Sun Yat-Sen Management Review
P125-157

A Study on the Performance Evaluation of Taiwan's Newly Reorganized Banks[1]

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Abstract

All companies face problems in their operation, just like human body. Yet, most problems elicit warning signals during the early stage. If we could conduct simple diagnosis or measurement for the company, we could early detect the problem before they become unmanageable, and could map out corresponding plans to cope with it. In this paper, we applied two mathematical tools, Grey Relation Analysis (GRA) and Data Envelopment Analysis (DEA), to evaluate the performance of commercial banks newly reorganized from trust businesses in Taiwan. Both methods have limitations in application as well as respective advantages and disadvantages. Analysis and comparison of the GRA and DEA when applied to the evaluation of performance are discussed. The empirical result shows that the rankings of the three firms in the empirical study by using DEA and GRA are the same: first, the United World Chinese Bank, second, China Trust Commercial Bank, and third, Chinfon Bank.

Keywords: Performance evaluation, Data envelopment analysis, Grey relation analysis, TOPSIS

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[1] The authors are grateful for the assistance of Manager Liao of Human Resources Department and Miss Chang Chui-Ping of the library in China Trust Commercial Bank, Miss Chou Pei-Chun of the library in Chinfon Bank, and Miss Chen Huei-Ling of the Accounting Department, Section Manager Chen of Human Resources of the United World Chinese Bank, for their generous supply of financial data.

I. Introduction

If the management of an enterprise could conduct their own measurement or diagnosis of the enterprises during the management cycle at regular intervals, they could understand better how effective they have used their resources. The result of the performance evaluation could also be served as reference for them in their future allocation of resources for the enterprise. Therefore, effective performance measurement for enterprises could definitely contribute to effective management. In addition, the evaluation of operational performance has always been a major concern for industries, governments and academe. Operational performance not only serves as a basis for organizational improvement and criteria for detecting problems in enterprises, but also as a policy determinant for governments in mapping out relevant plans. As Taiwan is making every effort to enhance its competitive advantage, its strengths in international finance, liberalization of the financial sector and internationalization, the trust business in Taiwan is still subject to regulation and restrictions. Recently, a number of trust businesses were reorganized into commercial banks in Taiwan. Knowledge of the operational performance after their reorganization would be vital for their sustained operation. Therefore, we conducted an empirical study on three banks reorganized from investment trust firms, to identify any inherent problems and solutions.

However, choosing a viable method for effective evaluation of performance is not an easy task. There is a substantial body of literature discussing different research methods applied to performance evaluation. These methods include (1) Multivariate Statistical Analysis (e.g., Huang 1986; Wey 1986; Chen 1991; Chen 1999; Fielding et al. 1985); (2) Data Envelopment Analysis (e.g., Seiford and Zhu 1999; Cheng 1998; Lin 1998; Liao 1993; Grosskopf and Valdmanis 1987); (3) Analytic Hierarchy Process (e.g., Lin 2000; Shih 2000; Hung 1998; Hsu 1995); (4) Fuzzy Set Theory (e.g., Shih 2000; Hu 2000); (5) Grey Relation Analysis (e.g., Feng and Wang 2000; Tsai 2000; Lin, 2000); (6) Balanced Scorecard (e.g., Chen 2000; Huang 1999; Jang 1999); and (7) Financial Statement Analysis (e.g., Collins 1980; Pantalone and Platt 1987; Espahbodi 1991). Some of the methods may have already been known to the public. Other methods were simply borrowed from the domain of industrial study and applied to commerce. Some are still in the embryonic stage. In this paper, we applied two mathematical tools, Grey Relation Analysis (GRA) and Data Envelopment Analysis (DEA), to evaluate the performance of commercial banks newly reorganized from trust businesses in Taiwan. Both methods have limitations in application as well as respective

advantages and disadvantages. Analysis and comparison of the GRA and DEA when applied to the evaluation of performance are discussed.

The remainder of the paper is organized as follows. Section 2 is the literature review. Section 3 describes the research method. Section 4 is the empirical result of GRA. Section 5 compares GRA results to the Data Envelopment Analysis (DEA). The conclusions are discussed in Section 6 and suggestions for future investigation are put forward.

II. Literature Review

2.1 The Investment Trust Business in Taiwan in Retrospect and its Current Situation

According to Article 20 of Taiwan's Banking Law, investment trust firm is one of the four types of banks defined in the law. The four types of banks are commercial bank, saving bank, specialized bank and investment trust. Currently, the trust divisions of banks also deal with trust business alongside investment trust firms. Investment trust firm is a mixture of trust and investment, and they are of equal weight. Therefore, investment trust firms deal with both trust and investment businesses except banking. As such, they fall into the domain of capital market, and can not deal with regular banking business like checking account or current account deposits. In the United Kingdom, United States of America, France and Japan, the running of “trust” and “investment” business is separated. The division that operates “investment” business tends to be a professional unit, and their business is confined to securities investment. For the running of “trust” business, it is usually operates by a functional division of a bank that can deal with savings. This is the first distinction from the operation in Taiwan (Wu 1999).

According to the study of Huang and Huang (1990) on the operation of investment trusts, Taiwan is different from Japan in terms of the legal regime, products and education in the trust business. The critical issue in operation is that both the “Trust Law” and “Trust Industry Law” were only passed in 1995 and 2000 respectively. Previously, there had been no legal guidelines for the operation of such business. Thus, the trust firms had no choice but to reorganize themselves into banks in order to keep the operation running. Knowledge of the operational performance after their reorganization would be vital for their sustained operation.

Therefore, we conducted an empirical study on three banks reorganized from investment trust firms, to identify any inherent problems and solutions.

2.2 Different Methods for Performance Evaluation

Essentially, performance evaluation carries a number of attributes (or criteria) and covers multiple levels. Items chosen for evaluating performance include both quantifiable and non-quantifiable indicators; they also may be mutually exclusive, related or independent of each other. In addition, the problems that are being faced are extremely complex and unpredictable. Therefore, a viable method for effective evaluation of performance aimed at providing solutions for issues with multiple variables and targets have recently been emerging.

