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# INCORPORATING THE CREDIT RANKING MEASURE TO EVALUATE THE OPERATING EFFICIENCY OF FINANCIAL HOLDING COMPANIES IN TAIWAN

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## ABSTRACT

*One hears that the credit ranking score has increased technical efficiency in financial holding companies, when a data envelopment analysis (DEA) is employed. Our empirical results show that the credit ranking scores will obviously affect the estimated results of efficiency measurement in Taiwan's financial holding companies. Additionally, the effects on technical inefficiency could be attributed to the under-utilization of inputs, rather than the inappropriate returns of scale, or the selection of incorrect input combinations. It shows that the pure technical efficiency change index number and the scale efficiency change index number are still improvement. Especially, when credit ranking score is incorporated as an important factor for efficiency measure, the credit ranking measure can be viewed as a discretionary variable for inputs.*

**Keywords:** Technical efficiency, Super efficiency, Data envelopment analysis, Malmquist productivity index, Credit ranking measure.

## INTRODUCTION

The financial holding companies in Taiwan are belonged to the capital intensity industry. The requirement of huge capital input and a great amount of high quality and professional human resource is the major characteristics in the financial holding companies. Owing to the fluctuations in the financial environment, the market uncertainty is increased. The issues of market risk are emerging when we evaluate the operating efficiency in the financial holding companies (Kliger and

Sarig, 2000). The Basel agreement can illustrate the importance of the risk control. The credit ranking systems not only can effectively disclosure the probability of the debt repayment, but also present the protection which is provided by the decision-making unit (DMU). The credit ranking mechanism can further present as a useful reference indicator to investors and legalistic institutions (Garner, 1999). Thus, incorporating the credit ranking mechanism into the performance evaluating system of financial holding companies can improve the effectiveness of the evaluation results because the invisible external and internal environment factors should be included in the evaluating system to fit the actual situations of the financial holding companies (Larsen, 2006).

The financial holding companies will emphasize the loans credit and the refund capability, when the credit ranking mechanism is viewed as the important inputs (Allen and Jatoani, 2000). Especially, the deregulation in banking industry may put an effort to enlarge the business scales; in the meantime, the repayment capability and credit ranking recognition may be neglected. We then employ data envelopment analysis method to evaluate the financial holding company performance to tailor the multi-input and multi-output industry setting.

The reminders of this paper are organized as follows. Section 2 presents a review of the relevant literature. Section 3 describes the study model and data. Section 4 presents the empirical results. The paper then provides the concluding remarks in section 6.

## LITERATURE REVIEW

Referring to the literature on efficiency of banks and financial holding companies, Allen and Rai (1996), Berger and Humphrey (1997), Berger and Mester (1997), Pastor *et al.* (1997), Berger (1999), Berger *et al.* (2000), and Dietsch and Lozano-Vivas (2000), conducted the state of the art in banks efficiency analysis, which highlighted the rationales to explain the differences in bank efficiency and pointed out some directions for future research. Amongst them, Berger's researches were regarded as pivotal works in this field. The authors' evidence of 'private good/public bad' contrasts sharply with the recent paper on the analysis of ownership and bank efficiency in German financial holding companies by Altunbas *et al.* (2001), which employed a translog cost function to find little evidence that private owned banks are more efficient than their mutual and public-sector counterparts. The research trends can withdraw back to the works of Aigner *et al.* (1977), and Meeusen and van den Broeck (1977), etc.

Since data envelopment analysis (DEA) allows researchers to avoid specification of an ad hoc functional form or error structure, many researchers have employed this approach to estimate cost efficiency, allocative efficiency and technical efficiency of banks and/or financial holding

companies, for instance, Aly *et al.* (1990), Yue (1992), Grabowski *et al.* (1993), Favero and Papi (1995), Zaim (1995), Resti (1997), Schaffnit *et al.* (1997), Bhattacharyya *et al.* (1997), and Fukuyama *et al.* (1999) have applied DEA to different fields. Favero and Papi (1995) measured allocative and technical efficiency by using an intermediation and asset approach, which employs a regression analysis on a bank-specific efficiency measurement to investigate the determinants of efficiency in financial holding companies. Schaffnit *et al.* (1997) presented the best empirical analysis to evaluate allocative efficiency of bank branches based on a DEA assurance region (DEA-AR) model which containing output multiplier constraints, with standard transaction and maintenance times. The paper uses the DEA approach to characterize the cost efficiency of the mixed financial holding companies and the results of allocative and technical efficiency during the period of the Asian financial crisis.

Sherman and Gold (1985) measured and evaluated the operating efficiency on bank branches that require the analytic techniques which can provide more insights than accounting ratio analysis, and DEA, a mathematical programming technique, can provide useful insights in that situation. Oral and Yolalan (1990) measured the operating efficiencies of 20 bank branches from a major Turkish commercial financial holding company which offering relatively homogeneous products in the multi-market business environment based on the concepts and principles of DEA. Yeh (1996) combined the concept of DEA and financial ratios to help bank regulators in Taiwan to evaluate the efficiency of banks. Chen and Yeh (1998) employed DEA to verify the private-owned banks enjoyed higher technical efficiency than the public-owned ones in Taiwan. Golany and Storbeck (1999) performed a multi-period DEA to determine the efficiencies of selected branches of a large US financial holding company (called big financial holding company in this paper) over six consecutive quarters. Dekker and Thierry (2001) presented a DEA model that changed the standard assumption of DEA, that is, replacing the concavity of the production frontier with the quasi-concavity which can be regarded as the less restrictive microeconomic assumption. Emel *et al.* (2003) upgraded the quantitative analysis used in the financial performance model of state-of-the-art credit scoring methodologies. Paradi and Schaffnit (2004) evaluated the performance of the commercial branches of a large Canadian financial holding company by using DEA, in the paper, output oriented models were used to reflect the financial holding company's recent growth in certain areas. Halkos and Salamouris (2004) showed that DEA can be applied to evaluate organization's performance and it can be regarded as an alternative or complement tool of ratio analysis. Recently, Grigorian and Manole (2006) estimated the efficiency indicators of commercial banks by applying DEA and obtained a initial knowledge of the optimal architecture of the banking system. Cook and Zhu (2006) developed a general framework for modeling and treating qualitative data in DEA and provide a unified structure for embedding rank order data into the DEA framework. Ataullah and Le (2006) proposed and tested the hypotheses regarding the possibility of

