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# Analyzing for profit efficiency of banks with undesirable output

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The primary objective of commercial banks is to maximize profit, but the usual ratio approach may encounter a problem when observed profit equals zero. This study uses the Nerlovian profit indicator, based on the difference rather than the ratio approach, to measure a profit efficiency indicator. We further decompose the profit efficiency indicator into technical and allocation efficiencies. The dataset consists of commercial banks from 1999 to 2007 in Taiwan. The empirical results show: (1) the shadow price affects the profit efficiency; (2) profit efficiency mainly comes from allocation efficiency; (3) the profit efficiency and allocation efficiency is better in old banks than in new ones; (4) the profit efficiency and allocation efficiency of banks belonging to a financial holding company are significantly higher than those not belonging to a financial holding company; (5) the diversification is really suitable for banking service in Taiwan.

Key words: Nerlovian profit indicators, non-performing loans, undesirable output, directional distance function, profit efficiency.

## INTRODUCTION

The primary purpose of commercial banks as well as manufacturing firms is to maximize profit. However, the usual ratio approach to measure efficiency, called indices, may not be appropriate since both maximum and observed profit may equal zero. This poses a problem in the ratio context. Färe and Grosskopf (2005) propose the Nerlovian profit indicator, based on the difference rather than the ratio approach, to measure profit efficiency, which could avoid the problem encountered by the ratio approach.

Loans are one of the major outputs provided by a bank, but as loan is a risk output, there is always an ex ante risk for a loan to eventually become non-performing.

Hence, non-performing loans (NPLs) are the by-products of producing loans and thus are undesirable outputs. A bank with more loans does not necessarily imply it has a higher efficiency especially if it is associated with sizable NPLs. Hence, it makes sense to evaluate the perfor-mance of banks by crediting performing loans (desirable outputs) and penalizing non-performing loans (undesira-ble outputs).

When the prices of undesirable outputs are unavailable, it creates difficulty in measuring banks' profit efficiency. Hence, this study first applies the directional output distance to estimate the shadow prices of NPLs. We then measure the Nerlovian profit indicator of Taiwanese commercial banks, and finally decompose it into the technical and allocation component indicators.

In the early 1980s, the Taiwan government started to open up the domestic financial market to both domestic and foreign banks in order to follow the global trend of financial deregulation. In 1991 Taiwan further released the Commercial Bank Establishment Promotion Decree to relax the legal entrance barriers to banking markets. The banking industry suddenly faced new competition

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Abbreviations: NPLs, non-performing loans; DEA, data envelopment analysis; CCR, Charnes-Cooper-Rhodes; DMUs, decision making units; FHC, Financial Holding Company.

and shocks when the deregulation began to take place. Because of increasing competition, many banks expanded into multiple ventures, effectively increasing their running risk and jeopardizing their productivity and management efficiency.

The 1997 Asian financial crisis had a great impact on Taiwan. NPLs had been swiftly accumulating in Taiwan as well as many other Asian economies (Krugman, 1998; Wade, 1998; Chang, 1998; Lauridsen, 1998; Robinson and Rosser, 1998; Demir et al., 2005).

The economist pointed out (November 11 2000) that bad loans in Taiwan's domestic banks reached new highs, and that a local financial crisis was immediate. New York Times (December 5 2000) and Business Week (December 11 2000) cited Salomon Smith Barney in that NPL ratio among listed banks in Taiwan amounted to more than 6%, and because of the narrow definition in official NPL statistics it could, in reality, be as high as between 10-15%. On December 6, 2000 Standard and Poors also revised its outlook on Taiwan from stable to negative. Many researchers began to warn that Taiwan may face a looming banking crisis (Montgomery 2002). Controlling NPLs is thus very important for banks' performance (Chang 1999; McNulty et al. 2001) and Taiwan's financial environment.

The profit efficiency model is better than just only technology efficiency model to describe the performance. Singh (2009) used data envelopment analysis (DEA) to analyze the profit efficiency and cost efficiency of the acquiring bank to see whether there have been gains from consolidation. Tripe (2010) applied a Charnes-Cooper-Rhodes (CCR) model, a profit efficiency model and a non-oriented slacks-based approach to investigate bank safely and soundness. Ray and Das (2010) used the nonparametric DEA methodology to estimate cost and profit efficiency of Indian banks during the post-reform period. Cummins et al. (2010) utilized DEA to estimate cost, revenue, and profit efficiency.

