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The Technology Management Efficiency of Banks under Taiwanese Financial Holding Companies

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Abstract
This study estimates the multi-component efficiency of banks under financial holding companies, including profitability and marketability efficiencies, by utilizing a RAM (Range-adjusted measure) variation model. The analysis process uses the three-dimensional BCG (Boston Consulting Group) matrix created by this study. We find that although semi-publicly-owned banks under financial holding companies in Taiwan have low profitability and marketability efficiency scores, they can be re-classified as a bank with medium multi-component efficiency and low multi-component efficiency by utilizing the three-dimensional BCG matrix.

Jel Code: C61, C67, D20, G21, M21

Keywords: Mmulti-component efficiency, financial holding companies, RAM variation model, three-dimensional BCG matrix

1. Introduction

The government and regulations protected Taiwan's banking industry in the past for a long time, but in 1991 the government allowed the establishment of privately-owned banks, and thus the number of them grew rapidly afterwards. The Financial Holding Company Act of Taiwan was passed by the Legislative Yuan in 2001, permitting publicly- and privately-owned banks to merge and for financial conglomerates to cross-own one another. By 2008, the total number of established financial holding companies had hit 14, with this increasing to 16 in 2012.

For stable financial development, the efficiency performance of the banking industry has always drawn considerable attention from both academicians and policy makers. Reviewing the previous literature, we find that many studies only focus on evaluating profitability efficiency (profit generating), but ignore market efficiency (market value increasing) in the banking industry. Although only a few studies focus on investigating both profitability efficiency and marketability efficiency, they overlook multi-component efficiency, including profitability and marketability efficiencies. To address this gap in the literature, we apply a RAM (Range-adjusted measure) model to estimate profitability and marketability efficiencies and create a RAM variation model to calculate multi-component efficiency in Taiwan's banking industry. Both the RAM model and the RAM variation model

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belong to one type of data envelopment analysis (DEA) approach, which calculates a single efficiency score for each bank based on multiple inputs and/or multiple output variables (Bauer, Berger, Ferrier & Humphrey, 1998) and does not assume an a priori production function for each bank (see Chebat, Ierre, Arnon & Sholomom, 1994 for a review).

The main purpose of evaluating a bank's efficiency is that managers or regulators can improve the bank's performance according to the estimation result (Chen and Yen, 2000). Numerous studies, for example Charnes, Cooper, Huang and Sun (1990), Oral and Yolalan (1990), Sherman and Gold (1985), and Sherman and Ladino (1995), have used DEA to estimate bank efficiency. Past studies about bank efficiency in Taiwan include Chen (1998) and Chen and Yen (2000), who compare the efficiencies of public-owned banks and private-owned banks, and Chen and Yen (2000) and Chan and Liu (2006), who measure the efficiency and productivity of new and old banks.

Aside from bank (operational) efficiency, many earlier studies about bank efficiency also emphasize profit efficiency, cost efficiency, or revenue efficiency such as Singh (2009) examining the profit efficiency and cost efficiency of the acquiring bank, Tripe (2010) investigating the profit efficiency of banks and bank safety and soundness, Ray and Das (2010) estimating cost and profit efficiencies of Indian banks during the post-reform period, and Cummins, Weiss, Xie Zi (2010) measuring the cost, revenue, and profit efficiency of banks. Since a zero or negative profit of a bank will cause the conventional DEA model to fail, Ke, Li and Chiu (2011) use the Nerlovian profit efficiency indicator to estimate the profit efficiency of banks. They also decompose the Nerlovian profit efficiency indicator into technical and allocation efficiencies. The conventional issues of profit and cost efficiencies in the banking industry have shifted to the fact that non-performing loans (NPLs) are undesirable outputs of banks. Studies about NPLs include Aly, Grabowski, Pasurka and Rangan (1990), English, Grosskopf, Hayes and Yaisawarng (1993), Favero and Papi (1995), Miller and Noulas (1996), Saha and Ravisankar (2000), Rezvanian and Mehdian (2002), and Fukuyama and Weber (2002).

The research objective of this paper is banks under financial holding companies (hereafter FHC bank(s)). Since financial holding companies (FHCs) allow the resources of individual financial institutions, including banks, securities, and insurance companies, to be consolidated and permit cross sector financial mergers, FHC banks have an ability to diversify and extend their business scope instead of competing against homogenous products with independent banks (Lee, 2001). Numerous studies focus on the efficiency and productivity of independent banks, but relatively few research studies evaluate the efficiency and productivity of FHC banks (Grabowski, Rangan and Rezavanian 1993; Kohers, Huang and Kohers, 2000; Vennet, 2002; Yamori, 2003). Recently, research issues in the banking industry have transferred to the multi-component efficiency combining profit, cost, revenue efficiencies, etc. into an aggregate efficiency. According to our best knowledge, there is no paper in the literature that discusses the multi-component of FHC banks. This present paper looks to fill this gap.