relationships between three elements of the economic reforms (ERs): namely, fiscal reforms, financial reforms and private investment liberalization and bank efficiency in developing countries. Bank efficiency is measured by using DEA. Santos (2006) presented the updates on credit rating agency reform legislation in the US. Crittenden (2006) reported the proxy variable of a bill designed to promote competition in the credit rating industry by the US Senate. Hume (2006) provided updates on the Credit Rating Agency Reform Act of 2006 in the US. According to the reports, the Senate passed the bill unanimously after Republican and Democratic leaders of the Senate Financial Holding Company Committee added an amendment. Cornwell (2006) presented information regarding the performance of credit scores, evaluated by analysts of Credit Sights Inc. in the US. Those analysts revealed that credit score inflation and the increases of the debt levels are projected to arise due to the debt repayment behavior. Kliger and Sarig (2000) and Larsen (2006) reported the credit rating agency; said Merrill's Dublin-based financial holding company was planning to expand in areas such as interest rate derivatives, corporate lending, and mortgage origination and loan trading.

## Study Model

In DEA, the concept of the efficiency came from Farell (1957) productive efficiency. Hines (1982) extended and developed a mathematical framework based on the work of Fare *et al.* (1985), and our study deals with three kinds of efficiency**:** technical efficiency, scale efficiency and pure technical efficiency. In this paper, we assume a convex reference technology and strong disposability of inputs and outputs. The disposability assumption implies that an increase in inputs never results in a decrease in outputs, and it is possible that outputs may decrease with the same amount of inputs. In the DEA model, the piecewise linear frontiers are constructed by employing mathematical programming techniques, first described by Charnes *et al.* (1978) (CCR model) and later extended by Banker Charnes and Cooper (1984) (BCC model). The CCR and BCC models do not relate to price information and only concern input and output quantities. If the input price is known in advance, the technical efficiency (TE) of each financial holding company may be calculated by solving the corresponding linear programming problem. The methodology of calculating DEA scores can be formulated as a fractional linear programming problem. $Y_{jn}$ denotes the $n$-th output of the $j$-th DMU and $X_{jm}$ denotes the $m$-th input of the $j$-th DMU. If a DMU uses $M$ inputs to produce $N$ outputs, the score of $j$-th DMU, $E_j$, is the solution derived from the following linear programming problem (CCR model):

$$\underset{U_n V_m}{Max} \quad E_j = \frac{\sum_{n=1}^{N} U_n Y_{jn}}{\sum_{m=1}^{M} V_m Y_{jm}}, m = 1,\ldots,M; n = 1,\ldots,N$$

$$s.t. \quad \frac{\sum_{n=1}^{N} U_n Y_{rn}}{\sum_{m=1}^{M} V_m X_{rm}} \leq 1,$$

$$U_n, V_m \geq 0$$

In the case of financial holding companies, the efficiency of a particular financial holding company is calculated by finding the ratio of a weighted sum of outputs and a weighted sum of inputs and can be presented as:

$$\underset{U_n V_m}{Max} E_j = \sum_{n=1}^{N} U_n Y_{jn}$$

$$s.t. \text{ (i)} \sum_{n=1}^{N} U_n Y_m - \sum_{m=1}^{M} V_m X_{rm} \leq 0$$

and

$$\text{(ii)} \quad \sum_{m=1}^{M} V_m X_{jm} = 1,$$

where $U_n$ and $V_m$ represent the weights associated with each output and input. Given that the number of constraint equations is larger than that of variables in the primal linear programming problem, we can rewrite the above problem as the following dual problem:

$$Min \quad TE = \theta_0 - \varepsilon\left(\sum_{m=1}^{M} S_{jm}^{-} + \sum_{n=1}^{N} S_{jn}^{+}\right) \qquad (1)$$

$$s.t. \quad \sum_{r=1}^{R} \lambda_r X_{rm} - \theta X_{jm} + S_{jm}^{-} = 0,$$

$$\sum_{r=1}^{R} \lambda_r Y_{rn} - S_{jn}^{+} = Y_{jn},$$

$$\lambda_r \geq 0, \; S_{jm}^{-} \geq 0, S_{jn}^{+} \geq 0, \qquad (2)$$

where $\theta_0$ represents the maximum proportion of input levels which can be employed to procure current output levels for the unit $r_0$. $\varepsilon$ is a non-Archimedean quantity. $S_{jm}^{-}$ and $S_{jn}^{+}$ are the input slacks and the output slacks, respectively. Note that for the *j*-th DMU the output slacks will be equal to zero only if $\sum_{r=1}^{R}\lambda_r Y_{rn} - Y_{jn} = 0$, while the input slacks will be equal to zero only if $\theta X_{jm} - \sum_{r=1}^{R}\lambda_r X_{rm} = 0$ for the given optimal values of $\theta$ and $\lambda$.

The pure technical efficiency can be derived by the condition of variable return on scale. We can add $\sum_{r=1}^{R}\lambda_r = 1$ to the above model to be the famous BCC model, which provides valuable information about the cost-benefit evaluation. We can calculate the pure technical efficiency score from the BCC model, and then the scale efficiency score can be derived from the technical efficiency and pure technical efficiency scores in that the technical efficiency score is equal to the multiplication of pure technical efficiency and scale efficiency scores (Fare *et al.*, 1985). Note that here allocative efficiency has not been analysed due to limited input price data.

