrac{1}{R}\sum_{r=1}^{R} \dfrac{\bar{y}_r}{y_{r0}}}$$

$$s.t. \quad \bar{x}_m \geq \sum\nolimits_{n=1, \neq 0}^{N} \lambda_{mn} x_{mn}, \ n=1, \cdots, N, \ m=1, \cdots, M \ ;$$

$$\bar{y}_r \leq \sum\nolimits_{n=1, \ n \neq 0}^{N} \lambda_{rn} y_{rn}, \ r=1, \cdots, R \ ;$$

$$1 = \sum\nolimits_{n=1, \ n \neq 0}^{N} \lambda_{mn}, \ 1 = \sum\nolimits_{n=1, \ n \neq 0}^{N} \lambda_{rn} \ ;$$

$$\bar{x} \geq x_0, \ \bar{y} \leq y_0, \ \bar{y} \geq 0, \ \lambda \geq 0. \tag{1}$$

Through the formula (1), the optimal solution, λ_{mn}^* ($n=1, \cdots, N$), can be computed out. The slacks of mth input can be calculated by using the following.

$$s_{mn} = x_{mn} - \sum\nolimits_{n=1}^{N} x_{mn} \lambda_{mn}^*, \ n=1, \cdots, N, \ m=1, \cdots, M \tag{2}$$

In the formula (2), s_{mn} represents the mth input slacks of the nth DMU, $\sum\nolimits_{n=1}^{N} x_{mn} \lambda_{mn}^*$ represents the optimal input quantity for the DMU.

2. The Second Stage

The SFA was primely developed by Aigner et al. (1977) to estimate efficiency indicator based on the approach of econometrics. Following researchers continuously improved the SFA in various aspects, including time varying (Cornwell et al. 1990; Battese and Coelli, 1992), penal data (Pitt and Lee, 1981; Schmidt and Sickles, 1984), and external factors estimating (Huang and Liu, 2004; Battese and Coelli, 1995).

In the study of Fried et al. (2002), the SFA was applied to screen out the impacts resulting from external factors. The dependent variables in regression function of the SFA are assumed as the input slacks which are solved from the first-stage, and the independent variables include external factors. The functional form, which refers Battese and Coelli (1992), is expressed as below.

$$s_{mn} = f^m(z_p \ ; \ \beta_p^m) + v_{mn} + u_{mn}, \ n=1, \cdots, N, \ m=1, \cdots, M \tag{3}$$

In the formula (3), z_p symbol the pth external factor; β_p^m means the estimated parameter for the pth external factor of the mth input; v_{mn} represents error term and characterizes the normal distribution [$v_{mn} \sim N(0, \sigma_v)$]; u_{mn} represents the inefficiency from management and characterizes the truncated normal distribution [$u_{mn} \sim N^+(\mu_m, \sigma_u)$]. v_{mn} and u_{mn} are independent of each other.

The logarithmic function restricts the dependent variables and must be greater than zero. That may make some inputs without slacks (i.e., $s_{mn}=0$) become unavailable in the SFA regression model. As a result, we adopt the linearity form for $f^m(z_p \ ; \ \beta_p^m)$ and specify the regression model as follows.

$$s_{mn} = \beta_0^m + R \beta_1^m + \left(\sum_{i=1}^{2} I_i^m \beta^m \right) + \left(\sum_{p=1}^{6} Z_p \beta^m \right) + v_{mn} + u_{mn}, \ n=1, \cdots, N, \ m=1, \cdots, M \tag{4}$$

There are 9 external factors (independent variables) in this model, which are classified as risk (R), internationalization (I_i), and environmental factors (Z_p). Their definitions are described as follows.
(1) Risk value (R): the risks considered in the model include interest risk, exchange risk, and
    equity risk. We use the Moving Average approach to define the risk value with the three

risk indicators.

(2) Degree of internationalization (I_1): we refer to Sullivan (1994) and use foreign sales of total sales, foreign assets of total assets, and number of foreign subsidiaries to measure the degree. The three indicators are combined into a single index in advance by using the Principal Component Analysis.

(3) The proportion of foreign ownership (I_2): refers to foreign shareholding of total shareholding. When bank issues foreign equities, they must be examined by using International standard of review. Therefore, that increases the degree of financial reporting transparency and prevents deceitful financial reporting.

(4) The proportion of government's ownership (Z_1): refers to governmental shareholding of total shareholding. Theoretically, the banks with higher governmental shareholding are more easily trusted by clients. Some researches argued the opposite - that publicly owned banks lack motivations to compete in the market (Boardman and Vining, 1991). Public banks also have to assist governmental policy in their business rather than focus purely on profit.