Bank efficiency has received much attention in the literature. In earlier efficiency literature, most studies focused on estimating the functional characteristics and economies of scale and scope, for example, Bell and Murphy (1967), Hunter and Timme (1986), Berger et al. (1987), Ferrier and Lovell (1990), Berger and Humphrey (1991), McAllister and McManus (1993) and Rhoades (1993), etc. The emphasis on bank efficiencies has recently shifted to productivity and efficiency. However, conventional measures of productivity and efficiency in the banking industry usually ignore the fact that NPLs are undesirable outputs (Aly et al., 1990; English et al., 1993; Elyasiani and Mehdian, 1995; Favero and Papi, 1995; Miller and Noulas, 1996; Saha and Ravisankar, 2000; Rezvanian and Mehdian, 2002; Fukuyama and Weber, 2002).

Non-performing loans are undesirable outputs for any bank that extends loans, which decrease a bank's performance (Chang, 1999). Controlling NPLs is thus very important for both an individual bank's performance

(McNulty et al., 2001). Li et al. (2002), Hu et al. (2004) and Li (2005) treat NPLs as undesirable outputs. Nevertheless, they do not measure banks' performance by expanding desirable outputs, and then contracting undesirable outputs and inputs simultaneously.

Chung et al. (1997) propose the directional distance function, which is capable of crediting desirable outputs and penalizing undesirable outputs, in order to construct a total factor productivity change index. Chambers et al. (1998) employ the directional distance function to construct the Nerlovian profit indicator.

Devaney and Weber (2002) use the Nerlovian profit indicator to analyze banks' profit efficiency, but they do not incorporate NPLs as an undesirable output. The difficulty in integrating NPLs into banks' profit efficiency is that, there are no markets for undesirable outputs, and thus the prices of NPLs must be estimated. Färe and Grosskopf (2005) suggest using the directional output distance function to estimate the shadow prices of undesirable outputs.

Hence, this study first employs the directional output distance function to estimate the shadow prices of NPLs for understanding the operating cost in each bank. And then, applies the Nerlovian profit indicator to evaluate the technical and allocation component indicators of Taiwanese commercial banks. Finally, using the profit indicators to analysis the performance of banks and give some useful advices to raise competition of banks.

## METHODOLOGY

According to Chung et al. (1997), Chambers et al. (1998) and Färe and Grosskopf (2005), to expand the desirable output and reduce the undesirable output simultaneously, this study applies the directional distance function. Suppose that there are $H$ decision making units (DMUs) using $N$ inputs to produce $M$ desirable and $J$ undesirable outputs, denoted by $x = (x_1,\ldots,x_N) \in R_+^N$, $y = (y_1,\ldots,y_M) \in R_+^M$, and $u = (u_1,\ldots,u_J) \in R_+^J$, respectively. The output set of production technology can be defined as:

$$P(x) = \left\{ (y,u): \ x \text{ can produce } (y,u) \right\}. \qquad (1)$$

We assume that, desirable and undesirable outputs are jointly produced, that is, $u$ is a byproduct of the production of $y$. To distinguish between desirable and undesirable outputs, two basic concepts should be discussed: null-joint outputs and weak disposability of outputs (Färe and Grosskopf, 2005). Desirable and undesirable outputs are null-joint outputs if:

$$(y,u) \in P(x) \text{ and } u = 0, \text{ then } y = 0. \qquad (2)$$

Equation 2 states that if a desirable output is produced in a positive amount, then some undesirable output must also be produced.

Färe and Primont (1995) define the weak disposability of undesirable outputs as follows:

$(y, u) \in P(x)$, and $0 \le \theta \le 1$ then $(\theta y, \theta u) \in P(x)$ (3)

Equation 3 means that a reduction of byproducts can only be achieved by simultaneously reducing desirable outputs, holding inputs constant. In contrast to undesirable outputs, we assume that desirable outputs are freely disposable, that is:

$(y, u) \in P(x)$, and $y^0 \le y$ implies $(y^0, u) \in P(x)$ (4)

Note that if a technology satisfies strong disposability, then it also satisfies weak disposability, but the converse does not follow.