We also employed the Malmquist total factor productivity (TFP) index to measure the effect of productivity change on the panel data, a method first developed by Caves *et al.* (1982a). Next, an output-based Malmquist productivity change index was developed by Fare *et al.* (1994), and then, Fare *et al.* (1994) applied that index to the cases of industrial countries. In their model, an index $M_0^1$, representing the productivity of the production point $(X^1,Y^1)$ relative to the production point $(X^0,Y^0)$, is shown as:

$$M_0{}^1(Y^1, X^1, Y^0, X^0) = \left[\frac{d^0(X^1,Y^1)}{d^0(x^0,Y^0)} \times \frac{d^1(X^1,Y^1)}{d^1(X,Y^0)}\right]^{1/2} \qquad (3)$$

The above index is, in fact, the geometric mean of two output-based Malmquist TFP indices. Next, a magnitude of the index which is greater than unity will represent positive TFP growth from the period $t_0$ to the period $t_1$. In addition, it assumes that the distance functions are translog form with identical second-order terms and the technology is a piecewise linear which allows for inefficiencies. According to the concept of Fare *et al.* (1992), the above index can be divided into two components, i.e., technical change measure and technical efficiency change measure. The above equation is rewritten as:

$$M_0{}^1(Y^1, X^1, Y^0, X^0) = \frac{d^1(X^1,Y^1)}{d^0(X^0,Y^0)} \times \left[\frac{d^0(X^1,Y^1)}{d^1(x^1,Y^1} \times \frac{d^0(X^0,Y^0)}{d^1(X^0,Y^0)}\right]^{1/2} \qquad (4)$$

The technical change measure is the ratio inside the bracket which measures the shift in frontier technology (SIFT) between the periods $t_0$ and $t_1$. The technical efficiency change measure is the quotient outside the brackets which represents the catching-up in efficiency (CIE). Note that SIFT is larger than one, indicating that the production technology is progressive within two periods and the technology level is depressive if the value of SIFT is smaller than unity. If CIE is larger than one means the efficiency improvement has occurred within the two periods, but if CIE were smaller than one, it indicates that the efficiency of financial holding company had become worse than before.

The intermediation approach views banks and/or financial holding companies as financial intermediaries where deposits are treated as inputs, since a financial holding company's main business is to borrow funds from deposits to lend to others (Favero and Papi, 1995; Berger and Humphrey, 1997). It emphasizes the financial intermediation function of the financial holding company in this paper, which is consistent with the competitive environment of financial holding companies in Taiwan. This can also effectively benefit financial holding company operations and improve their efficiencies. In accordance with this approach, we specify three types of financial holding company output, namely, the portfolio investment (mainly government securities and shares, and the securities of public and private enterprises), interest revenue (mainly the revenues from business and personal loans) and non-interest revenue (mainly the revenues from transaction fees, on securities investment and other business revenues). The first two types of output constitute the main activities of financial holding companies and the last represents an extra source of revenue for financial holding companies.

The input is measured by the operating resources which are entailed by the above output. Three input factors are selected in this paper as: number of staff employed, financial holding company fixed assets and operating expenses. These input factors represent the measures of financial holding company's labor, capital and other materials.

Next, the relationships between inputs and outputs are determined. The DEA model requires definitions of inputs and outputs so that when inputs are added, outputs will increase. A correlation analysis is employed to test for isotonicity (i.e., the positive direction of the relationship between inputs and outputs). According to the results of the inter-correlation analysis, it is clear that the correlation coefficients between our chosen outputs and inputs are all positive. Please note that we have also utilized sensitivity analysis to determine the appropriate inputs/outputs in this approach.

From the results of the sensitivity analysis, the inputs for the number of branch financial holding companies, interest expense and deposits are excluded in our DEA model.

Thus, we specify three types of financial holding company output, namely, portfolio investment, interest revenue and non-interest revenue. Three types of input, i.e., financial holding company staff, fixed assets and operating expense are also included.

The Department of Finance, Central Bank and the ROC Commission on National Corporations of the Ministry of Economic Affairs provide a rich source of data on the operations of all of Taiwan's financial holding companies. We have collected the requisite data of the 14 financial holding companies from 2006 to 2008, which represent more than 90% market share of the banking industry in Taiwan. Since the time span of the data does not include the financial tsunami period of 2006-2008, we can effectively avoid the one-time shock effect in the efficiency evaluation.

## Empirical Results

Based on Table 1, it can be observed that the calculated mean of technical efficiency between 2006 and 2008 was 0.917. Relative to their production frontier, financial holding companies operated efficiently with actual productions at 8.87% above the minimum cost levels. As to the technical efficiency in each year, we find that it was 0.878 in 2006, with a slight uplift to 0.938 in 2007and 0.874 in 2008. It is clear that average technical efficiency decreased in 2008 relative to 2007, since the effect of the US subprime mortgage event might hit Taiwan's financial holding companies. Based on our efficiency estimated, we also find that the mean of pure technical efficiency score of 0.925, during the year 2007, was higher than that during the year 2006, at 0.910. The technical efficiency score (TE) is equal to the multiplication of the pure technical efficiency (PTE) and the scale efficiency (SE) scores, and the relative magnitude of these scores provides the evidence of the source of the inefficiencies. The similar results can be found when PTE and SE scores are analyzed.

