Application of Data Envelopment Analysis to Operating Performance Evaluation of Financial System

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ABSTRACT Banking departments have been the focus of domestic financial system and played the critical role in the economic development process. Nevertheless, since the financial liberalization policy in the end of 1980, banks have encountered great challenges. Inspecting the brief situations of domestic banks in the past decade, the profits have been reduced and the operating efficiency is gradually decreasing. The risks of loans are increasing that it becomes a primary issue for the general deposit account and shareholders of banks knowing the operating problems of banks earlier and selecting the accurate and stable investment to ensure the personal profits. Based on the operation investigation of native banks in Taiwan in 2010-2012, Data Envelopment Analysis (DEA) and Malmquist Productivity Analysis are combined to measure Total Efficiency (TE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE) of 16 native banks in Taiwan for the reference of further improvement of operating efficiency. The empirical results show Bank of Taiwan and Taishin Bank being relatively efficient, as the operating efficiency achieves the ideal state, while the rest 14 native banks appear comparatively lower operating efficiency. Besides, it is found that merely Bank of Taiwan and Taishin Bank present improvement on the technical change in two periods, while the rest do not improve.

INTRODUCTION

The economy in Taiwan has turned down in the past years. Banks are the media of borrowing money for factoring companies and the public as well as the strategic executors of the government stabilizing the financial order. When there is operation crisis of banks, domestic stable economy would be influenced to result in the public panic and the economic recession. The importance of banking ecology for the economic development of a country is apparent. Several non-performing loans in the past years have oppressed the operating efficiency of banks in Taiwan; the non-performing loan ratio of some banks is so high that the increasing operating risks and the decreasing profits could result in bankruptcy at any time.

In regard to the overall situation of banking industry in the past years, the government has issued Standards Governing the Establishment of Commercial Banks, proceeded financial system reform, opened to the establishment of new banks, and formulated regulations for trust companies reforming commercial banks that the financial market presents a fresh atmosphere and the monopoly of old banks is broken. The deregulation of financial businesses aims to enhance the operating efficiency of domestic banks and activate the financial market. Nevertheless, the competitiveness has not been obviously enhanced after the openness to private banks and the privatization of large-scale public banks, but the banking system has been eroded because of changes of market structure, fierce competition, or non-performing loans resulted from government-business relations and bad loan-quality. Moreover, domestic banks will inevitably face greater impact in the 21st century, from the aspects of the functions, businesses, and operating methods or the changes of external environment. The former includes the business integration of securities, investment, insurance, and banking, the emphasis of businesses beyond the balance sheet, and the introduction of information technology, like electronic and automatic

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devices. The latter covers the increasing weight of direct finance, the takeover and merging of banks, and the impact resulted from joining in WTO. Such problems need to be overcome in the future.

The increasing loan risks of banks have affected the earning power and operating efficiency of banks. It is regarded as a primary issue for the general deposit account and the shareholders earlier knowing the operating problems of banks and selecting correct and stable investment to ensure personal profits. Accordingly, it is essential to, aiming at the operating performance, explore the hidden financial message and evaluate the overall operating efficiency of banks

Literature Review

I. Operating Performance

Operating Performance is considered as an effectiveness indicator inspecting the firm competitiveness of an enterprise (Hu and Shieh 2013). Favorable Operating Performance reflects the effective business model and industrial investment environment of the enterprise as well as the effectiveness of governmental policies. Many indicators have been utilized for measuring Operating Performance of an enterprise, such as Return on Investment, Growth Rate, Turnover Rate, and even Stock Market Index. Such measuring criteria for Operating Performance are further introduced in this study. Kang & Liao (2009) pointed out the indicators for measuring Return on Investment of an enterprise being Return on Investment, Growth Rate, Turnover Rate, Liquidity Ratio, and Risk Diversification Capacity, where the higher Return on Investment, Growth Rate, Turnover Rate, and Liquidity Ratio presented the better Operating Performance of an enterprise, while the risks should be the smaller the better. Chen (2010) measured performance with Earnings Per Share, Sales Growth Rate, and Yield Rate. Weng (2009) proposed Technological Innovation Performance as a part of Operating Performance, including Product Innovation Performance and Process Innovation Performance, which mainly measured R&D expenses, new product listing ratio, product cost reduction, or profit creation. Chiu (2010) evaluated the investment strategies and performance of enterprises in Taiwan with Sales Growth Rate, Profit Rate, and Employee Turnover Rate. Ma (2009) evalu-