A system is composed of multiple components, and the system's efficiency depends on all the components' efficiency. Since banks, car factories or universities are decision-making units (DMUs) with different tasks, different DMUs are made up of different components. For example, the components of a bank could be profitability and marketability, the components of a car factory could be production and administration, and the components of a university could be education and research. DMUs under this structure are called multi-component DMUs.

In the literature, Amirteimoori and Kordrostami (2005) and Cook, Hababou and Tuenter (2000) view banks as multi-component DMUs. If each component in the system is efficient, then the system is also efficient. However, the ordinary DEA model does not consider multi-component efficiency. The seminal study estimating the efficiency of each component and aggregated efficiency of units is Cook et al. (2000). Profitability and marketability efficiencies are the two main objectives of banks as emphasized by the banking efficiency literature (see Seiford and Zhu, 1999; Luo, 2003). Seiford and Zhu (1999) and Luo (2003) measure profitability efficiency through three inputs (employees, assets, and stockholders' equity) and two outputs (revenue and profits) and look at marketability efficiency through two inputs (revenue and profits) and three outputs (market value, return to investors, and earnings per share, i.e., EPS). Seiford and Zhu (1999) take the top 55 U.S. commercial banks as an example and conclude that larger banks perform better at profitability efficiency, while smaller banks obtain higher levels of marketability efficiency. They also indicate that bank acquisition has no influence on the efficiency of the merged banks, but rather impacts the efficiency of other unmerged banks.

Luo (2003) uses a sample of 245 large banks and concludes that there is a negative relationship between bank size and marketability efficiency. He also announces that banks' profitability and marketability efficiencies do not seem to be affected by the geographical location of the banks. Lo and Lu (2006) explore the profitability and marketability efficiencies of FHCs in Taiwan. Their study combines factor-specific measures and the BCC-DEA model (a data envelopment analysis (DEA) approach, as suggested by Banker, Charnes and Cooper. (1984)), to find the most important input and output factors that can be treated as the benchmarks of FHCs. Results indicate that large-size FHCs are generally more efficient than small-size ones. Noora, Lotfi and Payan (2011) take the data from a study by Amirteimoori and Kordrostami (2005) with some changes to measure the multi-component of 19 banks by a fractional program model.

The research on profitability and marketability efficiencies has been extended to the high-tech industry such as Lu and Hung (2009) who study the performance of information and communication (IC) fabless firms by utilizing a classical BCC-DEA method. They find that marketability performance is better than profitability performance for fabless firms in Taiwan. The issue of multi-component efficiency has been further extended to other industries such as Eslami, Mehralizadeh and Jahanshahloo (2009) who estimate the multi-component efficiency of 18 Iranian automobile and automobile parts manufacturing companies using modified DEA models. The component structure includes the components of production and administration where the component efficiencies are computed separately and then the aggregate efficiency is estimated. Jelodar, Shoja, Sanei and Abri (2009) measure the multi-component efficiency of 19 Iranian car factories by using a common set of weights model that obtains the efficiency scores of all components and the aggregated efficiency of all DMUs by solving only one linear programming problem, and all these car factories consist of production and administration components.

In this study we not only estimate the profitability and marketability efficiencies of banks, but their multi-component efficiency as well. Some previous studies such as Cook et al. (2000), Jahanshahloo, Amirteimoori snf Kordrostami (2004), and Amirteimoori and Nashtaei (2006) have mentioned the concept of a measurement for multi-component efficiency. In the multi-component efficiency model, some inputs are often shared among all those components, and all components are then combined to produce some outputs. Cook et al. (2000) use a major Canadian bank as an example to measure the multi-component efficiency score by involving the sales and service functions within the bank. Jahanshahloo et al. (2004) apply the model of an aggregate measure of efficiency with a component measurement on Iranian banks. Amirteimoori and Nashtaei (2006) take 14 Iranian bank branches as an example to define returns to scale in multi-component environments where each branch is investigated by means of sales and services as the two different components.

The model set-ups of Cook et al. (2000), Jahanshahloo et al. (2004), and Amirteimoori and Nashtaei (2006) are different from those of Seiford and Zhu (1999) and Luo (2003), where the former use the two-stage DEA to estimate the profitability and marketability efficiencies of banks. Koopmans (1951) initially provides the idea that the final output is also the intermediate input, believing that this idea fits with the international trade behavior for trading intermediate inputs. This concept is applied in a network activity analysis model in which some outputs are produced and then also used as intermediate inputs in the next production stage (Färe and Grosskopf, 1996; Seiford and Zhu, 1999; Luo, 2003).

The motivation of this paper is based on three facts: (i) a bank system is composed of many components such as profitability and marketability; (ii) the final outputs in stage 1 could be the inputs in the next stage; (iii) there is no paper in the literature that has studied the multi-component efficiency of FHC banks. The purpose of this paper is to introduce the RAM model initially proposed by Cooper, Park and Pastor (2000) and Sueyoshi and Goto (2011) to measure the profitability and marketability efficiencies of FHC banks. We also establish a RAM variation model to estimate the multi-component efficiency of a FHC bank. An original work by Seiford and Zhu (1999) suggests that profitability and marketability efficiencies are two emphasized objectives (components) in the banking industry, and thus our study also targets the multi-component efficiency of a FHC bank. The dataset includes 13 FHC banks in Taiwan and the time span of the data is from 2009 to 2011.