We further find that the mean of pure technical efficiency scores of financial holding companies (0.947) were lower than that of the scale efficiency score (0.967) during the period 2006 to 2008. This suggests that pure technical inefficiency is more significant than that of scale inefficiency to measure the inefficiency within all inefficient financial holding companies. Thus, given input quantities, the effects on technical inefficiency could be attributed to the under-utilization of inputs, rather than the inappropriate returns of scale, or the selection of incorrect input combinations.

Owing to the financial holding companies have the propriety of variable returns to scale, pure technical efficiency (PTE) is recognized as the target of the efficiency measurement. We further employ the super efficiency, proposed by Andersen and Petersen (1993), to discriminate the

**Table-1.** The Empirical Results of DEA Efficiency During 2006-2008

| DMU | FHC | TE | PTE | SE | NOR | Ranking |
|---|---|---|---|---|---|---|
| 1 | Hua-nan | 0.852 | 0.864 | 0.987 | 0 | 11 |
| 2 | Fu-bong | 1.000 | 1.000 | 0.911 | 0 | 12 |
| 3 | Kai-fa | 1.000 | 1.000 | 1.000 | 0 | 1 |
| 4 | Cathay | 1.000 | 1.000 | 1.000 | 4 | 1 |
| 5 | China-trust | 1.000 | 1.000 | 1.000 | 0 | 1 |
| 6 | SinoPac(Jian-hua) | 0.874 | 0.942 | 0.928 | 0 | 10 |
| 7 | E-sun | 0.759 | 0.878 | 0.865 | 4 | 14 |
| 8 | YuanTa(Fu-Hua) | 0.889 | 0.892 | 0.997 | 0 | 8 |
| 9 | Tai-shin | 0.886 | 0.935 | 0.948 | 0 | 9 |
| 10 | Shin-guang | 1.000 | 1.000 | 1.000 | 0 | 1 |
| 11 | Mega(Zhao-feng) | 1.000 | 1.000 | 1.000 | 4 | 1 |
| 12 | First | 1.000 | 1.000 | 1.000 | 0 | 1 |
| 13 | Ri-cheng | 0.773 | 0.848 | 0.912 | 0 | 13 |
| 14 | Guo-piao | 1.000 | 1.000 | 1.000 | 2 | 1 |
| Average | | 0.917 | 0.947 | 0.967 | | |

Source: our study.

**Notes:** 1. We employ the average data between 2006and 2008to run the DEA model, that is, there are only 14 DMUs in the DEA operation.

2. FHC = financial holding company, TE = the technical efficiency; PTE = the pure technical efficiency; SE = the scale efficiency; NOR = Number of reference set.

efficient DMUs, i.e., the DMUs that pure technical efficiency is equal to one. We first exclude the efficient DMUs in our DEA model, and then calculate the efficiency of the omit DMUs based on the other inefficient DMUs.

Note that the short-term evolution of technical efficiency for a financial holding company is also a critical factor in efficiency analysis and this issue has been shown by some empirical evidences using longitudinal analysis. The timespan of available data is from 2006 to 2008 because new financial holding companies entered the banking market after 2006. The results of super efficiency during the period 2006 to 2008 are presented as shown in Table 2. The average super efficiencies ranging from 2006 to 2008 are 1.157, 1.510 and 1.488, respectively. Furthermore, the average total factor productivity (Malmquist) index of the whole financial holding companies (TFPC) is equal to 1.272, representing a slightly increase in the productivity (as shown in Table 3). Based on the results of the Malmquist indexes, it can be found that the value of technical change index (TC) is equal to 1.125 and the value of technical efficiency change index (TEC) is equal to 1.131. This result implies that most of the growth in financial holding company productivity in the period 2006 to 2008 is resulted from technical progress and computerisation. According to the above results, it

can be concluded that Taiwan's financial market is highly competitive and the production technology of financial holding company has obviously grown. On the other hand, the improvement index for technical efficiency is equal to 1.131, showing the technology in inefficient financial holding companies has less necessarily improved. We can conclude that the productivity growth in financial holding company has probably occurred and can be attributed to improvements in production technology, rather than to cost savings in management. In addition, the value of pure technical efficiency change index (PTEC) is equal to 1.081 and the value of scale efficiency change index (SEC) is equal to 1.046. These indices indicate that the value of pure technical efficiency change index and the value of scale efficiency change index are still need to be improved during the period 2006 to 2008.Taiwanese credit ranking in Taiwan can evaluate the capability of the debt repayment and represent the overall ability to repay the debt. The higher the magnitude of the ranking is, the better the debt refund capability is. The credit ranking score can be derived as shown in Table 4.

**Table-2.** The Results of Super Efficiency During 2006-2008

| **DMU** | **2006** | | | **2007** | | | **2008** | | |
|---|---|---|---|---|---|---|---|---|---|
| FHC | TE | SupE | Ranking | TE | SupE | Ranking | TE | Super | Ranking |
| Hua nan | 0.880 | 0.880 | 10 | 0.877 | 0.877 | 9 | 0.838 | 0.838 | 11 |
| Fu-bong | 0.538 | 0.538 | 13 | 0.787 | 0.787 | 12 | 0.918 | 0.910 | 9 |
| Kai-fa | 1.000 | 1.415 | 4 | 1.000 | 1.564 | 5 | 1.000 | 1.356 | 4 |
| Cathay | 1.000 | 3.075 | 1 | 1.000 | 3.715 | 1 | 1.000 | 3.257 | 1 |
| China-trust | 0.805 | 1.034 | 8 | 1.000 | 1.117 | 7 | 1.000 | 1.356 | 8 |
| Sino Pac | 1.000 | 1.008 | 9 | 0.998 | 0.998 | 8 | 0.889 | 0.889 | 10 |
| E-sun | 0.591 | 0.591 | 12 | 0.793 | 0.793 | 11 | 0.815 | 0.815 | 12 |
| Yuan | 1.000 | 1.233 | 6 | 1.000 | 1.245 | 6 | 0.996 | 0.996 | 7 |
| Tai-shin | 0.479 | 0.479 | 14 | 0.871 | 0.871 | 10 | 0.945 | 0.945 | 8 |
| Shin-guang | 1.000 | 3.014 | 2 | 1.000 | 2.945 | 2 | 1.000 | 2.875 | 3 |
| Mega(Zhao- | 1.000 | 2.154 | 3 | 1.000 | 2.988 | 3 | 1.000 | 2.914 | 2 |
| First | 1.000 | 1.053 | 7 | 1.000 | 1.254 | 5 | 1.000 | 1.103 | 6 |
| Ri-cheng | 0.814 | 0.814 | 11 | 0.705 | 0.705 | 13 | 0.742 | 0.742 | 13 |
| Guo-piao | 1.000 | 1.402 | 5 | 1.000 | 2.082 | 4 | 1.000 | 2.095 | 4 |
| Average | 0.921 | 1.496 | | 0.961 | 1.129 | | 0.930 | 1.106 | |