Objectivity, fairness and feasibility are crucial for performance evaluation. This study examines seven methods applicable to the evaluation of performance. They are (1) Multivariate Statistical Analysis; (2) Data Envelopment Analysis; (3) Analytic Hierarchy Process; (4) Fuzzy Set Theory; (5) Grey Relation Analysis; (6) Balanced Scorecard; and (7) Financial Statement Analysis. The fundamental theories of the seven methods, their advantages and disadvantages when applied to performance evaluation are described in detail below:

(1) Multivariate Statistical Analysis: Based on the diversity of space in statistical method to quantitify complex issues or events and to arrange them systematically for the purpose of classification, inference, evaluation and forecast.

Strengths : (i) It is based on traditional methods of statistics, with a solid foundation on theoretical settings. (ii) The system is complete and could be applied in almost all areas of research.

Weaknesses: (i) It requires a large sample size and normal distribution. (ii) The research results could be influenced by subjective judgment. (iii) Methods without statistical testing cannot be used systematically, which hampers further interpretation of the results.

(2) Data Envelopment Analysis: Based on the concept of Pareto Optimality. When measuring the efficiency value of DMU, only the production margin is required. The production margin would then be compared with actual production for the efficiency value.

Strengths : (i) DEA could be used to handle problems with a number of inputs and outputs. (ii) It would not be influenced by different quantified units. (iii) The results of DEA evaluation on efficiency is a

composite indicator, and could be used to sketch out the concept of total production factors in economics. (iv) The weighed value in the DEA model is the product of mathematical calculation and hence free from human subjectivity, and it is therefore fair on the same platform (v) DEA not only deals with interval data, but also ordinal data. As such, it is highly flexible in handling data. (vi) The results of the evaluation by DEA could provide more information on the data used, which could be served as a reference in the decision-making process.

Weaknesses: (i) Study the authentic efficient distribution of data. (ii) Limited by sample size. If too small, the sample size would affect the outcome. (iii) Limitations on the input and output of variables; there should not be too many variables. (iv)The degree of relation between the input and output variables (indicators) is not discussed.

(3) Analytic Hierarchy Process: An approach on decision thinking. It can arrange complex and non-systematic issues into a systematic manner, from high to low hierarchy in a stepwise process and then build up the priority by the weighed value of options (indicators).

Strengths : (i) Easy to operate. (ii) The results are subject to consistency checking. (iii) Solid theoretical foundation and is objective. (iv) Easier to handle qualitative problems.

Weaknesses: (i) Fails to integrate the opinions of other experts. When there are great differences, they would cause incompatibility between the relative weighed value of the factors and the real world. (ii) Fails to discuss the relation between factors (indicators).

(4) Fuzzy Set Theory: Provides an overall evaluation on events or phenomenon influenced by a number of factors, by way of building up of subordinate functions. Accordingly, the qualitative and quantitative values of the indicators would be interchangeable, and a value in real numbers would be assigned to each factor under evaluation. Priority would then be arranged.

Strengths : (i) It can cope with a large number of uncertain problems. (ii) Since it is a simulation of human thought and decision processing, it is compatible with human behavior.

Weaknesses: (i) The degree of subordination is indicated by a value between 0

and 1, so the results of evaluation would be subject to influence by the choice over subordination function. (ii) The relation between variables (indicators) is not discussed.

(5) Grey Relation Analysis: Based on the homogeneity or heterogeneity of the trend development of factors to find out if there is Grey Relation between two indicators and to what extent.

Strengths : (i) No rigid requirement in sample size. (ii) Can still be applied when the distribution of data is uncertain. (3) Is based on data analysis, and is free from traditional subjectivity in decision-making. (iv) The method of calculation is simple and easy to apply.

Weaknesses: (i) Cannot directly handle qualitative issues (non-quantifiable). (ii) The criteria for choosing Grey Relation coefficient value would directly affect the final evaluation result.

(6) Balanced Scorecard: A performance evaluation system containing four components for evaluation. This is also called a strategic management system, which could help firms translate strategy into actions. The four components are finance, customer, internal process and learning and growth.

Strengths: (i) Can integrate information, and put various key factors for the success of the organization into one report. (ii) Avoids information overload since the indicators used for performance measurement are the key indicators.

Weaknesses: The procedure for the application of BSC is complex and time consuming.

(7) Financial Statement Analysis: People use this approach with the belief that the result of business activities of the firm would be reflected in its financial statement

Strengths: (i) Objective: It is the reflection of actual events. (ii) Concrete: All data in the financial statement can be quantitified. (iii) Measurable: Since the data in the financial statement can be quantitified, they are measurable.

Weaknesses: (i) There is no criterion for selecting a ratio that is agreeable by all users. (ii) The figures in the financial statement have been added or simplified, and could not satisfy the needs of all users. (iii)

Financial statement could not express qualitative information, such as ability, morale, potential and trust.

Each of the above seven methods can be independently applied to evaluating performance. However, no one of them is perfect. There is a saying that "Whenever there is an advantage, it entails a drawback." Researchers can only choose a method to evaluate performance that has the least amount of drawbacks for that study's particular situation. When the amount of sample data is large enough and it conforms to normal distribution, then most researchers use the Multivariate Statistical Analysis (e.g., factor analysis, cluster analysis, discriminate analysis, regression analysis) to conduct the selection of representative indicators. However, in the analysis of the empirical study (Taiwan's Newly Reorganized Banks), financial data is often incomplete or unclear, and this paper therefore is bound by realistic limits, confining itself to a situation where the amount of data is small and its significance indefinite. In this paper, GRA will be used to retrieve ratios most commonly used in financial analysis to tackle the problems of sample size and distribution uncertainty. In addition, this paper compares the GRA results with the DEA. Analysis and comparison of the GRA and DEA when applied to the evaluation of performance are discussed.

2.3 A Discussion of the Indicators for Performance Evaluation

Kaplan and Norton (1996), the inventors of the Balanced Scorecard, proposed that "measurement per se had created the focus," because when you determine what is to be measured, you have already made known what indicators are crucial. This is the reason why the selection of performance indicators is so controversial.