The contribution of our paper is as follows: (i) Use the RAM model to estimate the profitability and marketability efficiencies of FHC banks in Taiwan; (ii) Create the RAM variation model to estimate the multi-component efficiency of FHC banks in Taiwan; (iii) Create the three-dimensional BCG (Boston Consulting Group) matrix to analyze the results of the three kinds of efficiency. Figure 1 shows that the production process in the banking industry involves profitability and marketability efficiencies, which can be combined into multi-component banking efficiency.

The remaining framework of the paper is organized as follows. In the following section, we introduce the methodology. Section 3 presents the introduction of variables and data. Section 4 implements the empirical analysis and discusses the findings. In the final section we provide some concluding remarks.

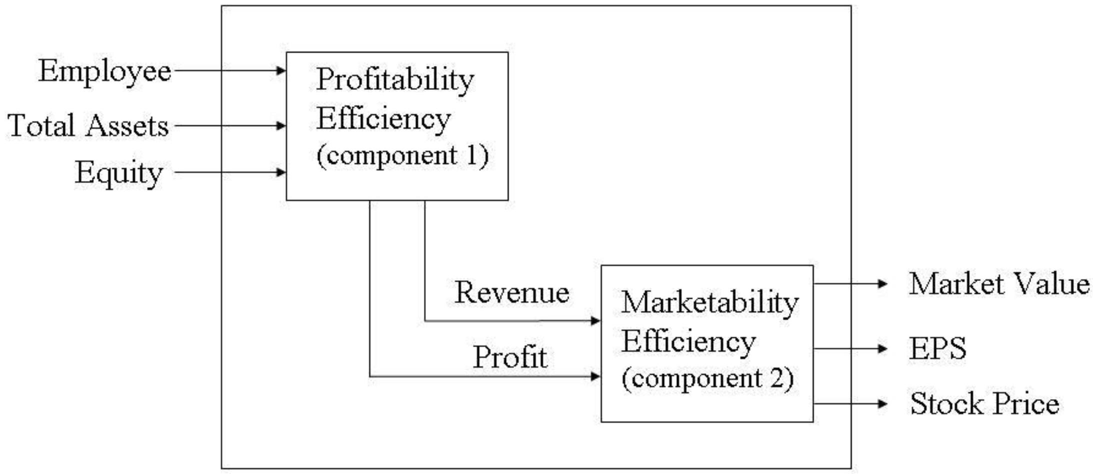

Figure 1. A multi-component banking efficiency model

2. Methodology: A RAM Model

In this section we first introduce the RAM model originally proposed by Cooper et al. (2000) and Sueyoshi and Goto (2011) to measure profitability and marketability efficiencies. We then establish the RAM variation model to measure the multi-component efficiency.

2.1. Profitability Efficiency

In order to apply the initial RAM model for estimating banking profitability efficiency, we consider n decision-making units (DMUs). In this stage, each DMU uses m kinds of inputs to produce s kinds of outputs. We define x_{ij} as the ith input for the jth DMU, and o_{rj} as the rth output for the jth DMU, where $j = 1,\ldots, n$; $i = 1,\ldots, m$; and $r = 1,\ldots, s$.

The profitability efficiency measurement of the specific kth DMU is computed by the following output-oriented RAM model:

$$Max \sum_{i=1}^{m} \Omega_i^x q_i^x + \sum_{r=1}^{s} \Omega_r^o q_r^o$$

s.t.

$$\sum_{j=1}^{n} x_{ij} u_j + q_i^x = x_{ik}$$

$$\sum_{j=1}^{n} o_{rj} u_j - q_r^o = o_{rk}$$

$$\sum_{j=1}^{n} u_j = 1$$

$$u_j \geq 0,\ q_i^x \geq 0, \text{ and } q_r^o \geq 0, \qquad (1)$$

where u_j represents the respective weights of the jth DMU used for connecting the input and output variables by a convex combination; q_i^x and q_r^o are slack variables related to the ith input and rth output, respectively.

The ranges in the RAM model are determined by the upper and lower bounds on the inputs and those of the outputs specified by $\overline{x}_i = \max\{x_i\}$, $\underline{x}_i = \min\{x_i\}$, $\overline{o}_r = \max\{o_r\}$, and $\underline{o}_r = \min\{o_r\}$. The ranges in the RAM model are $\Omega_i^x = 1 / [(m + s)(\overline{x}_i - \underline{x}_i)]$ and $\Omega_r^o = 1 / [(m + s)(\overline{o}_r - \underline{o}_r)]$. Hence, the profitability efficiency score (η) of the kth DMU is measured by subtracting the level of inefficiency from unity as follows:

$$\eta = 1 - [\sum_{i=1}^{m} \Omega_i^x q_i^{x*} + \sum_{r=1}^{s} \Omega_r^o q_r^{o*}]. \qquad (2)$$

The superscript * stands for the optimal slack variable determined on optimality in Equation (1).