Source: our study.

**Notes:** 1. We employ the yearly data with 2006, 2007 and 2008, respectively to run the DEA model, that is, there are also 14 DMUs in each DEA operation.

2. FHC = financial holding company; DMU = decision-making unit.

3. TE = the technical efficiency

4. SupE = the super efficiency

In addition, we incorporate the Taiwanese credit ranking into our evaluating system to be the input item. When the credit ranking is included, we can rerun the DEA model to calculate the TE, PTE and SE and their results can be presented as shown in Table 5. It can be found that the average technical efficiency is equal to 0.961, which is higher than that of the efficiency score, without Chinese credit ranking (i.e., 0.917) as shown in Table 5. We further find that financial holding company's average technical efficiency is higher when the corresponding Taiwanese credit ranking is higher. It can be seen

**Table-3.** Empirical Results of Productivity Changes in the DEA Model

| No | FHC | TEC | TC | PTEC | SEC | TFPC |
|---|---|---|---|---|---|---|
| 1 | Hua-nan | 0.963 | 0.968 | 0.965 | 0.998 | 0.932 |
| 2 | Fu-bong | 0.867 | 1.274 | 0.912 | 0.951 | 1.104 |
| 3 | Kai-fa | 0.780 | 1.515 | 0.815 | 0.968 | 1.195 |
| 4 | Cathay | 1.132 | 1.285 | 1.094 | 1.035 | 1.454 |
| 5 | China-trust | 1.133 | 0.905 | 1.045 | 1.084 | 1.025 |
| 6 | Sino Pac(Jian-hua) | 1.158 | 1.268 | 1.086 | 1.068 | 1.468 |
| 7 | E-sun | 1.007 | 1.036 | 1.045 | 0.964 | 1.044 |
| 8 | Yuan Ta(Fu-hua) | 0.961 | 0.934 | 0.997 | 0.964 | 0.898 |
| 9 | Tai-shin | 1.196 | 0.941 | 1.092 | 1.095 | 1.125 |
| 10 | Shin-guang | 1.157 | 0.945 | 1.179 | 0.982 | 1.093 |
| 11 | Mega(Zhao-feng) | 1.101 | 1.141 | 1.005 | 1.096 | 1.256 |
| 12 | First | 1.740 | 1.488 | 1.634 | 1.065 | 2.589 |
| 13 | Ri-cheng | 1.067 | 0.948 | 1.089 | 0.980 | 1.011 |
| 14 | Guo-piao | 2.426 | 1.480 | 1.098 | 2.210 | 3.590 |
| Average | | 1.131 | 1.125 | 1.081 | 1.046 | 1.272 |
| 2006-2007 | | 1.200 | 1.122 | 1.210 | 0.992 | 1.347 |
| 2007-2008 | | 1.048 | 1.201 | 0.952 | 1.101 | 1.259 |

Source: our study.

**Notes:** FHC = financial holding company;

TEC = the technical efficiency change index; TC = the technical change index;

PTEC = the pure technical efficiency change index; SEC = the scale efficiency change index;

TFPC = total factor productivity change (Malmquist) index (TFPC).

That Taiwanese credit ranking can be used as a controllable variable which can increase the corresponding technical efficiency. The similar situation can be founded when Chinese credit ranking is used as the output item in our DEA model. Additionally, bank operation is typically influenced by environmental factors beyond the control of DMUs. The Taiwanese credit ranking permits the evaluation of efficiencies in operation procedures remarked by the impact of these non-discretionary factors. Then, we analyze the effects of the non-discretionary of the efficiency

**Table-4.** Taiwanese Credit Ranking and Scores in Taiwan Bank and/or Financial Holding Companies

| Taiwanese credit ranking | Ranking distance | Credit ranking score |
|---|---|---|
| twAAA | 9 | 100 |
| twAA+ | 8 | 91 |
| twAA | 7 | 83 |
| twAA- | 6 | 76 |
| twA+ | 5 | 70 |
| twA | 4 | 65 |
| twA- | 3 | 61 |
| twBBB+ | 2 | 58 |
| twBBB | 1 | 56 |
| twBBB- | 0 | 55 |
| twBB+ | -1 | 54 |
| twBB | -2 | 52 |
| twBB- | -3 | 49 |
| twB+ | -4 | 45 |
| twB | -5 | 40 |
| twB- | -6 | 34 |
| twCCC | -7 | 27 |
| twCC | -8 | 19 |
| twR | -9 | 10 |
| twD | -10 | 0 |

Source: our study.