ated Operating Performance of an industry with Revenue, Stability, and Operating Capacity, where the major evaluation indicators focused on earning power, productivity, and management performance, covering profit rate, net profit margin, gearing ratio, total asset turnover rate, and employee productivity. There are plenty of indicators used for evaluating Operating Performance of an enterprise. In short, Operating Performance presents on Finance, Productivity, and Technique, where Finance and Productivity are commonly utilized for measuring Operating Performance of an enterprise; and, the performance of the three indicators are closely related. The excellent performance of production and technique is apparent in financial profits.

II. Input And Output Variables

Inputs/outputs in financial industry are not easily measured as those in manufacturing industry; the selection of inputs/outputs in various research on financial system performance evaluation was also distinct. For instance, Fukuyama and Weber (1999) considered 2 inputs (labor, real capital) and 2 outputs (brokerage income, underwriting business revenue); Wang et al. (2003) included 2 inputs (labor, floor area) and 3 outputs (brokerage income, self-employment income, underwriting business revenue); Zhang et al. (2006) used 3 inputs (labor reward, cost of capital, ownership equity) and 5 outputs (commission, margin loan profit, investment income, asset management income, total revenue); Fang and Hu (2009) applied 3 inputs (fixed assets, financial capital, general and administrative expenses) and 1 output (brokerage and self-employment trading market shares); and, Hu and Fang (2010) set 2 inputs (number of branches, commission discount) and 2 outputs (brokerage trading market shares0brokerage income). It is therefore considered that labor, constant assets, and borrowed funds are the basic inputs in a financial system for engaging in brokerage, underwriting, or self-employed securities businesses as well as dealing with financial and securities loan businesses and other businesses related to operation in order to acquire incomes and earn profits. The inputs and outputs are then set in this study, where the input variables include number of employees, net fixed assets, and other operating costs, and the output variables contain brokerage income, underwriting and self-

employment income, operating interest income, and other operating revenue. Such input/output variables are defined as below.

(I) Inputs

(1) Number of employees, the number of employees in the end of a season.
(2) Net fixed assets, deducting accumulated depreciation from the sum of constant assets as the beginning and ending mean of a season.
(3) Other operating costs, deducting labor costs, depreciation expense, and non-business expenditure from the sum of expenses in the income statement.

(II) Outputs

(1) Brokerage income, the brokerage fee income for dealing with buying and selling businesses for customers.
(2) Operating interest income, the interest incomes related to dealing with financial loan businesses, loose bond, and other operation.

RESEARCH EVALUATION

I. Evaluation of Efficiency

Efficiency evaluation aims to measure the relations between inputs and outputs of an enterprise. The evaluation results could be the performance standard as well as assist the managers in understanding the internal resources of the organization being effectively utilized so as to maximize the limited resources. Generally speaking, "relative" concept is applied to evaluating efficiency and comparing the selected samples. Research on Relative Efficiency started on Farrell (1957) who proposed the measurement of productive efficiency to estimate efficiency with Non-default Production Function. Such an approach divided Overall Efficiency (OE) into Technical Efficiency (TE) of the real input transferring to outputs and Price Efficiency (PE), or Allocative Efficiency (AE), of the optimal factor distribution. Byrnes et al. (1984) further divided Technical Efficiency into Pure Technical Efficiency (PTE), Scale Efficiency (SE), and Congestion Efficiency (CE), mainly to distinguish insufficient Technical Efficiency being the problems of pro-

duction techniques, too many production factors, or the sizes of scale. Different efficiency definitions revealed distinct efficiency meanings, in which Production Efficiency in economics was referred to Technical Efficiency and Overall Efficiency; Technical Efficiency explained the concept to avoid resource waste; and, Overall Efficiency indicated the optimal combination proportion of inputs and outputs when the input output prices were known. Technical Efficiency, Overall Efficiency, and Scale Efficiency are further explained as following.

(I) **Technical Efficiency.** Technical Efficiency aims to measure a production unit being able to effectively utilize the production elements and achieve the maximal production with the minimal input resources for the lowest costs but the largest profits.

(II) **Overall Efficiency.** Allocative Efficiency (or Price Efficiency) aims to measure the production unit being able to engage in the production with the minimal input combination, i.e. to select the input combination with the minimal costs to achieve the maximal Allocative Efficiency when the relative prices of the inputs are fixed.