**Shadow price of undesirable output**

As mentioned above, there is no market for undesirable output. The available data usually entail primal or quantity data. Hence, the dual method is an appropriate approach using quantity data to estimate shadow price.

Both the Shephard output distance function and the directional output distance function are dual to the revenue function (Färe and Grosskopf, 2005), but the Shephard output distance function seeks to radially increase all outputs proportionally. This implies that all outputs are desirable.

This study uses the directional output distance function, allowing for simultaneously expanding desirable outputs and contracting undesirable output. Färe and Grosskopf (2005) define the directional output distance function as follows:

$$\vec{D}_o(x, y, u; g_y, g_u) = \sup\{\beta : (y + \beta g_y, u - \beta g_u) \in P(x)\} \quad (5)$$

Equation 5 searches for the largest feasible expansion of desirable output vector $y$ in the $g_y$ direction and the largest feasible reduction of undesirable output vector $u$ in the $g_u$ direction. The revenue function is defined as:

$$R(x, p, r) = \max\{py - ru : (y, u) \in P(x)\} \quad (6)$$

where $p = (p_1, ..., p_M)$ is the desirable output price vector and $r = (r_1, ..., r_J)$ is the undesirable output price vector.

Equation 6 is the largest feasible revenue that can be obtained from input $x$ and output price vectors $p$ and $r$. Since $R(x, p, r) \ge py - ru$ for all $(y, u) \in P(x)$ and $(y + \vec{D}_o(x, y, u; g_y, g_u)g_y, \ u - \vec{D}_o(x, y, u; g_y, g_u)g_u)$ is feasible, then we have:

$$\frac{R(x, p, r) - (py - ru)}{pg_y + rg_u} \ge \vec{D}_o(x, y, u; g_y, g_u) \quad (7)$$

If the output set $P(x)$ is a closed, non-empty convex set, then the directional output distance function can be obtained from the revenue function as (Färe and Grosskopf, 2005):

$$\vec{D}_o(x, y, u; g_y, g_u) = \inf_{p, r} \frac{R(x, p, r) - (py - ru)}{pg_y + rg_u} \quad (8)$$

If Equation 8 is differentiable, then we apply the envelope theorem to obtain the shadow price vectors:

$$\nabla_y \vec{D}_o(x, y, u; g_y, g_u) = \frac{-p}{pg_y + rg_u} \quad (9)$$

and

$$\nabla_u \vec{D}_o(x, y, u; g_y, g_u) = \frac{r}{pg_y + rg_u}. \quad (10)$$

Suppose that the $m$-th desirable output price is known (or equal to the shadow price).

From Equations 9 and 10, we compute the shadow price of the $j$-th undesirable output as:

$$r_j = -p_m \frac{\partial \vec{D}_o(x, y, u; g_y, g_u) / \partial u_j}{\partial \vec{D}_o(x, y, u; g_y, g_u) / \partial y_m} \quad (11)$$

To empirically estimate Equation 11, we have to parameterize the directional output distance function.

Since the directional output distance function satisfies the translation property (Färe and Grosskopf, 2005), we have:

$$\vec{D}_o(x, y + \theta g_y, u - \theta g_u; g_y, g_u) = \vec{D}_o(x, y, u; g_y, g_u) - \theta \quad (12)$$

We parameterize the directional output distance function by the quadratic form, which can be readily restricted to satisfy the translation property.