**Notes:** The threshold point is the twBBB-, the upper is the invested institution and the ranking distance is positive.

measurement of the credit ranking as the non-discretionary inputs in the DEA model, which was proposed by Ruggiero (1998), and Syrjänen (2004). In other words, the credit ranking measurement has been considered as the non-discretionary factor (Table 5) which was based on the concept proposed by Ruggiero (1998) and Syrjänen (2004). However, non-discretionary factors should be treated as normal discretionary factors, which may lead to a biased view of efficiency.

Then we start to test the difference between two population means and conduct Wilcoxon signed-rank test to verify whether the credit ranking score can influence the result of the efficiency measurement. The null hypothesis states that there is no significant difference in the technical efficiency scores when incorporating the credit ranking as an incremental input in the DEA model. The alternative hypothesis is

**Table-5.** The Difference of the Efficiency Measurement Whether Inclusion of the Credit Ranking as the Input Items in the DEA Model (2006-2008)

| | | credit rank is excluded | | | credit rank is included | | |
|---|---|---|---|---|---|---|---|
| No | FHC | TE | PTE | SE | TE | PTE | SE |
| 1 | Hua-nan | 0.826 | 0.000 | 0.987 | 0.952 | 0.959 | 0.993 |
| 2 | Fu-bong | 0.979 | 1.000 | 0.979 | 0.904 | 0.964 | 0.938 |
| 3 | Kai-fa | 0.929 | 1.000 | 0.929 | 1.000 | 1.000 | 1.000 |
| 4 | Cathay | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 5 | China-trust | 0.916 | 0.994 | 0.922 | 1.000 | 1.000 | 1.000 |
| 6 | Sino pac (Jian-hua) | 0.948 | 0.957 | 0.991 | 0.904 | 0.958 | 0.944 |
| 7 | E-sun | 1.000 | 1.000 | 1.000 | 0.921 | 0.965 | 0.954 |
| 8 | Yuan Ta(Fu-hua) | 0.962 | 1.000 | 0.962 | 1.000 | 1.000 | 1.000 |
| 9 | Tai-shin | 0.821 | 0.828 | 0.992 | 0.931 | 0.968 | 0.962 |
| 10 | Shin-guang | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 11 | Mega (Zhao-feng) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 12 | First | 0.869 | 0.880 | 0.988 | 1.000 | 1.000 | 1.000 |
| 13 | Ri-cheng | 0.819 | 0.945 | 0.867 | 0.865 | 0.922 | 0.938 |
| 14 | Guo-piao | 1.000 | 1.000 | 0.470 | 1.000 | 1.000 | 1.000 |
| Average | | 0.886 | 0.960 | 0.927 | 0.961 | 0.981 | 0.980 |

**Notes:** 1. We employ the yearly data with 2006, 2007 and 2008, respectively to run the DEA model, that is, there are also 14 DMUs in each DEA operation. Finally, we average them to obtain the above magnitude.

2. TE = the technical efficiency; PTE = the pure technical efficiency; SE = the scale efficiency; FHC = financial holding company.

That financial holding companies in the period 2006 to 2008 have different technical efficiency scores when credit ranking was incorporated as an incremental input. Wilcoxon signed-rank test is used to test the inefficiency differences between the two different efficiency scores. The settings of Wilcoxon tests can be found in the notes of Table 6.

According to Table 6, the null hypothesis is rejected when the credit ranking was incorporated as incremental inputs. (P-values are all smaller than 0.05). We can conclude that the credit ranking measures will obviously influence the results of efficiency measurement (the Z-statistics is 2.413, 2.015, and 2.415, respectively). This evidence suggests that the credit ranking should be incorporated as incremental inputs for financial holding companies in Taiwan.

**Table-6.** Summary of Test Results on Efficiency Difference

| Condition | Criterion | 2006 data | 2007 data | 2008 data |
|---|---|---|---|---|
| Credit rank | \|Z\| Statistics | 2.413 | 2.015 | 2.415 |
| As inputs | P-value | 0.038** | 0.042** | 0.015** |
| Credit rank | \|Z\| Statistics | 2.315 | 0.148 | 1.841 |
| As outputs | P-value | 0.021** | 0.842 | 0.062 |

**Notes:** Wlicoxon signed-rank test is a rank test of non-parameter test, which consider both the sign of the difference value of paired sample and the magnitude of the difference value of paired sample. The testing procedure is as follows**:**

1. Compute the difference of paired observations $D_j = (X_1 - X_2)$ and then omit the indifferences$(D_j = 0)$ and compute the absolute value.
2. Ranking the absolute of $|D_j|$ from the smallest to the largest and rank them. We employ the mean of two continuous rank to rank it if there are two same$|D_j|$ in it. We have to put the positive or negative sign when we offer the ranking.
3. Add the rank of all positive signs to obtain $T^+$ and add the rank of all negative signs to obtain $T^-$. Let T = min$\{T^+, T^-\}$.
4. Thus, the statistics of Wilcoxon sign test is:

$$Z = \frac{T - n(n+1)/4}{\sqrt{n(n+1)(2n+1)/24}}$$

Given that the Z statistics is close to the standardized normal distribution, we can conduct the regular test procedure.

## Discussions and Concluding Remarks

The empirical results indicate that for financial holding companies in Taiwan, the pure technical inefficiency has greater significance than scale inefficiency. Thus, the technical inefficiency could be resulted from under-utilization of inputs or incorrect input combinations.

Moreover, the main reasons of scale inefficiency may arise from over-investment or unlimited operating scale. Therefore, the financial holding company does not produce the output at the optimum operating scale and results in the higher operating cost. Additionally, when the credit ranking mechanism includes controlled input in our evaluating system, the technical inefficiency is lower than that of the credit ranking mechanism which is excluded.