2.2. Marketability Efficiency

It is interesting that the outputs in the stage of profitability efficiency measurement are the inputs in the stage of marketability efficiency measurement. According to this concept, we define o_{rj} as the rth input for the jth DMU, and y_{fj} as the fth output for the jth DMU, where $f = 1,\ldots, h$. The marketability efficiency measurement of the specific kth DMU is done by the following output-oriented RAM model:

$$Max \sum_{r=1}^{s} \Lambda_r^o w_r^o + \sum_{f=1}^{h} \Lambda_f^y w_f^y$$

s.t.

$$\sum_{j=1}^{n} o_{rj}\phi_j + w_r^o = o_{rk}$$

$$\sum_{j=1}^{n} y_{fj}\phi_j - w_f^y = y_{fk}$$

$$\sum_{j=1}^{n} \phi_j = 1$$

$$\phi_j \geq 0,\ w_r^o \geq 0, \text{ and } w_f^y \geq 0, \quad (3)$$

where ϕ_j show the respective weights of the jth DMU used for connecting the input and output variables by a convex combination in this stage, and w_r^o and w_f^y are slack variables related to the rth input and fth output, respectively.

In this stage, the upper and lower bounds on the inputs and those of the outputs are determined by $\overline{o}_r$ = max $\{o_r\}$, $\underline{o}_r$ = min $\{o_r\}$, $\overline{y}_f$ = max $\{y_f\}$, and $\underline{y}_f$ = min $\{y_f\}$. Thus, $\Lambda_r^o = 1 / [(s + h)(\overline{o}_r - \underline{o}_r)]$ and $\Lambda_f^y = 1 / [(s + h)(\overline{y}_f - \underline{y}_f)]$ stand for the respective ranges for the inputs and outputs in Equation (3). The marketability efficiency score (ρ) of the kth DMU is measured by subtracting the level of inefficiency from unity as follows:

$$\rho = 1 - [\sum_{r=1}^{s} \Lambda_r^o w_r^{o*} + \sum_{f=1}^{h} \Lambda_f^y w_f^{y*}]. \quad (4)$$

The superscript * stands for the optimal slack variable determined on optimality in Equation (3).

2.3. Multi-Component Efficiency: A RAM Variation Model

Multi-component efficiency combines profitability efficiency and the marketability efficiency. In order to measure multi-component efficiency, we must establish a RAM variation model that is different from the respective profitability and marketability performance measures.

The ranges for the multi-component efficiency model are specified as follows: $\Omega_i^x = 1 / [(m + s + h)(\overline{x}_i - \underline{x}_i)]$, $\Omega_r^o = \Lambda_r^o = 1 / [(m + s + h)(\overline{o}_r - \underline{o}_r)]$, $\Lambda_f^y = 1/ [(m + s + h)(\overline{y}_f - \underline{y}_f)]$. The new type of combination for measuring multi-component efficiency on the kth DMU has the following mathematical structure:

$$Max \sum_{i=1}^{m} \Omega_i^x q_i^x + \sum_{r=1}^{s} \Omega_r^o (q_r^o + w_r^o) + \sum_{f=1}^{h} \Lambda_f^y w_f^y$$

s.t.

$$\sum_{j=1}^{n} x_{ij}u_j + q_i^x = x_{ik}$$

$$\sum_{j=1}^{n} o_{rj}u_j - q_r^o = o_{rk}$$

$$\sum_{j=1}^{n} u_j = 1$$

$$\sum_{j=1}^{n} o_{rj}\phi_j + w_r^o = o_{rk}$$

$$\sum_{j=1}^{n} y_{fj}\phi_j - w_f^y = y_{fk}$$
$$\sum_{j=1}^{n} \phi_j = 1$$
$$u_j \geq 0$$
$$\phi_j \geq 0$$
$$q_i^x \geq 0$$
$$q_r^o \geq 0$$
$$w_r^o \geq 0$$
$$w_f^y \geq 0, \qquad (5)$$

where u_j (ϕ_j) present the respective weights of the *j*th DMU used for connecting the inputs and the outputs by a convex combination in the stage of profitability (marketability) efficiency measurement; q_i^x and q_r^o are slack variables related respectively to the *i*th input and *r*th output in the stage of profitability efficiency measurement; w_r^o and w_f^y are also slack variables related respectively to the *r*th input and *f*th output in the stage of marketability efficiency measurement.

The multi-component efficiency score (λ) solved by means of linear programming is measured on the optimality of Equation (5):

$$\lambda = 1 - [\sum_{i=1}^{m} \Omega_i^x q_i^{x*} + \sum_{r=1}^{s} \Omega_r^o (q_r^{o*} + w_r^{o*}) + \sum_{f=1}^{h} \Lambda_f^y w_f^{y*}]. \qquad (6)$$

Equation (6) indicates that the multi-component efficiency score is obtained by subtracting the level of inefficiency from unity.