We attempted to adopt the five-power analysis and a review of the literature to select different ratios in financial analysis. Based on a review of the literature (from Taiwan and other countries) on financial ratios used to evaluate the performance of the banks, the ratios were classified in accordance with their respective attributes under the five-power analysis criteria commonly used in financial analysis: safety, profitability, liquidity, efficiency and growth. Ratios that have been used twice in other studies were included in this study. As shown in Table 1, this study was based on a review of 11 articles from Taiwan and six from other countries, from which we selected 39 financial ratios as the aggregated indicators for evaluating the performance of the banks in question. There are nine ratios for analyzing safety, eight for profitability, six for liquidity, ten for efficiency, and six for growth.

Table 1. The preliminary selection of aggregated financial ratios and their frequency of appearances in the literature

Type of Ratio	Ratio Code	Content of ratio	Su (1981)	Chen (1985)	Huang (1986)	Wei (1986)	Hsu (1986)	Chou (1989)	Chen (1991)	Chen (1991)	Chu (1992)	Hung (1994)	Su (1996)	Sinkey (1975)	Collins (1980)	West (1985)	Pantalone & platt (1987)	Espahbodi (1991)	Meinster & Elyas (1991)	Total appearances
Safety	S_1	Deposits / Stockholders' equity		*		*	*				*									4
	S_2	Stockholders' equity / Total Assets	*	*						*	*	*	*			*			*	8
	S_3	Liabilities / Stockholders' equity		*			*	*	*		*						*			6
	S_4	Stockholders' equity / Investment & Loans					*	*												2
	S_5	Total Assets / Stockholders' equity						*	*											2
	S_6	Loans and Lease Financing/Stockholders' Equity						*	*											2
	S_7	Stockholders' equity / Deposits	*							*										2
	S_8	Loans / Stockholders' equity									*						*			2
	S_9	Reserve for credit losses to loan / Loans and Lease Financing						*					*							2
Profitability	P_1	Operating Income/ Operating Revenues	*	*	*	*	*	*	*		*	*	*							10
	P_2	Earning Before Taxes/ Operating Revenues		*	*		*				*	*								5
	P_3	Earning Before Taxes/Average Stockholders' equity	*			*					*	*	*							5
	P_4	Earning Before Taxes / Average Total Assets	*			*					*	*	*							5
	P_5	Operating Profit / Total Assets	*					*	*	*	*	*								6
	P_6	Operating Income/ Average Stockholders' equity							*	*										2
	P_7	Net Earning / Total assets								*						*				2
	P_8	Net Earning / Average Stockholders' equity														*			*	2
Liquidity	C_1	(Cash + Deposits in Other Banks + Government Bonds) / Deposits	*	*																2
	C_2	First and Second Reserve / Deposits				*		*				*								3
	C_3	Cash + Deposits in Other Banks / Deposits					*	*	*			*	*							5
	C_4	Current Reserve / Deposits	*						*				*							3
	C_5	(Cash + T-Bills) / Total Assets												*				*		2
	C_6	Loans / Total Assets														*		*		2
Efficiency	E_1	Operating Revenues / Fixed Assets			*							*								2
	E_2	Operating Revenues / Total Assets			*	*						*								3

Type of Ratio	Ratio Code	Content of ratio	Su (1981)	Chen (1985)	Huang (1986)	Wei (1986)	Hsu (1986)	Chou (1989)	Chen (1991)	Chen (1991)	Chu (1992)	Hung (1994)	Su (1996)	Sinkey (1975)	Collins (1980)	West (1985)	Pantalone & platt (1987)	Espahbodi (1991)	Meinster & Elyas (1991)	Total appearances
Efficiency	E_3	Noninterest Interest Expenses/Operating Revenues	*	*									*							3
	E_4	Noninterest Interest Expenses / Total Assets	*	*																2
	E_5	Reserve for credit losses to loan / Loans and Lease Financing		*				*	*											3
	E_6	Reserve for credit losses to loan / Total assets		*				*	*											3
	E_7	(Deposits + Interest Expenses) / Deposits	*									*							*	3
	E_8	Interest Income on Loans / Average Total Loans									*	*							*	3
	E_9	Operating Expenses / Operating Revenues										*		*				*		3
	E_{10}	Deposits and Borrowed Fund/Operating Revenues	*	*																2
Growth	G_1	(Operating Revenues of Current Period – Operating Revenues of Last Period) / Operating Revenues of Last Period	*	*								*	*							4
	G_2	(Loans and lease Financing of Current Period – Loans and lease Financing of Last Period) / Loans and lease Financing of Last Period		*								*								2
	G_3	(Total Assets of Current Period – Total Assets of Last Period) / Total Assets of Last Period	*	*					*				*							4
	G_4	Operating Revenues of Current Period / Operating Revenues of Last Period				*		*												2
	G_5	Total Assets of Current Period / Total Assets of Last Period				*		*												2
	G_6	(Deposits of Current Period – Deposits of Last Period) / Deposits of Last Period							*				*							2

III. Methodology

3.1 Data and Sample

According to the statistics released by the Central Bank on the business of the financial institutions as shown in Table 2, Taiwan has five commercial banks

reorganized from investment trust firms up to April 1, 2000. Since Taiwan First Investment Trust and China Development Trust was reorganized into Banks recently. There is no adequate data available for both banks. Therefore, this paper only applies GRA to three reorganized banks (China Trust, Chinfon and United World Chinese). The data sources for this study included all the financial documents of the commercial banks after reorganization from investment trust firms. These documents included audited financial statements and annual financial reports (as shown in Table 3 and Appendix). We are very grateful for three banks in the assistance of generous supply of financial data.