In contrast, the translog function can easily fulfill the homogeneity, but not translation (Färe and Grosskopf, 2005). The quadratic form of the directional output distance function is:

$$\vec{D}_o(x, y, u; y, u) = \alpha_0 + \sum_{n=1}^{N} \alpha_n x_n + \sum_{m=1}^{M} \beta_m y_m + \sum_{j=1}^{J} \gamma_j u_j + \frac{1}{2}\sum_{n=1}^{N}\sum_{n'=1}^{N} \alpha_{nn'} x_n x_{n'} + \frac{1}{2}\sum_{m=1}^{M}\sum_{m'=1}^{M} \beta_{mm'} y_m y_{m'} + \frac{1}{2}\sum_{j=1}^{J}\sum_{j'=1}^{J} \gamma_{jj'} u_j u_{j'}$$
$$+ \sum_{n=1}^{N}\sum_{m=1}^{M} \delta_{nm} x_n y_m + \sum_{n=1}^{N}\sum_{j=1}^{J} \nu_{nj} x_n u_j + \sum_{m=1}^{M}\sum_{j=1}^{J} \mu_{mj} y_m u_j.$$

(13)

This research employs the linear programming suggested by Aigner and Chu (1968) to estimate unknown parameters.

In other words, we try to estimate the parameters of a deterministic quadratic directional output distance function by solving the following problem:

$$\min_{\substack{\alpha_0;\alpha_1,...,\alpha_N; \\ \beta_1,...,\beta_M;\gamma_1,...,\gamma_J; \\ \delta_{11},...,\delta_{NM};v_{11},...,v_{NJ}; \\ \mu_{11},...,\mu_{MJ};}} \sum_{k=1}^{K} \vec{D}_o\left(x^k, y^k, u^k; g_y, g_u\right)$$

(14)

s.t.                                                                 (i)

$$\vec{D}_o\left(x^k, y^k, u^k; g_y, g_u\right) \geq 0, \ k=1,...,K$$

(ii)

$$\frac{\partial \vec{D}_o\left(x^k, y^k, u^k; g_y, g_u\right)}{\partial u_j} \geq 0 \ , \ k=1,...,K \ , \ j=1,...,J$$

(iii)

$$\frac{\partial \vec{D}_o\left(x^k, y^k, u^k; g_y, g_u\right)}{\partial y_m} \leq 0, \ k=1,...,K, \ m=1,...,M$$

(iv)

$$\frac{\partial \vec{D}_o\left(x^k, y^k, u^k; g_y, g_u\right)}{\partial x_n} \geq 0 \ , \ k=1,...,K \ , \ n=1,...,N$$

$$\sum_{m=1}^{M} \beta_m - \sum_{j=1}^{J} \gamma_j = -1,$$

$$\sum_{m'=1}^{M} \beta_{mm'} - \sum_{j=1}^{J} \mu_{mj} = 0, \ m=1,...,M$$

$$\sum_{j'=1}^{J} \gamma_{jj'} - \sum_{m=1}^{M} \mu_{mj} = 0, \ j=1,...,J$$

$$\sum_{m=1}^{M} \delta_{nm} - \sum_{j=1}^{J} v_{nj} = -1, \ n=1,...N$$

(v)

$$\vec{D}_T\left(x,y,u; g_x, g_y, g_u\right) = \sup\left\{\beta : (x - \beta g_x) \text{ can produce } \left(y + \beta g_y, u - \beta g_u\right)\right\}$$

(16)

The observed DMU is efficient in the directional vector $g = \left(-g_x, -g_u, g_y\right)$ if $\vec{D}_T\left(x,y,u; g_x, g_y, g_u\right) = 0$. This efficiency depends on the choice of the directional vector. In other words, it is possible that one DMU is efficient in one directional vector, but inefficient in another directional vector. However, there is not a general rule for determining those vectors (Färe and Grosskopf, 2005). For this study let $g_x = x$, $g_y = y$, and $g_u = u$ (Devaney and Weber, 2002).

The definition of $\Pi(p,r,w)$ to accordingly be the maximum profit is:

$$\Pi(p,r,w) \geq py - ru - wx \quad \text{for all } x \text{ can produce } (y,u)$$

(17)

$$\alpha_{nn'} = \alpha_{n'n} \ , \ n=1,...,N; \ n'=1,...,N$$

(vi)

$$\beta_{mm'} = \beta_{m'm} \ , \ m=1,...,M; \ m'=1,...,M .$$

The first restriction in Equation 14 is to constrain each observation to be on or below the production frontier of $P(x)$. Constraints (i) state each firm is feasible in this frontier restriction (ii) presents the directional output distance function as a non-decreasing function of undesirable outputs; constraints (iii) offer the directional output distance function as a non-increasing function of desirable outputs; and restriction (iv) shows the directional output distance function as a non-decreasing function of inputs. The last two constraints satisfy the translation property and symmetry, respectively.