(III) **Scale Efficiency.** Scale Efficiency aims to measure the production unit being able to precede the production under the optimal production scale, whose essential condition is the constant returns to scale.

II. Data Analysis

Data Envelopment Analysis (DEA) is utilized for evaluating the efficiency. Unlike traditional Regression Analysis, which merely looks for the mean path from a series of data, it envelopes the data of various samples and tries to find out the relations that it present the necessary advantages of a favorable efficiency evaluation model. With linear programming, the performance among the evaluated units could be evaluated the factors and compared the performance among the units with similar characteristics.

Ferrel (1957), as the pioneer in efficiency measurement, first proposed the concept of Production Frontier which, with the setting of Isoquant Curve, regarded the track of isoquant factor combination as Production Frontier to estimate Technical Efficiency of an individual manufacturer (relative to the optimal one). The basic idea of mea-

suring the efficiency with DEA was based on the efficiency of Pareto Optimality, which indicated that no-one could increase another person's profits without damaging the others' benefits. According to such an idea, the efficiency could be measured by comparing the real production and Production Frontier, when Production Frontier (the ideas of envelope or efficiency frontier in economics) was known. With the concept of envelope, inputs and outputs of all Decision Making Units (DMU) were taken into account in DEA to calculate the relative efficiency of an individual manufacturer to the other ones.

The Financial Institutions Merger Act, Financial Holding Company Act, and Business Mergers and Acquisitions Act were issued by the government, allowing the merging or multi-business among the financial systems of banking, insurance, and securities, in which the subsidiary companies of banks appeared the most applications. Apparently, native banks with financial holding companies are increasing, and the establishment of financial holding companies could change the competition and operating performance in financial industry. The relevant data are mainly from Taiwan Economic Journal Database, Financial Institutions Major Business Statistics, and publicly issued financial statements of banks. Domestic banks are sampled in this study, as they share about 70% financial institutions deposit ratio and 90% loan ratio in Taiwan that they are the core of banking departments. According to the time of establishment and the soundness of the state of operation, the scores and the ranking of individual banks are analyzed for ranking the operating conditions between old and new banks for further sampling. The sampled banks contain

(1) *Old Banks:* Land Bank, Bank of Taiwan, Chang Hwa Bank, First Bank, Taiwan Cooperative Bank, Farmers Bank, Bank of Communication, and Taipei Bank.

(2) *New Banks:* Cosmos Bank, E.Sun Bank, Fubon Bank, Yuanta Bank, Taishin Bank, Far Eastern Bank, Ta Chong Bank, and EnTie Bank.

Empirical Analysis

I. Analysis of Relative Efficiency

The efficiency evaluation result with DEA could assist in understanding the relative efficiency of Operating Performance among native banks. A DMU achieves the relative efficiency when the efficiency reveals 1, while it is relatively inefficient when the efficiency appears less than 1. The empirical results, Table 1, showed that Bank of Taiwan and Taishin Bank, with the efficiency=1, were relatively efficient, presenting the operating efficiency achieved the ideal state. The rest 14 banks, on the other hand, revealed comparatively lower operating efficiency.

Table 1: Relative Efficiency of native banks

Native bank	Overall efficiency	Pure technical efficiency	Scale efficiency
Land Bank	0.86	0.88	0.85
Bank of Taiwan	1.00	1.00	1.00
Chang Hwa Bank	0.79	0.77	0.80
First Bank	0.85	0.83	0.82
Taiwan Cooperative Bank	0.94	0.95	0.90
Farmers Bank	0.67	0.62	0.70
Bank of Communication	0.66	0.64	0.60
Taipei Bank	0.76	0.71	0.70
Cosmos Bank	0.90	0.88	0.91
E.Sun Bank	0.80	0.82	0.76
Fubon Bank	0.95	0.91	0.96
Yuanta Bank	0.83	0.85	0.81
Taishin Bank	1.00	1.00	0.98
Far Eastern Bank	0.72	0.73	0.71
Ta Chong Bank	0.92	0.90	0.88
EnTie Bank	0.82	0.80	0.75
Sum	0.84	0.83	0.82

II. Analysis of Malmquist Productivity Indexes

Various Malmquist efficiency analyses in 2008-2012 are shown in Table 2, where Total Factor Productivity of Bank of Taiwan and Taishin Bank was larger than 1, while the other native banks appeared it less than 1, showing the decreasing productivity. In terms of Pure Technical Efficiency change, both Bank of Taiwan and Taishin Bank improved the efficiency, while the other native banks worsened the efficiency. In regard to Scale Efficiency in two periods, both Bank of Taiwan and Taishin Bank were approaching the permanently optimal scale, while the other native banks, with the efficiency less than 1, were getting far away from the permanently optimal scale. Furthermore, it was found that the technical change in two periods of Bank of Taiwan and Taishin Bank was improved, while the others were not.