Table 2. Commercials Banks Reorganized from Investment Trust Firms

Name of Firm	Date of Reorganization	Name of Bank
China Trust Investment	July 2, 1992	China Trust Commercial Bank
Cathy Investment Trust	October 11 1994	Chinfon Bank
Overseas Chinese Investment Trust	April 17, 1995	United World Chinese Bank
Taiwan First Investment Trust	November 16 1998	Cathay United Bank
China Investment Trust	January 1 1999	China Development Bank

Source: Statistics on Yearbook of Central Bank on Business of Financial Institutions (2001)

3.2 Grey Relation Analysis

3.2.1 Introduction

GRA was first proposed by Deng (1982), and was based on the theory of grey relation space. The fundamental definition of "greyness" is information being incomplete or unknown, thus an element from an incomplete message is considered a grey element. Grey relation means the measurement of changing relations between two systems or between two elements that occur in a system over time (Shih et al. 1994), and grey relation analysis is a research method used to measure the relationships among elements when the trends of their development have either homogeneity or heterogeneity (Deng 1989). If two elements develop in a consistent trend, the two elements have a high level of relation, or if two elements

develop in an inconsistent trend, they have a low level of relation. Its definition and model in mathematics are as follows:

Let $X=\{x_j \mid j=1,2,\ldots,n\}$ as factors in grey relations in sequential order, $x_1 \in X$ as reference sequence; $x_j \in X$ $(j \neq 1)$ as comparative sequence. Then $x_1(i)$ and $x_j(i)$ (i=1,2,…,m；j=2,3,…,n) would be the values of x_1 and x_j at point i. If $\gamma(x_1(i), x_j(i))$ are real numbers, then it can be defined as (Deng 1989)

$$\gamma(x_1, x_j) = \frac{1}{m}\sum_{i=1}^{m}\gamma(x_1(i), x_j(i)) \qquad (1)$$

$\gamma(x_1, x_j)$ would be the grey relation of x_j to x_1. Similarly, $\gamma(x_1(i)$ and $x_j(i))$ would be the grey relational coefficient of x_j to x_1 at point i. This is shown mathematically below:

$$\gamma(x_1(i), x_j(i)) = \frac{\min_j \min_i |x_1(i) - x_j(i)| + \zeta \max_j \max_i |x_1(i) - x_j(i)|}{|x_1(i) - x_j(i)| + \zeta \max_j \max_i |x_1(i) - x_j(i)|} \qquad (2)$$

where $\zeta \in [0,1]$ is the distinguished coefficient, the function of which is to reduce its numerical value by $\max_j \max_i |(x_1(i), x_j(i))|$ getting large, so as to effect its loss-authenticity and to heighten the remarkable difference among relation coefficients.

3.2.2 The scope of application of GRA

GRA can be applied to a wide array of studies, and is especially helpful in the analysis of elements with high levels of uncertainty, multivariate inputs, disperse data or incomplete data (Wu et al. 1996). As it is based on the homogeneity or heterogeneity of trend development of the elements to determine how closely they are related to one another, there is no rigid requirement for a large sample size. Similarly, a normal distribution is not required. Furthermore, the results match those of qualitative analysis, and hence this method has been adopted extensively (Deng 1989).

3.2.3 How GRA can be applied to performance evaluation

In GRA, the value of the grey relation coefficient between the elements is used to determine the relation between the elements. In other words, some elements have higher degrees of relation and can be grouped together, and one

member of this group is chosen as the indicator for the entire group for performance evaluation.

3.3 TOPSIS

TOPSIS was proposed by Hwang and Yoon (1981). The purpose is to find a solution closest to the "positive ideal solution" and furthest from the "negative ideal solution". "Positive ideal solution" refers to the most effective or least costly value among a set of feasible solutions. Conversely, a value of least effectiveness and highest cost would be the negative ideal solution. TOPSIS is used as the ranking method with GRA in the case study. The advantages of this method are that it is relatively simple and yields a highly reliable preference order. The steps are as follows:

Step I: Normalization of initial value: In this study, the application of GRA and TOPSIS uses vector normalization, which uses the ratio of the original value and the square root of the sum of the original indicator values.

The formula is as follows:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}} \tag{3}$$

i: the i_{th} bank; j: the j_{th} financial ratio; r_{ij}: the performance value of financial ratios after vector normalization for magnitude and direction; x_{ij}: the original performance value of financial ratios.

Step II: Find the positive ideal solution (A^+) and negative ideal solution (A^-):

$$A^+ = \left\{ \left(\max_i x_{ij} \,\middle|\, j \in J\right), \left(\min_i x_{ij} \,\middle|\, j \in J'\right) \,\middle|\, i = 1,2,\ldots, m \right\}$$
$$= \left\{A_1^+, A_2^+, \ldots, A_j^+, \ldots, A_k^+\right\}$$

$$A^- = \left\{ \left(\min_i x_{ij} \,\middle|\, j \in J\right), \left(\max_i x_{ij} \,\middle|\, j \in J'\right) \,\middle|\, i = 1,2,\ldots, m \right\}$$
$$= \left\{A_1^-, A_2^-, \ldots, A_j^-, \ldots, A_k^-\right\}$$

$$J = \left\{j = 1,2,\ldots, k \,\middle|\, \text{k is efficiency}\right\}; \; J' = \left\{j = 1,2,\ldots, k \,\middle|\, \text{k is cost}\right\}$$

(Efficiency criteria imply a larger indicator value and a higher performance score; Cost criteria imply a smaller indicator value and a higher

performance score.)

Step III: Calculate the distance from each solution (bank) to the positive ideal solution (S_i^+) and to the negative ideal solution (S_i^-):

$$s_i^+ = \sqrt{\sum_{j=1}^{k}\left(v_{ij} - A_j^+\right)^2} \qquad i = 1,2,\ldots, m$$

$$s_i^- = \sqrt{\sum_{j=1}^{k}\left(v_{ij} - A_j^-\right)^2} \qquad i = 1,2,\ldots, m$$

Step IV: Calculate the proximity of each solution (bank) to the positive ideal solution (C_i^*):

$$C_i^* = \frac{s_i^-}{s_i^+ + s_i^-} \tag{4}$$

Step V: Conduct the outranking among solutions (banks). Based on the value of C_i^* from Step IV, we can outrank the performance among the solutions.