**The Nerlovian profit indicator**

After obtaining the shadow price of undesirable output, we now measure the Nerlovian profit indicator.

Färe and Grosskopf (2005) define the Nerlovian profit indicator for $h$-th DMU as follows:

$$NI\left(p,r,w,y^h,u^h,x^h; g_x, g_u, g_y\right) = \frac{\Pi(p,r,w) - \Pi^h}{wg_x + pg_y + rg_u}$$

(15)

where $\Pi(p,r,w)$ is the maximum profit value; $\Pi^h$ is the observation profit value for the $h$-th DMU; $p$, $r$, and $w$ are the price vector of desirable outputs, shadow price vector of undesirable output, and the input price vector, respectively; and $g_x$, $g_y$, and $g_u$ are directional vectors.

Let the directional vectors $g = \left(-g_x, -g_u, g_y\right)$, and then the technical efficiency can be measured from a directional distance function (Chambers et al., 1998):

Thus, we have:

$$\frac{\Pi(p,r,w) - (py - ru - wx)}{wg_x + pg_y + rg_u} \geq \vec{D}_T\left(x,y,u; g_x, g_y, g_u\right)$$

(18)

Färe and Grosskopf (2005) name the gap as allocation efficiency. Hence, the Novlovian profit indicator can be decomposed into two parts: technical efficiency $\vec{D}_T(\cdot)$ and allocation efficiency $\vec{AE}_T$ . that is:

$$\frac{\Pi(p,r,w) - (py - ru - wx)}{wg_x + pg_y + rg_u} = \vec{D}_T\left(x,y,u; g_x, g_y, g_u\right) + \vec{AE}_T$$

(19)

We must solve maximizing profit and technical efficiency for each DMU. The linear programming problems for maximizing profit and technical efficiency are as follows.

Maximizing profit:

$$\Pi(\boldsymbol{p},\boldsymbol{r},\boldsymbol{w}) = \max \quad \sum_{m=1}^{M} p_m y_m - \sum_{j=1}^{J} r_j u_j - \sum_{n=1}^{N} w_n x_n \tag{20}$$

s.t.

$$\sum_{k=1}^{K} z_k y_{km} \geq y_{km} \ , \quad m = 1,...,M$$

$$\sum_{k=1}^{K} z_k u_{kj} = u_{kj} \ , \quad j = 1,...,J$$

$$\sum_{k=1}^{K} z_k x_{kn} \leq x_{kn} \ , \quad n = 1,...,N$$

$$\sum_{k=1}^{K} z_k = 1 \ , \quad z_k \geq 0 \ , \quad k = 1,..., K .$$

Directional distance function:

$$\vec{D}_T(\boldsymbol{x},\boldsymbol{u},\boldsymbol{y};\boldsymbol{g_x},\boldsymbol{g_u},\boldsymbol{g_y}) = \max \beta \tag{21}$$

s.t.

$$\sum_{k=1}^{K} z_k y_{km} \geq y_{km} + \beta g_{ym} \ , \quad m = 1,...,M$$

$$\sum_{k=1}^{K} z_k u_{kj} = u_{kj} - \beta g_{uj} \ , \quad j = 1,...,J$$

$$\sum_{k=1}^{K} z_k x_{kn} \leq x_{kn} - \beta g_{xn} \ , \quad n = 1,..., N$$

$$\sum_{k=1}^{K} z_k = 1 \ , \quad z_k \geq 0 \ , \quad k = 1,...,K .$$

## DATA SOURCES AND EMPIRICAL RESULTS

The dataset, obtained from Taiwan Economic Journal Data Bank, consists Taiwanese commercial banks for the period from 1999 to 2007. This study views banks as intermediary institutions that choose the number of bank employees, net fixed assets, and total deposits as input variables. The output variables consist of two desirable outputs, performing loans and portfolio investments, and one undesirable output, non-performing loans. Since we have a nine-year panel data, all nominal variables are deflated by the GDP deflator with 2001 as the base year.