Table 2: 2010-2012 Analysis of Malmquist efficiency

Bank	Technical change in two periods (TECHCH)	Pure technical efficiency change (PECH)	Scale efficiency in two periods (SECH)	Total factor productivity change (TFPCH)
Land Bank	0.80	0.82	0.82	0.80
Bank of Taiwan	1.03	1.01	1.02	1.01
Chang Hwa Bank	0.78	0.80	0.78	0.76
First Bank	0.79	0.81	0.76	0.83
Taiwan Cooperative Bank	0.94	0.95	0.90	0.92
Farmers Bank	0.63	0.64	0.68	0.62
Bank of Communication	0.65	0.66	0.60	0.60
Taipei Bank	0.72	0.73	0.70	0.70
Cosmos Bank	0.83	0.86	0.91	0.93
E.Sun Bank	0.83	0.84	0.73	0.82
Fubon Bank	0.91	0.93	0.92	0.97
Yuanta Bank	0.74	0.81	0.76	0.80
Taishin Bank	1.07	1.08	1.06	1.04
Far Eastern Bank	0.66	0.69	0.70	0.71
Ta Chong Bank	0.82	0.87	0.82	0.94
EnTie Bank	0.73	0.75	0.73	0.79
Sum	0.81	0.83	0.81	0.83

CONCLUSION

Taking the years 2010-2012 as the dimensions to investigate Operating Performance of native banks, total 16 native banks are selected as the valid samples for the evaluation of Operating Performance with Data Envelopment Analysis. The research results reveal that Bank of Taiwan and Taishin Bank present higher Overall Efficiency, Pure Technical Efficiency, and Scale Efficiency than the other native banks in the three years, possibly because of the monopoly of public banks in domestic market and the governmental resource assistance. In comparison with newly established private banks or the immature ones, public banks present higher advantages on the operation, which responds to higher Technical Efficiency. When evaluating the operating efficiency between old and new banks from the aspect of the openness of financial system reform, new banks appear better performance on Technical Efficiency than old banks do, as most banks could hardly make changes under the protection of financial control, when there was no competition, and gradually lost the competitiveness. When the government opened to the establishment of new banks, a lot of banks emerged in the financial market. In order to share the market, new banks present strict internal requirements that they show higher Technical Efficiency than old banks do. Most native banks present unfavorable Operating Performance, possibly because of the economic downturn in the past years, the serious non-performing loan problems caused by the excess loans of government-business or the representatives of public opinions, and unfavorable profits of traditionally large-scale enterprises. Non-performing loans are currently increasing, reflecting the increasing unemployment rate, that the public cannot afford a loan. Such a problem is the primary issue for various banks tending to reduce the non-performing loan ratio.

RECOMMEDATIONS

According to the research results, several domestic banks present continuous loss because of unfavorable Operating Performance. By analyzing the problems, unfavorable Operating Performance and increasing risks of bankruptcy are the keys in decreasing profits of banks. For this reason, it is necessary to adjust the attitudes that, in addition to passively "preventing malpractice", actively "increasing profits" should be taken into consideration. In other words, the financial policies of the government should prevent financial institutions from problems, try to establish the profits of banks, and create the environment for making money. In accordance with the regulations and other mechanisms (such as deposit insurance), the financial supervisory units could properly, accurately, and continuously expose the operating conditions of banks to reach the information transparency. In this case, banks with favorable op-

erating conditions could acquire better transaction conditions and opportunities; the public and enterprises could well select banks to reduce the uncertainties when making decisions; and, the government could release some duty for bank supervision and management to the market constraints. The banks therefore could be automatically segmented the level of operating conditions, the systematic risks and Domino Effect could be avoid, and the supervision pressure could be reduced so that the operating efficiency of the financial market could be fundamentally enhanced.

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