IV. Empirical Results

4.1 The Value for Evaluation Items of Each Banks

From the set of performance indicators (Table 1), 38 ratios were included. The ratio of "deposits and borrowed fund / operating revenues" (E_{10}) was excluded because the inadequacy of data. The 38 financial ratios were classified into five categories: safety, profitability, liquidity, efficiency, and growth. The original value of each bank is shown in Table 3. The vector normalization of each financial ratio is shown in Table 4.

Table 3. The original value of 38 financial ratios for the three banks in 1997

Safety	Ratio Code	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9
China Trust		862.63%	8.24%	1114.29%	12.84%	1214.29%	7.61%	11.59%	7.61%	0.67%
Chinfon		1024.52%	7.69%	1200.14%	10.71%	1300.14%	9.29%	9.76%	8.73%	1.2%
United World Chinese		728.23%	10.41%	860.46%	17.25%	960.46%	5.86%	13.73%	5.69%	1.02%
Profitability	Ratio Code	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	
China Trust		9.12%	9.71%	13.74%	1%	0.91%	12.91%	0.715%	8.68%	
Chinfon		-2.86%	0.15%	0.14%	0.011%	-0.21%	-2.7%	0.015%	0.2%	
United World Chinese		18.25%	18.37%	15.74%	1.38%	1.29%	15.64%	1.09%	10.43%	
Liquidity	Ratio Code	C_1	C_2	C_3	C_4	C_5	C_6			
China Trust		5.86%	30.99%	4.61%	27.48%	16.18%	62.67%			
Chinfon		14.34%	14.83%	9.34%	10.74%	4.42%	67.13%			
United World Chinese		17.77%	42.5%	6.13%	38.75%	23.58%	61.02%			
Efficiency	Ratio Code	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9
China Trust		291.09%	10.03%	39.6%	3.97%	0.67%	0.42%	7.24%	12.12%	13.2%
Chinfon		338.94%	7.28%	31.4%	2.28%	1.2%	0.86%	6.6%	10.57%	21.72%
United World Chinese		187%	7.09%	21.18%	1.5%	1.02%	0.62%	5.67%	11.21%	81.75%
Growth	Ratio Code	G_1	G_2	G_3	G_4	G_5	G_6			
China Trust		25.71%	11.48%	6.61%	125.71%	106.61%	12.54%			
Chinfon		14.41%	11.42%	11.7%	114.41%	111.7%	14.05%			
United World Chinese		9.04%	10.98%	13.47%	109.04%	113.47%	15.64%			

Table 4. Vector normalization value on the financial ratios of the three banks in the preliminary selection process

Ratio Code	China Trust	Chinfon	United World Chinese	Ratio Code	China Trust	Chinfon	United World Chinese
S_1	0.566	0.672	0.478	C_3	0.381	0.773	0.507
S_2	0.537	0.501	0.678	C_4	0.564	0.221	0.796
S_3	0.602	0.649	0.465	C_5	0.559	0.153	0.815
S_4	0.534	0.446	0.718	C_6	0.568	0.609	0.553
S_5	0.601	0.643	0.475	E_1	0.601	0.700	0.386
S_6	0.570	0.695	0.439	E_2	0.702	0.510	0.497
S_7	0.567	0.477	0.671	E_3	0.723	0.573	0.387
S_8	0.590	0.677	0.441	E_4	0.824	0.473	0.311
S_9	0.391	0.701	0.596	E_5	0.391	0.701	0.596
P_1	0.443	-0.139	0.886	E_6	0.368	0.754	0.544
P_2	0.467	0.007	0.884	E_7	0.640	0.583	0.501
P_3	0.658	0.007	0.753	E_8	0.618	0.539	0.572
P_4	0.587	0.006	0.810	E_9	0.154	0.254	0.955
P_5	0.571	-0.132	0.810	G_1	0.834	0.467	0.293
P_6	0.631	-0.132	0.764	G_2	0.587	0.584	0.561
P_7	0.548	0.012	0.836	G_3	0.347	0.615	0.708
P_8	0.640	0.015	0.769	G_4	0.622	0.567	0.540
C_1	0.249	0.608	0.754	G_5	0.556	0.583	0.592
C_2	0.567	0.271	0.778	G_6	0.512	0.574	0.639

Note: The values from Table 3 were input into Equation (3) to produce these values.

4.2 The Grouped Indicators and Representative Indicators

For convenience of calculating the coefficient of grey relation among the financial ratios, this study used Turbo Pascal 7.0 for the calculation. The values from Table 4 were input into the program, and the program automatically grouped them into categories according to the values, and then selected the values that were most significant. This is shown in Table 5.

Table 5. Financial ratios that represent their respective cluster

Cluster	Represented by	Ratios within the cluster	Cluster	Represented by	Ratios within the cluster
S－I	S_8	S_1、S_3、S_5、S_6	E－I	E_2	E_3、E_7、E_8
S－II	S_7	S_2、S_4	E－II	E_6	E_5
S－III	S_9	－	E－III	E_4	－
P－I	P_1	P_2	E－IV	E_9	－
P－II	P_8	P_3、P_6	E－V	E_1	－
P－III	P_7	P_4、P_5	G－I	G_1	－
C－I	C_3	C_1	G－II	G_5	G_2、G_4、G_6
C－II	C_4	C_2、C_5	G－III	G_3	－
C－III	C_6	－			

All 38 financial ratios preliminarily selected were divided into 17 clusters via grey relation analysis, and 17 ratios that represent the clusters were also retrieved (Table 5). Among them, S－III, C－III, E－III, E－IV, E－V, G－I, and G－III have only one ratio each, which indicates that the ratios have a lower degree of grey relation with other ratios, and hence are independent from them.

4.3 The Evaluation Result of GRA and TOPSIS

The TOPSIS method was used to calculate the total performance score of each bank. Fifteen of the 17 financial ratios are efficiency based, while E4 and E9 are cost based. After conducting the TOPSIS (Please see section 3.3 for steps), we found the ranking of the three banks in "Safety", "Profitability", "Liquidity", "Efficiency", "Growth" as well as "Overall Performance" (Table 6). The numbers inside the parentheses refer to the relative closeness to the ideal solution. The higher the number is, the closer the distance is.