(5) The length of time of bank operations (Z_2): we evaluate the variable with the number of years that the bank has been operating. A bank with longer years of operation would accumulate a greater number of clients over time, indicating stability and steady profits (Chiu and Chen, 2009).

(6) Loan-to-Deposit Ratio (Z_3): the indicator is measured as the ratio of total loans to total deposit. A low ratio implies that the bank employs an inactive loan strategy which would reduce profitability. A high ratio would reduce solvency due to a low degree of liquidity.

(7) Size of bank (Z_4): we use the natural logarithm of total properties to measure the size of bank. A large operating size would bring the advantage of economies of scale, but it has small operational flexibility (Chiu and Chen, 2009).

(8) Economic growth rate (Z_5): the economic growth rate implies intensity of demand for funds. A high rate means a booming economic situation. This results in a greater demand for funds, and thereby higher operating profit (Pastor, 2002).

(9) Growth rate of the money supply (Z_6): it is a prior indicator for economic situation. When government increases money supply, the short-term outputs also rise (Drake et al., 2006). Consequentially, that increases frequency of financial trade for banks.

3. The Third Stage

Through the regression model as the second stage, estimated parameters ($\hat{\beta}_p^m$) can be estimated and are used to adjust the input factors. The estimated error term ($\hat{v}_{mn}$) is measured as $\hat{E}[v_{mn}|v_{mn}+u_{mn}]=s_{mn}-z_n\hat{\beta}^m-\hat{E}[u_{mn}|v_{mn}+u_{mn}]$, $n=1, \cdots, N$, $m=1, \cdots, M$, according to the study of Jondrow et al. (1982). The adjusted input factors are defined as follows.

$$x_{mn}^A=x_{mn}+[\max_n\{z_n\hat{\beta}^m\}-z_n\hat{\beta}^m]+[\max_n\{\hat{v}_{mn}\}-\hat{v}_{mn}], \quad n=1, \cdots, N, \ m=1, \cdots, M \qquad (5)$$

After the process above, we re-model the Super-SBM and formulate as follows.

$$Min \ \rho^A=\frac{\frac{1}{M}\sum_{m=1}^{M}\frac{\bar{x}_m^A}{x_{m0}^A}}{\frac{1}{R}\sum_{r=1}^{R}\frac{\bar{y}_r}{y_{r0}}}$$

$$s.t. \quad \bar{x}_m^A \geq \sum\nolimits_{n=1, \neq 0}^{N} \lambda_{mn} x_{mn}^A, \ n=1, \cdots, N, \ m=1, \cdots, M \ ;$$

$$\bar{y}_r \leq \sum\nolimits_{n=1, n \neq 0}^{N} \lambda_{rn} y_{rn}, \ r=1, \cdots, R \ ;$$

$$1 = \sum\nolimits_{n=1, n \neq 0}^{N} \lambda_{mn}, \ 1 = \sum\nolimits_{n=1, n \neq 0}^{N} \lambda_{rn} \ ;$$

$$\bar{x}^A \geq x_0^A, \ \bar{y} \leq y_0, \ \bar{y} \geq 0, \ \lambda \geq 0. \tag{6}$$

Through the optimized process of mathematical planning program for formula (6), the pure efficiencies, which exclude the influence of external factors on efficiency, are evaluated. The performances based on DMUs' managerial ability are revealed by the pure efficiencies.

4. The Empirical Data

From 2004 through 2009, Taiwan placed great emphasis on internationalization in its attempt at financial reform. Prior to 2004, the focus was on liberalization of the financial markets, and after 2009, the government focused on improving banking institutions. For this reason, this study chooses the 2004-2009 period for observation and evaluation. The data used in this study contains 19 banks' annual reports from 2004 through 2009, which are collected from the Securities and Futures Commission of the R.O.C. The assumption of a bank's inputs and outputs adopts the Intermediation Approach to evaluate efficiency as well as former work of Chansarn (2008). The inputs include employees, deposits, fixed assets, and operating expenses; and the outputs include loans, investments, and non-interest revenues. The descriptions for inputs and outputs are as follows, and the descriptive statistics and the results of correlation test for the explanatory variables are reported in Table 1 and 2, respectively.