3. Variables and Data

According to the two classic studies by Seiford and Zhu (1999) and Luo (2003), we follow their choice of input and output variables as follows: (i) In the stage of profitability efficiency estimation, the three input variables are employees, assets, and equity, and the two output variables are revenue and profits. (ii) In the stage of marketability efficiency estimation, the two input variables are revenue and profits, and the three output variables are market value, EPS, and stock price. Data are from the Taiwan Economic Journal Data Bank. The data period is from 2009 to 2011. The total number of FHC banks is 16 in 2012, but we eliminate a newly established FHC bank and two FHC banks with incomplete data. Thus, our sample is 13 FHC banks in Taiwan.

Table 1 reports the descriptive statistics of the input and output variables, where the standard deviation (std. dev.) values of employee, total assets, equity, revenue, profit, and market value are large, which represents that there is a large scale difference among the FHC banks' sample. The average values of data from 2009 to 2011 show that the mean value is 5566.72 and standard deviation is 2318.92 for number of employees. The mean and standard deviation are respectively NT$1,370,014.97 million and NT$745,551.04 million for total assets. The mean and the standard deviation of equity are NT$78,702.85 million and NT$42,993.08, respectively. Revenue has a mean value of about NT$53,587.59 million with a standard deviation of NT$27,218.17. The mean value and the standard deviation of market value are NT$154,861.71 million and NT$117,135.65, respectively. The mean value is NT$1.20 and standard deviation is NT$0.44 for EPS, whereas the mean value and standard deviation of stock price are NT$19.73 and NT$10.52, respectively. The relative small standard deviation values for EPS and the stock price imply that the FHC banks have similar results in the capital market.

Table 1**.** Descriptive statistics for the database

		2009	2010	2011	Avg.
Employee (persons)	**Mean**	5,455.154	5,581.615	5,663.385	5,566.72
	Std. Dev.	2,311.842	2,336.765	2,306.260	2,318.29
Total assets (NT$1 million)	**Mean**	1,293,076.538	1,373,974.923	1,442,993.462	1,370,014.97
	Std. Dev.	739,416.245	741,577.224	755,659.663	745,551.04
Equity (NT$1 million)	**Mean**	73,872.154	78,333.154	83,903.231	78,702.85
	Std. Dev.	42,084.233	43,163.891	43,731.108	42,993.08
Revenue (NT$1 million)	**Mean**	54,714.000	50,746.308	55,302.462	53,587.59
	Std. Dev.	27,915.177	27,143.233	26,596.095	27,218.17
Profit (NT$1 million)	**Mean**	10,829.077	7,512.538	8,623.231	8,988.28
	Std. Dev.	5,110.296	4,794.969	5,820.772	5,242.01
Market value (NT$1 million)	**Mean**	137,346.558	156,131.481	171,107.077	154,861.71
	Std. Dev.	111,175.980	125,003.006	115,227.968	117,135.65
EPS	**Mean**	1.168	1.183	1.256	1.20
	Std. Dev.	0.535	0.439	0.356	0.44
Stock price (NT$)	**Mean**	17.850	20.008	21.343	19.73
	Std. Dev.	10.531	11.495	9.520	10.52

Data source: Taiwan Economic Journal Data Bank.

4. Empirical Results

In this section we estimate and analyze the profitability and marketability efficiencies of the FHC banks by the RAM model and BCG matrix. We also estimate and analyze the multi-component efficiency of FHC banks by creating the RAM variation model and the three-dimension BCG matrix. Finally, we investigate the relationship between bank size and the three kinds of efficiency scores and compare the results with those in Seiford and Zhu (1999).

4.1. Empirical Results on the Profit Efficiency and Market Efficiency

Table 2 shows that the mean values of profitability and marketability efficiencies from 2009 to 2011 are 0.938 and 0.834, respectively. The mean values of profitability efficiency for 6 out of 13 FHC banks (about 46%) are lower than the average profitability efficiency. Similarly, the mean values of marketability efficiency for 7 out of 13 FHC banks (about 54%) are lower than the average marketability efficiency. On the other hand, we find that profitability efficiency is better than marketability efficiency for all 13 FHC banks. This result shows that FHC banks' earnings do not mainly come from the stock market, but rather from operating profits. This can be treated as supporting that the stock prices of FHC banks do not respond to bank profitability.

We employ profitability and marketability efficiencies as two indices to classify the 13 FHC banks into the traditional two-dimensional BCG matrix. All banks are split into four quadrants. The meanings for the four quadrants are outlined as follows.

Quadrant I (value type FHC bank with a high profitability efficiency score and a high marketability score): 'Value' type FHC banks in quadrant I indicate banks with excellent performance on profitability and marketability. The FHC banks that are this type include CUB, FbB, YtB, SKB, and JSB, which can be viewed as benchmarks for the others. Moreover, the samples located in quadrant I are all privately-owned FHC banks.