Table 1 reports the summary statistics of inputs and outputs used in the analysis. From this table, we find that the desirable and undesirable outputs are null-joint outputs. According to the concept of null-join output, from Equation 2, if a desirable output is produced in a positive amount, then the undesirable output also is produced. We can adopt the methodologies mentioned previously, because each output is greater than zero. The Bank of Taiwan had the biggest operating size in output and input terms. The Taiwan Cooperative Bank had the maximum non-performing loan in 2000. The smallest operating size is Taitung District Small and Medium Enterprises Bank. The Hwatai Commercial Bank had the minimum non-performing loan in 2006.

## DISCUSSION

This study employs the mathematical programming software LINGO 8.0 to calculate the shadow prices of undesirable output, the Nerlovian profit indicator, and the directional distance function. Table 2 shows the values of estimated parameters from the Equation 14. Using these parameters we can estimate the shadow prices of undesirable output in Equation 11. The shadow price of undesirable output means the cost that the bank has to spend to deal with the non-performing loan per dollar. For example, the average shadow price is 0.195 means each bank must pays $0.195 to eliminate one dollar non-performing loan in average. The higher shadow price causes the higher operating cost and lowers the banking performance.

After obtaining the shadow prices of NPLs, we estimate the inefficient values of Nerlovian profit indicators, uses the Equation 15; directional distance function (technical efficiency), uses the Equation 21, and allocation efficiency, the difference between Nerlovian profit indicator and technical efficiency from the Equation 19. Profit inefficiency can be decomposed into technical inefficiency and allocation inefficiency. We use Equation 20 to find the maximizing profit, and then, adopting the information of shadow price to measure the Nerlovian profit inefficiency value. We use Equation 21 to find the technical inefficiency value. The allocation inefficiency value equals profit inefficiency value minuses technical inefficiency values. If the inefficiency value is on the frontier then we can get the value equal zero, if not, the value will greater than zero. The larger inefficiency value means more inefficiency.

These observation banks were classified in three different ways. First, the banks were sorted out in years, from 1999 to 2007. Second, the banks are decomposed into two groups according to operating life. In operating

**Table 1.** Descriptive statistics of input and output variables.

| Variable | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|
| **Output** | | | | |
| Portfolio investment (NT$ million) | 68540 | 101078 | 817 | 745762 |
| Normal loans (NT$ million) | 367133 | 361810 | 22351 | 1828344 |
| NPLs (NT$ million) | 15439 | 19280 | 1102 | 132679 |
| | | | | |
| **Input** | | | | |
| Total number of employees person) | 3009 | 2118 | 506 | 8792 |
| Net fixed assets (NT$ million) | 12589 | 15110 | 948 | 108127 |
| Deposits (NT$ million) | 446797 | 462895 | 32876 | 2381592 |

Number of observation: 392

**Table 2.** Parameter estimates of the directional output distance function.

| $\alpha_{output}$ | | $\alpha_{output, output}$ | | $\beta_{input}$ | | $\beta_{input, input}$ | | $\gamma_{input, output}$ | |
|---|---|---|---|---|---|---|---|---|---|
| $\alpha_1$ | 0.1168 | $\alpha_{11}$ | -0.2290 | $\beta_1$ | -0.1212 | $\beta_{11}$ | 0.0605 | $\gamma_{11}$ | 0.0443 |
| $\alpha_2$ | 0.0005 | $\alpha_{12}$ | 0.0003 | $\beta_2$ | -0.1005 | $\beta_{12}$ | -0.0271 | $\gamma_{12}$ | -0.0633 |
| $\alpha_3$ | 0.2063 | $\alpha_{13}$ | 0.1932 | $\beta_3$ | 0.7783 | $\beta_{13}$ | -0.0271 | $\gamma_{13}$ | -0.0189 |
| | | $\alpha_{21}$ | 0.0003 | | | $\beta_{21}$ | -0.0271 | $\gamma_{21}$ | 0.0005 |
| Constant | | $\alpha_{22}$ | -0.00033 | | | $\beta_{22}$ | -0.1147 | $\gamma_{22}$ | -0.0002 |
| $\alpha_0$ | -0.0842 | $\alpha_{23}$ | 0.0019 | | | $\beta_{23}$ | -0.0271 | $\gamma_{23}$ | 0.0002 |
| | | $\alpha_{31}$ | 0.1932 | | | $\beta_{31}$ | -0.0271 | $\gamma_{31}$ | -0.0469 |
| | | $\alpha_{32}$ | 0.0019 | | | $\beta_{32}$ | -0.0271 | $\gamma_{32}$ | -0.0057 |
| | | $\alpha_{33}$ | 0.0019 | | | $\beta_{33}$ | -0.0542 | $\gamma_{33}$ | -0.0526 |