Table 6. The ranking of overall performance of the three banks

Item	Ranked 1st	Ranked 2nd	Ranked 3rd
Safety	Chinfon (0.668)	United World Chinese (0.522)	China Trust (0.340)
Profitability	United World Chinese (1.000)	China Trust (0.649)	Chinfon (0.000)
Liquidity	United World Chinese (0.684)	China Trust (0.429)	Chinfon (0.408)
Efficiency	Chinfon (0.775)	China Trust (0.568)	United World Chinese (0.374)
Growth	China Trust (0.598)	Chinfon (0.459)	United World Chinese (0.402)
Overall performance	United World Chinese (0.613)	China Trust (0.577)	Chinfon (0.399)

Note: The numbers in parentheses indicate the proximity to the positive ideal solution.

The ranking of overall performance of the three banks by using GRA and TOPSIS is shown in Table 6. We can see that United World Chinese outperformed China Trust and Chinfon overall. However, using the five-power analysis, we can see that its performance in “efficiency” and “growth” was below the other two banks. The management of United World Chinese should be aware of this disadvantageous position and seek to improve. For Chinfon Bank, its overall performance ranked last. Yet, it has an edge in “safety” and “efficiency”, being ranked first. This shows that the overall performance was influenced by “profitability” and “liquidity”. For its marketing strategy, it could strengthen its safety in deposits and lending as well as the efficiency of its operations. In internal control, it could make improvements in the liquidity of cash flow and cost control. For China Trust, it is time to exert proper safety measures in improving its financial position. They should pay attention to the appropriate proportions between assets and owner equity, as well as the use of financial leverage.

V. Discussion

In order to compare the results from using GRA, this paper also uses DEA to evaluate the performance of the three banks. The DEA evaluation process for three banks is described as follows. The results show that a consistent effect be obtained and we can derive that GRA can be successfully used in evaluating bank performance.

5.1 Data and Sample

The data sources for this study included all the financial documents of the commercial banks after reorganization from investment trust firms. These documents included audited financial statements and annual reports (as shown in Appendix 1). The standards for selecting the targets for the analysis and the period of the study are described below. In this study, the performances of the same bank in different years were treated as different DMUs (Charnes et. al. mentioned in their work in 1978 that the same DMU of different years could be treated as different entities for easy comparison of the changes in the efficiency value). Therefore, each bank in different years constitutes a different independent DMU.

(1) China Trust Investment was reorganized into the China Trust Commercial Bank on July 2, 1992. Therefore, its financial statements for that year fell into two industries (Banking and Trust Businesses), and were excluded from this study. This study covers seven years after the reorganization from the year of reorganization. The codes are tentatively set as: C1993[2] , C1994, C1995, C1996, C1997, C1998, C1999, a total of 7 fiscal years and hence 7 DMU.

(2) The Cathay Investment Trust was reorganized into Chinfon Bank on October 11, 1994. Its financial statements for that year fell into two industries, and were excluded. This study covers five years after the reorganization from the year of reorganization. The codes are tentatively set as: F1995, F1996, F1997, F1998, F1999, a total of five fiscal years, and hence five DMUs.

(3) The Overseas Investment Trust was reorganized into the United World Chinese Bank on April 17, 1995, and its financial statements for this year fell into two industries and were excluded. This study covers four years after the reorganization from the year of reorganization. The codes are tentatively set as: U1996, U1997, U1998, U1999, a total of four years, and hence four DMU.

Overall, the study covers China Trust, Chinfon Bank and United World Chinese Bank with a total of 16 fiscal years (16 DMU).

5.2 Input and Output Variable Selection

In choosing the inputs and outputs for DEA, we reviewed 11 articles by

[2] Description on the codes: C stands for China Trust, F stands for Chinfon, U stands for United World Chinese, and the numbers represent the year.

researchers in Taiwan and five articles from other countries on the measurement of operational performance of banks by applying the DEA method. We selected variables that have been used more than five times for the analysis. As shown in Table 7, we selected eight variables for the measurement of performance evaluation of commercials banks reorganized from investment trust firms after the reorganization. Among the eight variables, five are input variables and three are output variables.

Table 7. The preliminary selection of input and output variables and their frequency of appearances in banking literature

Type of Variable	Variable Code	Content of Variable	Ma (1993)	Chen (1994)	Shin (1995)	Lee (1995)	Wu (1995)	Hung (1996)	Hung (1996)	Wang (1997)	Hsu (1998)	Cheng (1998)	Luo (1998)	Buono & Eakin (1990)	Yue (1992)	Siems (1992)	Chen & Yeh (1998)	Seiford & Zhu (1999)	Total Appearances
Input	I1	Assets	*			*	*	*						*					5
	I2	Employee	*		*							*				*	*	*	6
	I3	Interest Expenses	*	*						*	*	*	*		*	*	*		8
	I4	Other Expenses	*													*			2
	I5	Deposit		*	*	*	*	*			*	*		*					8
	I6	Non Interest Expenses		*						*			*		*				4
	I7	Net Worth			*														1
	I8	Total branches			*														1
	I9	Loans				*													1
	I10	Borrowed Fund				*				*				*		*			4
	I11	Government Bond				*													1
	I12	Other Investment				*	*												2
	I13	Guaranty Money				*													1
	I14	Labor					*							*					2
	I15	Fixed Assets						*				*				*	*	*	5
	I16	Operating Expenses						*									*		2
	I17	Owner's Equity									*							*	2
	I18	Branching Numbers									*						*		2
	I19	Checkable Deposits													*				1
	I20	Non Checkable Deposits													*				1
	I21	Salaries and Wages														*			1
	I22	Time Deposits								*									1
	I23	Demand Deposits								*									1
	I24	Interest-bearing Deposits at Banks and Mortgages held for sale								*									1
Output	O1	Interest Income	*	*							*	*			*	*	*	*	8
	O2	Other Income	*																1
	O3	Loans	*	*	*		*	*			*	*	*		*		*		10
	O4	Deposits	*										*			*			3
	O5	Non Interest Income		*								*	*		*		*		5
	O6	Investments and Securities			*												*		2
	O7	Retained Earnings			*	*					*							*	4
	O8	Marketable Securities					*										*		2
	O9	Operating Assets						*								*			2
	O10	Operating Revenue						*											1

A feasible set of five input variables and three output variables was selected, as shown in Figure 1. Because DEA is derived from the Pareto Optimality, if there are too many input and output variables that could affect the DMU performance, most of the efficiency value of DMU would be equal to 1. In this case, the measurement of performance would become meaningless. Furthermore, if the input and output variables selected are highly complementary or could be mutually substituted, the result of the evaluation may be biased. Therefore, we also considered the account titles that would be highly complementary in this study. For example, the account titles of deposits and interest expenses are highly complementary, and therefore only one was chosen.