Table 2. The profitability and marketability efficiency scores of 13 FHC banks

Bank	Profitability efficiency				Marketability efficiency			
	2009	2010	2011	Ave.	2009	2010	2011	Ave.
FB	1.000	0.886	0.897	0.928	0.734	0.767	0.714	0.738
HNB	0.815	0.804	0.853	0.824	0.787	0.874	0.800	0.820
MB	1.000	1.000	1.000	1.000	0.655	0.764	0.785	0.735
CTB	0.713	1.000	1.000	0.904	0.801	0.701	0.703	0.735
CUB	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
FbB	1.000	0.999	1.000	1.000	0.814	1.000	1.000	0.938
BSP	0.906	0.898	0.891	0.898	0.755	0.841	0.791	0.796
ESB	0.901	0.910	0.870	0.894	0.778	0.879	0.873	0.843
YtB	1.000	0.999	1.000	1.000	1.000	1.000	1.000	1.000
TsB	1.000	1.000	1.000	1.000	0.601	0.688	0.622	0.637
SKB	1.000	0.964	1.000	0.988	0.910	0.974	0.891	0.925
JSB	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TCB	0.766	0.740	0.755	0.754	0.608	0.767	0.645	0.673
Avg.	0.931	0.938	0.944	0.938	0.803	0.866	0.833	0.834

Quadrant II (monitor type FHC bank with a low profitability efficiency score, but a high marketability score): "Monitor" type FHC banks in quadrant II have low profitability, but high marketability. Generally speaking, high profitability induces high marketability. Thus, we propose that the true value of a "Monitor" type FHC bank has already been over-reflected. In our sample, ESB is a "Monitor" type FHC bank.

Quadrant III (ready type FHC bank with a low profitability efficiency score and a low marketability score): The "Ready" type FHC banks are located in quadrant III. These FHC banks have poor profitability and poor marketability. In the future, they should put more care into activities of earning profits and market attractiveness. These FHC banks include FB, HNB, CTB, BSP, and TCB, with the proportion of semi-publicly-owned FHC banks in this list over 50%, including FB, HNB, and TCB. Moreover, all three semi-publicly-owned banks are located in quadrant III. This result can be treated as showing that the performances of semi-publicly-owned FHC banks are always inferior to those of privately-owned FHC banks.

Quadrant IV (latent type FHC bank with a high profitability efficiency score, but a low marketability score): We propose the label "latent" for FHC banks in quadrant IV, since these FHC banks have high profitability, but low marketability efficiency. Because of a positive relationship between profitability and marketability, we expect these FHC banks, including MB and TsB, to show significant progress in marketability efficiency.

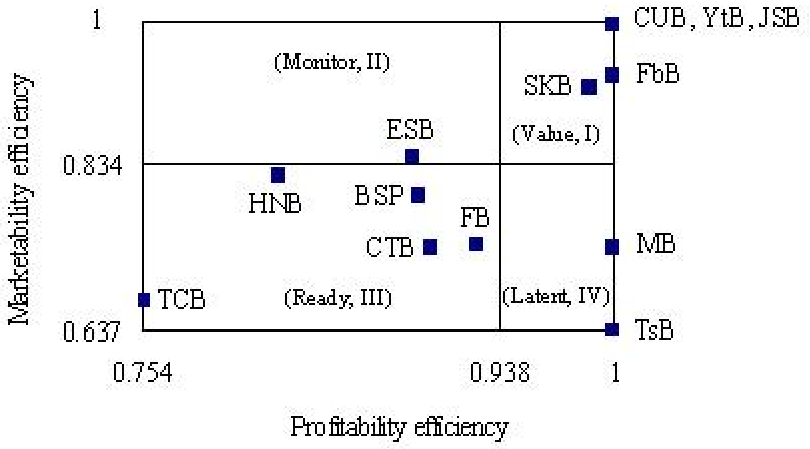

Figure 2. BCG matrix

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3.2. Multi-Component Efficiency: A New Thinking Framework

Based on the result of the RAM variation model, we divide 13 FHC banks into three sections: low, middle, and high multi-component efficiencies. The classified process is shown in Table 3, and the classified result is shown in Table 4 where there are 7 FHC banks with high multi-component efficiency scores in Cluster 1. The FHC banks in Cluster 1 include MB, CUB, FbB, YtB, TsB, SKB, and JSB. Cluster 2 includes HNB, BSP, and ESB, which have middle multi-component efficiency scores. The remaining FHC banks include FB, CTB, and TCB, which have low multi-component efficiency scores. Three semi-publicly-owned FHC banks, including HNB, FB, and TCB are divided into Clusters 2 and 3, which have the lower or middle multi-component efficiency scores.