life, the government deregulated strict establishing restrictions and permitted new banks setting up in 1991. The banks are named old banks that established before 1991. Others named new banks that established after 1991.

Third, the banks were separated by operating attribute. The passage of Financial Holding Act in 2001 lead financial industry expand its business, it can be concluded bank, insurance, security and the relative works. The financial holding company founded in 2002. The operating attribute depends on whether belong to financial holding company.

Table 3 presents these three indicators. We find that the profit and allocation inefficient value do not have significance difference, but they still have some different. In Figure 1, the profit and allocation inefficiency have almost the same trend. The inefficient value increased in the dot-com bubble in 2001 and the ratio of NPL was the highest from 2001 to 2002. But some banks joined to financial holding company and did not get worse in 2002.

What we focus is technical inefficient value. It shows a significance difference in different years in Table 3. And Figure 2 shows that there is a highest peak in 2006. On the other hand, there was a serious problem about the possession of credit cards. Each person had 4.5 credit cards in average and there were too much credit cards and cash cards in the market from 2004. Then, the loan form cards has exceeded NT$800 billion during 2005 and 2006. That caused card debt and credit broken problem, so it lowed the performance of banks in 2006. After that, the Financial Supervisory Commission enforced the proceeding of negotiation between banks and debtors to reduce the operation risk and technical inefficiency of banks.

Shadow price is lower in old banks. The old banks have a significance better profit efficiency than new banks in Table 3. The old banks have already operated for long time and got a great credit, so they did have to compete for loans. They paid lower cost for non-performing loans and got better profit efficiency. In Figure 3, old banks have longer operating life to get abundant experiences to achieve their maximum profit target and lower shadow price, so profit inefficient value is lower.

New banks have shorter operating life, in order to expend their business they have to do some product innovations. The technical inefficient value is lower than old banks, just like other literatures. Banks whether belong to financial holding company have a significance difference in shadow price and inefficient values in Table 3. The banks could get better profit performance when

**Table 3.** Shadow price and inefficiencies.

| Year | Shadow price | Profit inefficiency | Technical inefficiency | Allocation inefficiency |
|---|---|---|---|---|
| 1999 | 0.298 | 1.348 | 0.082 | 1.265 |
| 2000 | 0.142 | 1.377 | 0.084 | 1.292 |
| 2001 | 0.257 | 1.327 | 0.094 | 1.234 |
| 2002 | 0.187 | 1.859 | 0.124 | 1.736 |
| 2003 | 0.127 | 1.901 | 0.106 | 1.796 |
| 2004 | 0.125 | 1.627 | 0.086 | 1.541 |
| 2005 | 0.131 | 1.463 | 0.113 | 1.350 |
| 2006 | 0.123 | 1.125 | 0.171 | 1.255 |
| 2007 | 0.137 | 1.393 | 0.129 | 1.263 |
|  |  |  |  |  |
| P value | <0.001*** | 0.553 | 0.04** | 0.519 |
| Old banks | 0.131 | 0.907 | 0.137 | 0.770 |
| New banks | 0.272 | 2.229 | 0.071 | 2.158 |
| P value | <0.001*** | <0.001*** | <0.001*** | <0.001*** |
| Banks belong to FHC | 0.119 | 1.257 | 0.149 | 1.108 |
| Banks not belong to FHC | 0.223 | 1.608 | 0.091 | 1.517 |
| P value | <0.001*** | 0.009*** | 0.001*** | 0.002*** |