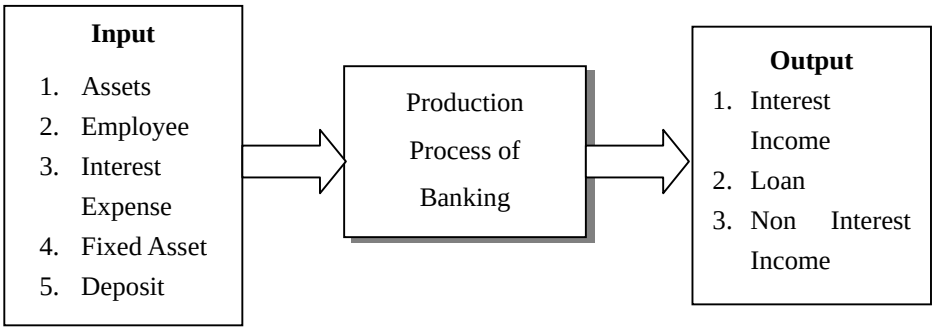

Figure 1: Production process of banking

In addition, in consideration of the common concept of business operation for the banks and investment trust firms (as shown in Table 8), we selected four input variables and two output variables shown below and in Table 9. The Pearson Product Moment Correlation Coefficients of all input and output variables are shown in Table 10. The four input variables and the two output variables chosen for this study are highly correlated.

Table 8. The business operation of banks and investment trust firms

Business of the banks		Inputs and outputs
1. As debtor	→	1. Sources of capital (including deposits, borrowing, and the issuance of financial bills). 2. Interest expenses.
2. As Creditor	→	1. The outflow of capital (including financing, investments and other interest-bearing assets). 2. Interest incomes.
3. Offering agency service 4. Trust Business 5. Other services	→	1. Non-interest expenses. 2. Non-interest incomes.

Source: Adopted from Ma et al (1997) on the chart of inputs and outputs of the banks.

Table 9. The four input variables and two output variables that were selected.

Input		Output
1. Assets	3. Employee	1. Interest Income
2. Interest Expenses	4. Fixed Assets	2. Non Interest Income

Table 10. The pearson product moment correlation coefficients of all input and output variables

Input / Output	Assets	Employee	Interest Expense	Fixed Assets
Interest Income	0.99	0.95	0.94	0.96
Non Interest Income	0.51	0.62	0.43	0.67

5.3 DEA Model

In this paper, the revised CCR model is used, and is demonstrated below. Assuming that there are n decision units and each DMU_j use m input X_{ij} to produce S output Y_{rj}, we can use the following equation to describe the revised CCR model if the scale of return is constant:

$$\text{Min } H_k = \phi_k - \varepsilon \left(\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+ \right)$$

$$s.t. \quad \phi_k X_{ik} = S_i^- + \sum_{j=1}^{n} X_{ij} \lambda_j$$

$$Y_{rk} = -S_r^+ + \sum_{j=1}^{n} Y_{rj} \lambda_j$$

$$\lambda_j, S_r^+, S_i^- \geqq 0 \text{ for all j,r,i}$$

r =1……s

i =1……m

j =1……n

H_k is the value of operation efficiency.

X_{ij} is the *i*th input of the *j*th DMU.

Y_{rj} is the *r*th output of the *j*th DMU.

S^- is the difference input variable.

S^+ is the difference output variable.

λ_j is the *j*th DMU weigh value.

ε is the Archimedes value, usually set as 10^{-4} or 10^{-6}.

5.4 The findings and analysis

5.4.1 The method for calculating DEA efficiency value

The data from all the DMUs in this study were analyzed using the Frontier Analyst software based on the revised CCR model, to obtain the DEA performance values. A DEA performance value equal to 1 means the best efficiency, and hence the unit is the most efficient.

5.4.2 Total Potential Improvements in input and output

Figure 2 (This figure derives from the Frontier Analyst software and is a distinguishing feature of the Frontier Analyst software) shows all factors from the DMU input and output variables that could be subject to future improvement. If specific input or output variables constitute a larger percentage in the pie chart, it indicates that those factors are more likely to be subject to future improvement. Conversely, smaller proportions in the chart indicate lesser likelihood that the factors shall need future improvement.

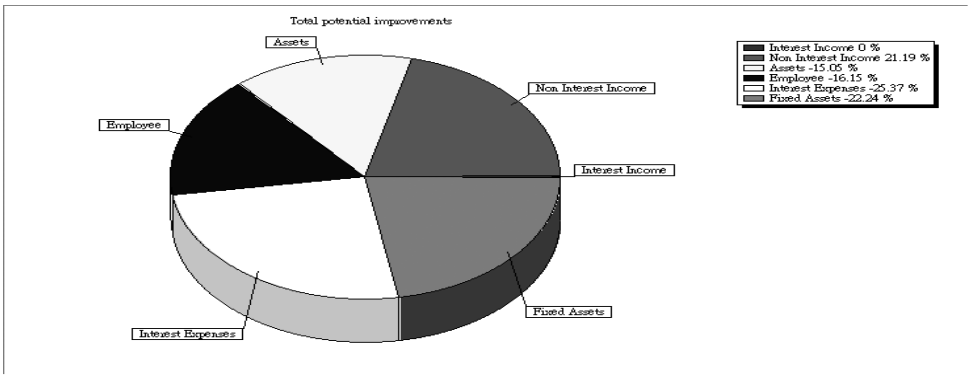

Figure 2. Total potential improvements in input and output

Interest expense had the highest percentage (25.37%) in the pie chart (Figure 2), which means that this area has the largest room for improvement, followed by fixed assets, then non-interest income, number of employees, assets and interest income. We find that interest expense fixed assets, and non-interest income are top three factors that could be subject to future improvement for inefficiency banks. This implies that we can effectively promote resource utilization efficiency in inefficient banks by better handing their deposit and fixed asset utilization efficiency and enlarging the bank investment functions. We suggest that these banks should address three areas in order to enhance their performance.