Table 3. The multi-component efficiency scores of FHC banks for clustering

Bank	Multi-component efficiency											
	2009	**2010**	**2011**	**Avg.**	**2009**	**2010**	**2011**	**Avg.**	**2009**	**2010**	**2011**	**Avg.**
FB	1.000	0.782	1.000	0.927	0.999	1.000	1.000	0.999	1.000	1.000	1.000	**1.000**
HNB	0.846	0.776	0.838	0.820	1.000	1.000	1.000	**1.000**	–	–	–	–
MB	1.000	1.000	1.000	**1.000**	–	–	–	–	–	–	–	–
CTB	0.809	1.000	1.000	0.936	0.999	1.000	1.000	0.999	1.000	1.000	1.000	**1.000**
CUB	1.000	1.000	1.000	**1.000**	–	–	–	–	–	–	–	–
FbB	1.000	1.000	1.000	**1.000**	–	–	–	–	–	–	–	–
BSP	0.832	0.817	1.000	0.883	1.000	1.000	1.000	**1.000**	–	–	–	–
ESB	0.813	0.853	0.865	0.844	1.000	1.000	1.000	**1.000**	–	–	–	–
YtB	1.000	1.000	1.000	**1.000**	–	–	–	–	–	–	–	–
TsB	1.000	1.000	1.000	**1.000**	–	–	–	–	–	–	–	–
SKB	1.000	1.000	0.999	**1.000**	–	–	–	–	–	–	–	–
JSB	1.000	1.000	1.000	**1.000**	–	–	–	–	–	–	–	–
TCB	0.657	0.663	0.710	0.677	1.000	1.000	0.999	0.999	1.000	1.000	1.000	**1.000**

Combining the cluster result in Table 4 and the result in the BCG matrix (Figure 2), we create a three-dimensional BCG matrix in Figure 3, which provides a new thinking framework and a clearer classification than that in the traditional BCG matrix. The three semi-publicly-owned FHC banks - FB, HNB, and TCB - are divided into the “ready” type FHC bank in the traditional BCG matrix (Figure 2). In the three-dimensional BCG matrix, HNB has middle multi-component efficiency, and FB and TCB have low multi-component efficiency. The three-dimensional BCG matrix provides a better classification as follows.

Table 4. Cluster result of FHC banks

Cluster	Banks
1	MB CUB FbB YtB TsB SKB JSB
2	HNB BSP ESB
3	FB CTB TCB

(i) High multi-component efficiency (H) for the “value” type FHC bank: CUB, YtB, JSB, FbB, and SKB.
(ii) High multi-component efficiency for the “latent” type FHC bank: MB and TsB.
(iii) Middle multi-component efficiency (M) for the “monitor” type FHC bank: ESB.
(iv) Middle multi-component efficiency for the “ready” type FHC bank: HNB and BSP.
(v) Low multi-component efficiency (L) for the “ready” type FHC bank: FB, CTB, and TCB.

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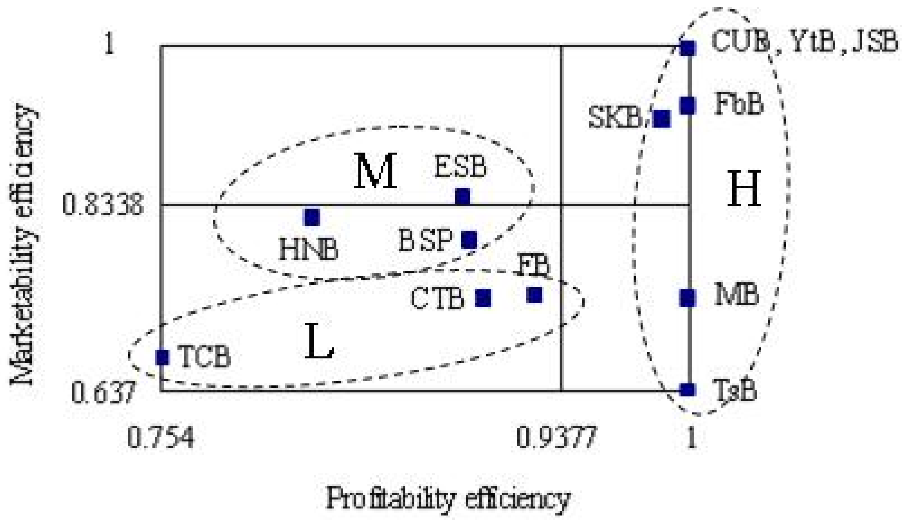

Figure 3. Three-dimensional BCG matrix

Based on the result in Figure 3, we assert that there is a relationship among profitability, marketability, and multi-component efficiencies and outlined by Figure 4 as follows.

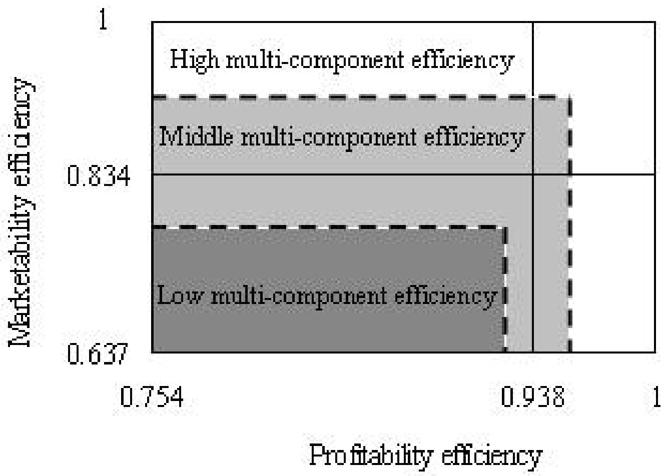

Figure 4. The relationship among the three kinds of efficiency

In Figure 4, the high profitability and (or) high marketability efficiencies should be treated as high multi-component efficiency; the middle profitability and (or) middle marketability efficiencies should be treated as middle multi-component efficiency; the low profitability and (or) low marketability efficiencies should be treated as low multi-component efficiency.