Input factors:
(1) Number of employees (persons): labor is the basic factor in production for every industry. We use the total number of employees to represent the factor of labor.
(2) Total deposits (NT$ million): commercial bank characterizes the financial intermediary, which receives deposits and extends credit to profit. Therefore, we define deposits as an input factor for banks.
(3) Fixed assets (NT$ million): the fixed assets contain land, structures, equipment, etc., which are used in bank operations.
(4) Number of operating expenses (NT$ million): operating expenses refer to the total expenses excluding salary expense.

Output factors:
(1) Number of loans (NT$ million): refers to the total amount of loans which are the source of bank revenue.
(2) Number of investment (NT$ million): refers to the total value of stocks and bonds held by the banks as investment.
(3) Non-interest revenue (NT$ million): the indicator is measured as the total amount of operational income excluding interest revenue.

TABLE 1. DESCRIPTIVE STATISTICS FOR BANKS

	Mean	Std. Deviation	Minimum	Maximum
Employee	7,104,869	5,068,822	14,794,897	1,104,086
Deposit (Million NT$)	4,316	2,308	8,077	1,013
Fixed asset (Million NT$)	117,565	91,407	318,159	21,467
Operating expense (Million NT$)	88,565	63,889	280,082	15,601
Loans (Million NT$)	5,562,583	3,745,356	12,096,800	652,320
Investment (Million NT$)	1,286,317	1,610,543	4,691,259	138,636
Non-interest revenue (Million NT$)	66,545	62,329	263,866	7,784
Risk value	2,946,266	3,095,858	11,105,647	150,485
Degree of internationalization (Million NT$)	703,731	548,845	1,788,033	143,954
Proportion of foreign ownership (%)	22.2	16.7	55.1	0.9
Proportion of government's ownership (%)	10.8	14.5	47.8	0.0
Length of time of bank's operating (Year)	33.4	18.5	62.0	16.0
Loan-to-Deposit Ratio (%)	78.9	6.3	90.4	65.9
Size of bank	15.9	0.9	17.3	14.7
Economic growth rate (%)	2.7	0.0	2.7	2.7
Growth rate of the money supply (%)	5.5	0.0	5.5	5.5

TABLE 2. RESULT OF CORRELATION TEST FOR THE EXPLANATORY VARIABLES

	Risk value	Degree of internation-alization	Proportion of foreign ownership	Proportion of govern-ment's ownership	Length of time of bank's operating	Loan-to-Deposit Ratio	Size of bank
Risk value	-						
Degree of international-ization	0.183	-					
Proportion of foreign ownership	-0.166	-0.004	-				
Proportion of govern-ment's ownership	0.117	0.429	-0.329	-			
Length of time of bank's operating	0.560	0.516	-0.419	0.337	-		
Loan-to-Deposit Ratio	-0.089	0.057	-0.035	0.272	-0.024	-	
Size of bank	0.202	0.825	0.145	0.143	0.433	-0.329	-

IV. *Empirical Results*

This study uses the software of DEA-SOLVER Pro 5 to evaluate the efficiencies in the first and third stages. Table 3 shows the results of input slacks evaluated from the first stage. On average, the slack of deposit is 2.05 million NT dollars. No.6 has the highest value at 8.6 million NT dollars. No. 1 and 12 do not have any slack on their deposits. The average of employee slack is 1.66 thousand persons. No. 7 has the greatest value of slack as 3.9 thousand persons. No. 13 has a zero slack value which means the utilization of employees is efficient. The slack value of fixed asset is 39.7 thousand NT dollars on the average. The highest value of

TABLE 3.   RESULTS OF BANKS' INPUT SLACKS

DMU(No.)	Deposit (million $)	Employee (thousand person)	Fixed asset (thousand $)	Expense (thousand $)
1	0.0	0.9	45.4	44.4
2	3.2	1.2	24.2	17.9
3	2.5	1.6	73.0	98.5
4	3.4	2.2	18.2	28.6
5	2.6	1.5	34.2	35.5
6	8.6	3.4	94.6	58.8
7	2.0	3.9	107.5	66.0
8	1.7	1.5	22.6	16.9
9	0.9	1.1	25.6	16.0
10	1.1	2.5	46.8	27.8
11	0.2	0.2	9.5	2.8
12	1.4	1.4	9.2	20.0
13	0.0	0.0	21.0	6.6
14	2.3	1.7	47.2	30.8
15	0.5	2.0	54.8	42.4
16	1.2	2.1	49.8	26.2
17	0.5	0.3	12.1	7.9
18	2.5	1.1	18.8	14.2
19	4.5	2.8	39.6	36.0

107.5 thousand NT dollars belongs to No. 7. Every bank has a slack on their fixed asset utilization. The average expense slack is 31.44 thousand NT dollars, and the highest is No. 3 at 98.5 thousand NT dollars. From the results of inputs slacks, we find most banks to have positive values on their slacks, which imply excess inputs utilization exists in most of them. Only a few practice efficient utilization on their deposit and employee, such as No. 13.