Note: *** represents significance at the 1% level; ** represents significance at the 5% level.
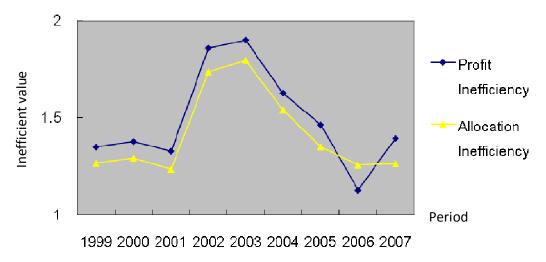


**Figure 1.** Profit and allocation inefficient value.

shadow price and allocation inefficient value were lower. In Figure 4, banks belong to financial holding company have lower profit inefficient value means banks in this type could easier than the other to approach the maximum profit target, because they pay lower cost for non-performing loans, and operate in better performance. The banks that belong to financial holding company have various works to do include banking, insurance and security businesses. Lower allocation inefficiency means they can make good use of inner resources between the subsidiaries. So, the diversification is really suitable for banking service in Taiwan. The banks belong to Financial Holding Company (FHC) have got better performance in the beginning, but the inefficient value raised in the next year. The President proceeded to announce the Second Financial Reforms to expend the scale and increase the national competition for financial industry in 2004. From Figure 4 we can check this reform does work, it makes the inefficient value get down.

In general, the FHC is suitable for financial industry in Taiwan. First, the average shadow price of banks belong to FHC is lower, means these banks can lower the operating cost. And then the FHC also can expend the diversification and scale to increase the operating
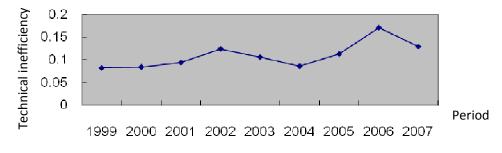
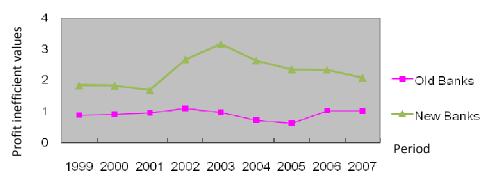**Figure 2.** Technical inefficient value in operating risk.



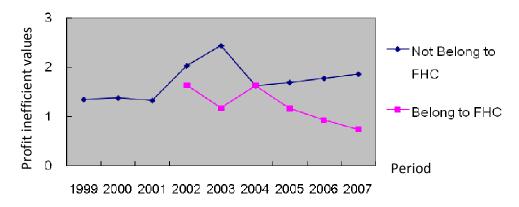**Figure 3.** Profit inefficient value in operating life.



**Figure 4.** Profit inefficient value in operating attribute.

performance and national competition.

## CONCLUDING REMARKS

Profit maximization is the primary objective of commercial banks as well as manufacturing firms. However, the usual ratio approach may encounter problems when observed profit equals zero. Furthermore, NPLs are by-products of producing loans and thus are undesirable outputs. An appropriate approach to measure banks' efficiency should be able to credit desirable outputs and penalize undesirable outputs. The difficulty in incorporating NPLs into banks' profit efficiency is that there are no markets for undesirable outputs, and thus the prices of NPLs must be estimated. Using directional distance function to estimate the profit efficiency is more complete than other methods to discuss banking performance. This study applies the directional output distance to estimate the shadow prices of NPLs at first. We then measure the Nerlovian profit indicator of Taiwanese commercial banks and decompose it into the technical and allocation component indicators.

The dataset obtained from Taiwan Economic Journal

Data Bank. It consists of commercial banks in Taiwan from 1999 to 2007. The empirical results show that the shadow price affects the level of Nerlovian profit indicator. The observation banks are classified to three types and compare the inefficiency. The technical inefficiency has a significance difference in study period. The old banks have a better profit efficiency than new banks; the banks that belong to financial holding company have a better profit efficiency. The origination of financial holding company is helpful to banking profit and allocation efficiency. They have large amount input factors, and can search the best resource allocation to produce. The financial holding company integrated diverse financial industries. The diversification is suitable for banking service in Taiwan.

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