The technical efficiencies of the 14 financial holding companies in Taiwan are not significantly different. Four reasons can be used to explain that phenomenon. The first reason is that many new employees are needed when a new private financial holding company is established. Since the new financial holding companies may recruit talented staffs of financial holding company from other

financial holding companies rather than train up inexperienced personnel themselves, the established financial holding companies take steps to ensure their staffs not to stray and thereby disrupt business. One upshot of this situation is the increased salaries, which can push up the labour costs of a financial holding company. The established financial holding companies raise salaries in order to attract new employees and result in the increasing of labour costs. This process offsets the improvements of existing efficiency and reduces the impacts on technical upgrading (Chen, 2002). The second reason is that when new privately-owned financial holding companies plan to set up some new branches in order to response the market competition, additional financial holding company staffs are required, producing the surplus manpower at the same time (Muniz, 2002). The third reason points to the prosperity of the direct financial markets in Taiwan, which will decline the activities of the related financial intermediates. New privately-owned financial holding companies, therefore, make an effort to absorb deposits and loans by means of competitive interest rates, reducing the interest rates among commercial financial holding companies. This will reduce the technical efficiency and magnitude of the Malmquist index (Fare, 1994).

We recommend that the Taiwanese credit ranking system can be considered as a controllable input when performance evaluation is conducted in the financial holding companies (Banker and Morey, 1986). Obviously, Chinese credit ranking is a useful evaluation resource, and it can prompt the financial holding companies to emphasize their repayment capability and credit reputation. Furthermore, it can also promote the operating/technical efficiency under the positive cycle. Additionally, the usage of Taiwanese credit ranking is beneficial to legitimize the related financial holding company laws that can promote the development of the financial market in Taiwan. A set of open, fairly and transparency credit ranking system that we can be viewed it as a lighting-house in the seashore, guiding the steamboat safety back to port. The credit ranking system is a useful public reference and guidance when the openly financial market is considered to be invested (Ruggiero, 1998; Syrjänen, 2004).

Note that the concluding remarks and policy implications in our study are derived from the empirical data in Taiwan and the given research method and model. Extending the research scope of our study, one should prudently consider the particular situation and any environmental change. A flexible consideration should be required, to avoid over-applying this research results in the near future. Furthermore, we can generate the alternate performance evaluation results using the three-stage DEA mechanism proposed by Fried *et al.* (2002) to compare the different evaluating aspects. One can also separate the financial holding company outputs or activities into the detailed items to catch the more practical implications and highlight the required improvement with respect to a certain activities or output item. This way can provide more meaningful implications to the managers of financial holding companies when they plan to develop the practical business strategy.

## REFERENCES

Aigner, D.J., C.A.K. Lovell and P. Schmidt, 1977. Formulation and estimation of stochastic frontier production models. Journal of Econometrics, 6: 21-37.

Allen, L. and J. Jatoani, 2000. The risk effects of combining banks, securities, and insurance activities. Journal of Economics and Business, 52: 485-497.

Allen, L. and A. Rai, 1996. Operational efficiency in banking: An international comparison. Journal of Banking and Finance, 20: 655-672.

Altunbas, Y., L. Evans and P. Molyneux, 2001. Bank ownership and efficiency. Journal of Money, Credit and Banking, 33: 926-954.

Aly, H.Y., R. Grabowski, C. Pasurka and N. Rangan, 1990. Technical, scale, and allocative efficiencies in us banking: An empirical investigation. Review of Economics and Statistics, 30: 211-218.

Andersen, P. and N.C. Petersen, 1993. A procedure for ranking efficiency units in data envelopment analysis. Management Science, 39: 1261-1264.

Ataullah, A. and H. Le, 2006. Economic reforms and bank efficiency in developing countries: The case of the Indian banking industry. Applied Financial Economics, 16: 653-660.

Banker Charnes, R.D.A. and W.W. Cooper, 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science, 30: 1078-1092.

Banker, R.D. and R.C. Morey, 1986. The use of categorical variables in data envelopment analysis. Management Science, 12: 1613-1627.

Berger, A.N., 1999. The consolidation of the financial service industry: Causes, consequences, and implications for the future. Journal of Banking and Finance, 23: 135-194.

Berger, A.N. and L.D.B. Humphrey, 1997. Efficiency of financial institutions: International survey and directions for future research. European Journal of Operational Research, 98: 175-212.

Berger, A.N. and L. Mester, 1997. Inside the black box: What explains differences in the efficiencies of financial institutions. Journal of Banking and Finance, 21: 895-947.

Berger, D., A.R., H. Genary and G. Udell, 2000. Globalization of financial institutions: Evidence from cross-border banking performance, brookings-wharton papers on financial service 3. NY: Whartons.

Bhattacharyya, A., C.A.K. Lovell and P. Sahay, 1997. The impact of liberalization on the productive efficiency of indian commercial banks. European Journal of Operational Research, 98: 332-345.

Caves, D.W., L.R. Christensen and W.E. Diewert, 1982a. Multilateral comparisons of output, input, and productivity using superlative index number. Economic Journal, 92: 73-86.

Caves, D.W., L.R. Christensen and W.E. Diewert, 1982b. The economic theory of index numbers of input, output, and productivity. Econometrica, 50: 1393-1414.

Charnes, A., W.W. Cooper and E. Rhodes, 1978. Measuring the efficiency of decision marking units. European Journal of Operational Research, 2: 429-444.

Chen, T.Y., 2002. An estimation of x-inefficiency in Taiwan's banks. Applied Financial Economics, 11: 237-242.

Chen , T.Y. and T.L. Yeh, 1998. A study of efficiency evaluation in Taiwan's banks. International Journal of Service Industry Management, 9: 402-415.

Cook, W.D. and J. Zhu, 2006. Rank order data in dea: A general framework. European Journal of Operational Research, 174: 1021-1032.

Cornwell , T., 2006. Credit Scores Created New Paths, Mortgage Servicing News, 10: 1-29.