In the second stage, this study uses the SFA model to estimate the influence of external factors on efficiency through the software FRONT 4.1. The efficiencies used are independent variables and the external factors are dependent variables in the regression function. The estimated coefficients are presented in Table 4. Entire estimated coefficients characterize significance in statistics, except the item of constant. Three external factors have negative estimated coefficients, including Risk value, the Loan-to-deposit ratio, and Size; 6 factors have positive estimated coefficients, including Degree of internationalization, the Proportions of

TABLE 4.   RESULTS OF ESTIMATED COEFFICIENTS FOR EXTERNAL FACTORS

Variables	Coefficient	Standard deviation	t-value
Constant	-13.148	1.116	-11.861
Risk value	-0.785***	0.264	-2.973
Degree of internationalization	1.993***	0.714	2.800
Proportion of foreign ownership	5.569***	2.153	2.586
Proportion of government's ownership	0.328***	1.191	1.715
Length of time of bank's operating	0.875***	0.316	2.766
Loan-to-Deposit Ratio	-0.333***	1.530	-2.180
Size of bank	-8.100***	2.232	-3.686
Economic growth rate	10.703***	2.371	4.500
Growth rate of the money supply	0.851***	0.315	2.703
Log likelihood function		-67.619	

foreign ownership, and government's ownership, Length of operating time, Economic growth rate, and Growth rate of the money supply.

The results imply a high risk value or a high Loan-to-deposit ratio is disadvantageous to bank efficiency. In addition, enlarging a bank's size is also a negative influence on efficiency. On the contrary, a high degree of internationalization or increasing scale of foreign ownership benefits bank efficiency. Form the viewpoint of economic environment, a high economic growth rate and money supply increases are beneficial in enhancing bank efficiency. Banks with government ownership ratios also perform highly on their efficiency. In addition, a longer length of operating time brings more experience to banks and is a benefit to increased efficiency.

The third stage uses the estimated coefficients and error terms computed from the second stage to adjust the original inputs. We then use the adjusted and original inputs to evaluate bank efficiencies as shown in Table 5. In Table 5, the first column reveals the number code. The results of the efficiency score and rank calculated by using original inputs are reported in the part under the heading "first-stage" and the results of using adjusted inputs are reported under the heading "third-stage."

In the results of the first stage, 4 banks (No. 5, 6, 7, and 19) are assessed to be efficient and have a score greater than one. Since the efficiency scores are computed from super efficiency measurement, we identify No. 6 as performing the best amongst all efficient units and having the highest score as 4.903. No. 7 and 5 rank second and third, respectively. No. 9 has the lowest score of 0.336. In the results of the third stage, 5 banks have a score greater than one and are evaluated to be efficient, including No, 5, 6, 7, 11, and 13. The unit with highest score of 4.065 is No. 6. No. 5 and 13 rank in second and third, respectively. No. 16 is last.

In order to understand the difference between using original and adjusted inputs, we

TABLE 5.   RESULTS OF BANKS' EFFICIENCY IN THE FIRST AND THIRD STAGES

DMU(No.)	First-stage		Third-stage	
	Score	Rank	Score	Rank
1	0.924	8	0.895	7
2	0.783	10	0.828	9
3	0.724	12	0.670	10
4	0.748	11	0.565	15
5	1.324	3	1.674	2
6	4.903	1	4.065	1
7	1.544	2	1.002	5
8	0.368	18	0.613	13
9	0.336	19	0.854	8
10	0.507	15	0.537	16
11	0.969	6	1.046	4
12	0.558	14	0.898	6
13	0.948	7	1.089	3
14	0.607	13	0.591	14
15	0.446	16	0.402	18
16	0.837	9	0.346	19
17	0.982	5	0.477	17
18	0.402	17	0.639	11
19	1.114	4	0.631	12

compare the ranks of banks in Table 5. Ten banks made progress on their rankings from the first to the third stage, Including No. 1, 2, 3, 5, 8, 9, 11, 12, 13, and 18; 8 banks are regressive, including 4, 7, 10, 14, 15, 16, 17, and 19. No. 6 maintains the position of first. In the progressive units, 3 banks, No. 9, 12, and 18, make substantial progress (a difference of more than 5 rankings). That means the 3 units have better performance if they are evaluated purely on their operating metric. If the 3 units are evaluated with external factors included, they perform relatively lower. Three banks show significant regression, including No. 16, 17, and 19. That means the 3 units are identified as having relatively better performance when the external effects are considered into the efficiency evaluation. If we assess the 3 units purely from the aspect of internal operations, we find they perform with relatively lower efficiency compared to others. As a reference, the results evaluated with original three stage SBM model are listed in the Appendix (Table A1).