4.3. A Relationship between Market Size and Three kinds of Efficiency Scores

In our sample, FB, HNB, and TCB are three semi-publicly-owned FHC banks. Generally speaking, the size of total assets of a semi-publicly-owned FHC bank is always larger than that for a privately-owned FHC bank in Taiwan. This finding can be confirmed by Figure 5 as follows.

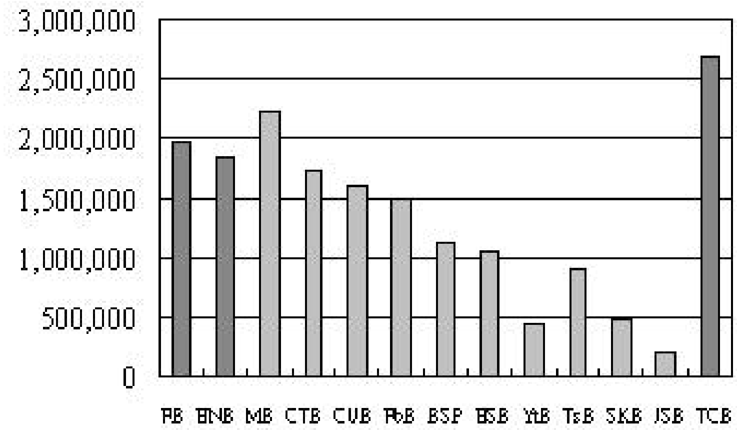

Figure 5**.** The average total asset size of FHC banks in Taiwan

The analysis results in the BCG matrix (Figure 2) and the three-dimensional BCG matrix (Figure 3) tell us that the three semi-publicly-owned FHC banks always have more inferior profitability, marketability, and multi-component efficiency scores than the remaining privately-owned FHC banks. Thus, we are interested in the relationship between the total asset size of FHC bank and the three kinds of efficiency scores. The analysis result is shown in Table 5.

Table 5. An analysis on the truncated regression from 2009 to 2011

	Constant	**Total assets**
Profitability efficiency score	1.0239^{***} ($p < 0.01$)	$-6.29*10^{-8**}$ ($p < 0.05$)
Marketability efficiency score	0.9746^{***} ($p < 0.01$)	$-1.03*10^{-7**}$ ($p < 0.05$)
Multi-component efficiency score	1.0332^{***} ($p < 0.01$)	$-7.55*10^{-8**}$ ($p < 0.05$)

Note: ** represents the coefficient is significant under the 95% confidence level; *** represents the coefficient is significant under the 99% confidence level.

The result in Table 5 shows that there is a significant negative relationship between the total asset size of a FHC bank and the three kinds of efficiency scores. This finding is very different with that in Seiford and Zhu (1999), who take the top 55 U.S. commercial banks as an example and conclude that larger banks have higher levels of profitability efficiency, while smaller banks have better performance on marketability efficiency.

5.Concluding Remarks

Profitability and marketability are the two major operation targets of a bank. The previous literature has measured profitability and marketability efficiencies by using the radical-DEA measurement as a research approach. In this paper we also estimate the profitability and marketability efficiencies of FHC banks, but use the RAM-DEA approach. Moreover, we create a RAM variation model to estimate the multi-component efficiency of FHC banks. The analysis process creates and uses two new analysis methods: one is the bank classification by our RAM variation model; the other one is the three-dimensional BGC matrix proposed by our paper.

This study has examined the operation performances of 13 FHC banks, including 3 semi-publicly-owned and 10 privately-owned FHC banks, by utilizing the RAM model to estimate the profitability and marketability efficiencies and by utilizing the RAM variation model to estimate the multi-component efficiency. We classify the three semi-publicly-owned FHC banks in the BCG matrix as “ready” type FHC banks with low profitability and low marketability efficiency scores. However, the three semi-publicly-owned FHC banks can be re-classified into middle multi-component efficiency and low multi-component efficiency by using the three-dimensional BCG matrix.

A semi-publicly-owned FHC bank in Taiwan, generally speaking, has more total assets than a privately-owned FHC bank. However, no matter in the traditional BCG matrix or in the three-dimensional BCG matrix, the analysis results always show that the three semi-publicly-owned FHC banks have a more inferior performance than the privately-owned FHC banks. Thus, we examined the relationship between the total asset size of a FHC bank and the three kinds of efficiency scores. The empirical result presents that the total asset size of a FHC bank and the three kinds of efficiency scores have a negative relationship. This finding is very different with that provided by Seiford and Zhu (1999).

The multi-component efficiency of FHC banks in this paper only includes two components: one is profitability efficiency and the other is marketability efficiency. In a future study, the concept of multi-component efficiency can be applied in another industry that is composed of more than two components.

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