5.4.3. The DEA performance and analysis of the three banks in the empirical study after the reorganization

The ranking of the three banks in terms of DEA performance value is shown in Table 11. United World Chinese Bank ranked first, with China Trust second, and Chinfon Bank third.

Table 11. The ranking of the three banks in terms of DEA performance value

Bank	Reorganization	1993	1994	1995	1996	1997	1998	1999	Average	Rank
na Trust	After	0.7658	0.6476	0.5838	0.5975	0.6032	0.7081	0.6848	0.6601	2
BANK	Reorganization	1995	1996	1997	1998	1999			AVERAGE	3
Chinfon	After	0.6055	0.7381	0.6547	0.6545	0.6303			0.6566	
BANK	Reorganization	1996	1997	1998	1999				AVERAGE	1
United World Chinese	After	0.8019	0.8508	0.9428	0.9165				0.8019	

5.5 Comparison of DEA and GRA

From the above empirical results, we found that both methods can be successfully used in evaluating corporate performance, and that the rankings of the three banks in the empirical study by using DEA and GRA are the same: first, the United World Chinese Bank, second, China Trust Commercial Bank, and third, Chinfon Bank. Table 12 shows the analysis and comparison between DEA and GRA (Table 12).

Table 12. A comparison of DEA versus GRA

Method	DEA	GRA
Basic Principle	Based on the concept of Pareto Optimality. When measuring the efficiency value of DMU, only the production margin is required. The production margin would then be compared with actual production for the efficiency value.	Based on the homogeneity or heterogeneity of the trend development of elements to find out if there is a grey relation between two indicators and to what extent.
Strengths for Application	1. DEA can easily deal with a large number of inputs and outputs. 2. Not affected by units under different measurements. 3. No need to preset the weighed value of indicators, as this value from DEA is derived from mathematics. Hence, there is no human subjectivity, so the method is fair and just. 4. More information on the use of resources can be obtained from the results, which could be used as a reference in making decisions.	1. No rigid requirement in sample size. 2. Can be applied when the distribution of data is uncertain. 3. Is based on data analysis, and is free from traditional subjectivity in decision-making. 4. The method of calculation is simple and easy to apply.
Weaknesses for Application	1. Limited by sample size. If too small, the sample size would affect the outcome. 2. Limitations on the input and output of variables: there should not be too many.	1. Cannot directly handle qualitative issues (non-quantifiable). 2. The criteria for choosing grey relation coefficient value directly affects the final evaluation result.

VI. Conclusions and Future Research

This study successfully singled out a ranking system applicable to the evaluation of performance with small sample size where the distribution of data is unknown. It yielded expected results in an empirical study on three banks restructured from investment trust companies. Grey Relation Analysis was used to retrieve financial ratios that could represent the cluster they belonged to. This could avoid the waste of resources due to the uncertainty of relations among the ratios when using them for analysis. TOPSIS was used for the outranking of the subject of the study. By considering the performance of the banks relative to each other, we can use this method to assist managers in understanding the current

situation of their companies, so that they can plan measures for improving performance.

The authors employed a review of literature and five-power analysis to aggregate financial ratios appropriate for the analysis. This practice may cause incompleteness in the aggregation of ratios, and requires adjustment when other issues for analysis are concerned. Perhaps future researchers could set up a specific model for the preliminary selection of financial ratios in accordance with their respective study interests, in order to make studies of this kind more complete.

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Appendix

Financial Data of the Banks in the Empirical Study

Variables	INPUT				OUTPUT	
YEAR	ASSETS	EMPLOYEE	INTEREST EXPENSES	FIXED ASSETS	INTEREST INCOME	NON INTEREST INCOME
C1993	279,478,023	1,861	16,526,005	12,774,781	20,444,026	4,304,393
C1994	332,419,340	2,181	16,094,591	14,635,915	20,218,876	5,572,230
C1995	373,732,042	2,731	17,944,000	15,402,761	22,292,000	8,550,335
C1996	424,658,001	3,374	18,798,000	17,422,106	25,958,000	8,981,433
C1997	544,860,165	3,854	22,649,508	16,898,678	32,979,314	13,351,138
C1998	580,861,534	4,283	29,861,812	20,002,328	42,019,737	16,224,326
C1999	628,409,140	4,675	27,837,166	22,529,054	43,870,450	19,463,863
F1995	136,557,568	882	5,431,039	3,481,848	7,661,196	539,808
F1996	146,589,590	931	7,632,211	3,552,648	9,857,525	617,217
F1997	161,647,028	1,096	7,619,749	3,528,808	10,293,390	1,076,241
F1998	178,670,175	1,370	9,295,325	3,837,877	12,006,382	1,001,644
F1999	183,154,686	1,305	8,855,856	4,071,908	11,798,357	1,409,640
U1996	413,072,618	2,311	18,318,641	18,191,131	26,583,025	2,748,726
U1997	490,098,718	2,533	20,278,278	19,630,159	30,914,812	5,264,680
U1998	556,104,955	2,675	23,892,935	21,051,032	36,174,699	3,274,262
U1999	619,619,706	2,727	22,077,611	21,599,786	35,850,359	3,566,705

Note: Description on the codes: C stands for China Trust; F stands for Chinfon; U stands for United World Chinese; while the numbers stand for respective year.

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