V.   *Conclusions*

This study applies the three stage Super-SBM model, which combines the approaches of Fried et al. (2002) and Tone (2002), to analyze the influence of bank internationalization and risk on efficiency. In addition to the use of the empirical model, the main differences between former works, such as Chiu and Chen (2009), also includes the effect of internationalization. The main results are summarized above.

Firstly, the results from the empirical evaluation show that increasing the degree of internationalization and foreign ownership can be advantageous in enhancing the efficiency of commercial banks. We use the density of foreign sales, assets, and subsidiaries to measure the degree of internationalization. That implies foreign direct investment to be a beneficial strategy in bank performance. Taiwan is characterized the limitations by the island economics and is short in great market scale as to develop financial industries. Expanding to overseas market has gradually become an important direction for development in the banking sector. In addition to foreign direct investment, the results reveal increasing foreign ownership to also be beneficial in enhancing performance. That implies increasing foreign shareholding to be positive for local banks in Taiwan. Besides improving the degree of financial reporting transparency, bankers can learn managerial knowledge and techniques from spillover effects (Sinani and Meyer, 2004). Reputation from foreign investors may boost business for invested banks.

Secondly, we find that banks with a higher risk value also have lower efficiency scores, which is consistent with the finding of Pastor (1999, 2002). Some previous studies, such as Chiu and Chen (2009) assumed risk as an input factor that is also theoretically defined as a negative relationship between risk and efficiency. We evaluate high loan-to-deposit ratio and bigger size to have a negative impact on bank efficiency. Although the high loan-to-deposit ratio might bring profits to banks, nevertheless, it also implies a high risk on bank liquidity. Large size banks need to spend most of their expenses in operating costs, which create a decline in efficiency.

Thirdly, we also evidence that operating experiences and macroeconomic booms are positively related to bank efficiency. These results are consistent with most prior studies.

Finally, in the comparison between original and adjusted input models, we find 3 banks to show significant progress in the adjusted model. This implies that the banks have a fine

management capacity. However, their efficiencies are easily affected by external factors and may decline as a result. The other 3 banks performed highly, when effects of external factors are considered into the efficiency evaluation. This means that these external factors are the main sources of several banks' efficiency. If the external factors are excluded from the evaluation model, they would become inefficient units.

In summary, we evidence the influence of internationalization to be positive on bank efficiency. Because of the trend of financial liberalization, many foreign banks set up branches in Taiwan frequently. Local banks have to confront with more competitors in the tiny local market. Through the strategies of internationalization, such as foreign direct investment and increasing foreign shareholding, Taiwanese banks are able to exploit new markets overseas and acquire advantage in competition. The results also imply that customers' confidence is positive to commercial banks' performance. Theoretically, a restriction for the degree of loan-to-deposit ratio would limit to profiting for a commercial banks. Nevertheless, a high liquidity risk index might cause customers to reduce confidence in a bank's debt-paying ability, especially in the unstable global financial environment. This study suggests that the size of a bank should not be large, even though a large size could obtain benefits from economies of scale. When systematic risk happens, bagger banks would suffer relatively a greater loss. In addition, economies of scale are not effective for large banks under a narrow local market in Taiwan.

APPENDIX

Table A1 shows the results computed by the original three stage SBM model.

TABLE A1.   RESULTS EVALUATED BY THREE STAGE SBM MODEL

DMU(No.)	First-stage		Third-stage	
	Score	Rank	Score	Rank
1	0.844	8	0.845	8
2	0.783	10	0.784	10
3	0.722	12	0.724	12
4	0.724	11	0.727	11
5	0.933	3	0.933	3
6	0.912	4	0.912	4
7	0.944	2	0.942	2
8	0.368	18	0.370	18
9	0.336	19	0.327	19
10	0.507	15	0.507	15
11	0.884	7	0.884	7
12	0.550	14	0.551	14
13	0.905	5	0.906	5
14	0.607	13	0.612	13
15	0.435	16	0.433	16
16	0.807	9	0.809	9
17	0.885	6	0.884	6
18	0.402	17	0.405	17
19	0.956	1	0.956	1

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