Crittenden, M.R., 2006. Do Credit Scores Mislead Lenders? CQ Weekly, 64: 2568-2569.

Dekker, D. and P. Thierry, 2001. A quasi-concave dea model with an application for bank branch performance evaluation. European Journal of Operational Research, 132: 296-311.

Dietsch , M. and A. Lozano-Vivas, 2000. How the environment determines banking efficiency: A comparison between french and spanish industries. Journal of Banking and Finance, 24: 985-1004.

Emel, A.B., M. Oral, R. Arnold and R. Yolalan, 2003. A credit scoring approach for the commercial banking sector. Socio-Economic Planning Sciences, 37: 103-124.

Fare, R., 1994. Biased technical change and the malmquist productivity index. Scandinavian Journal of Economics, 99: 119-127.

Fare, R., S. Grosskopf, B. Lindgren and P. Roos, 1992. Productivity changes in swedish pharmacies 1980-1989: A non-parametric malmquist approach. The Journal of Productivity Analysis, 3: 85-101.

Fare, R., S. Grosskopf and C.A.K. Lovell, 1985. The measurement of efficiency of production, boston. US: Kluwer Academic Publishers.

Fare, R., S. Grosskopf and C.A.K. Lovell, 1994. Production frontiers, cambridge. UK: Cambridge University Press.

Fare, R., S. Grosskopf, M. Norris and Z. Zhang, 1994. Productivity growth, technical progress, and efficiency changes in industrialised countries. American Economic Review, 84: 66-83.

Farell, M.J., 1957. The measurement of productive efficiency. Journal of Royal Statistical Society, 120: 253-581.

Favero, C.A. and L. Papi, 1995. Technical efficiency and scale efficiency in the Italian banking sector. Applied Economics, 27: 385-395.

Fried, H.O., C.A.K. Lovell, S.S. Schmidt and S. Yaisawarng, 2002. Accounting for environmental effect and statistical noise in data envelopment analysis. Journal of productivity Analysis, 17: 157-174.

Fukuyama, H., R. Guerra and W.L. Weber, 1999. Efficiency and ownership: Evidence from Japanese credit cooperatives. Journal of Economics and Business, 51: 473-487.

Garner, B.A., 1999. Black's law dictionary. NY: West Publishing Co.

Golany , B. and J.E. Storbeck, 1999. A Data Envelopment Analysis of the Operational Efficiency of the Operational Efficiency of Bank Branches, Interfaces, 29: 14-26.

Grabowski, R., N. Rangan and R. Rezvanian, 1993. Organizational firms in banking: An empirical investigation of cost efficiency. Journal of Banking and Finance, 17: 31-538.

Grigorian, D.A. and V. Manole, 2006. Determinants of commercial bank performance in transition: An application of data envelopment analysis. Comparative Economic Studies, 48: 497-508.

Halkos, G.E. and D.S. Salamouris, 2004. Efficiency measurement of the greek commercial banks with the use of financial ratios: A data envelopment analysis approach. Management Accounting Research, 15: 201-224.

Hines, A., 1982. The measurement of productive efficiency. Journal of the Royal Statistical Society A: General, 120: 253-281.

Hume, L., 2006. NASD Council: Sisung, President Violated G-37, Bond Buyer, 357: 1-4.

Kliger, D. and O. Sarig, 2000. The information value of bond ratings. The Journal of Finance, 6: 2879-2902.

Larsen, P.T., 2006. Merrill's Dublin-based Financial Holding Company is Planning to Expand in Areas, Financial Times, 10: 15-16.

Meeusen , W. and J. van den Broeck, 1977. Efficiency estimation from cobb-douglas production functions with composed error. International Economic Review, 15: 271-287.

Muniz, M.A., 2002. Separating managerial inefficiency and external conditions in data envelopment analysis. European Journal of Operational Research, 143: 625-643.

Oral, M. and R. Yolalan, 1990. An empirical study on measuring operating efficiency and profitability of bank branches. European Journal of Operational Research, 46: 282-294.

Paradi, J.C. and C. Schaffnit, 2004. Commercial branch performance evaluation and results communication in a canadian bank: A dea application. European Journal of Operational Research, 156: 719-725.

Pastor, J., F. Perez and J. Quesada, 1997. Efficiency analysis in banking firms: An international comparison. European Journal of Operational Research, 98: 396-408.

Resti, A., 1997. Evaluating the cost efficiency of the Italian banking system: What can be learned from the joint application of parametric and non-parametric techniques. Journal of Banking and Finance, 21: 221-250.

Ruggiero, J., 1998. Non-discretionary inputs in data envelopment analysis. European Journal of Operational Research, 101: 461-469.

Santos , T., 2006. Credit Rating Agency Reform Update, AFP Exchange, 26: 30-31.

Schaffnit, C., D. Rosen and J.C. Paradi, 1997. Best practice analysis of bank branches: An application of dea in a large Canadian bank. European Journal of Operational Research, 98: 269-289.

Sherman, H.D. and F. Gold, 1985. Bank branch operating efficiency: Evaluation with data envelopment analysis. Journal of Bank and Finance, 9: 297-315.

Syrjänen, M.J., 2004. Non-discretionary and discretionary factors and scale in data envelopment analysis. European Journal of Operational Research, 158: 20-33.

Yeh, Q.J., 1996. The application of data envelopment analysis in conjunction with financial ratios for bank. Journal of the Operational Research Society, 47: 980-989.

Yue, P., 1992. Data Envelopment Analysis and Commercial Bank Performance: a Primer with Application to Missouri Banks, Federal Reserve Bank of ST. Louis, 74: 31-45.

Zaim, O., 1995. The effect of financial liberalization on the efficiency of Turkish commercial banks. Applied Financial Economics, 5: 257-264.