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**Applying the Two-Stage Slacks-Based Measure to
Organizational Performance Measurement: An Empirical
Study of Domestic and Foreign Banks in Taiwan**

Chiun-Sin Lin

Professor, Department of Business and Entrepreneurial Management,
Kainan University, Taiwan, ROC

Hsin-Yi Lin

Doctoral Candidate, Department of Management Science,
National Chiao Tung University, Taiwan, ROC

Corresponding Author: Hsin-Yi Lin

Abstract

This research project looked to develop a network slacks-based measure approach for creating a better organizational performance measurement. We adopted a performance evaluation structure under a two-stage network data envelopment analysis (DEA) structure using a network slacks-based measure with production efficiency and profitability efficiency. In the empirical study we collected data from the annual reports and databases of domestic and foreign banks in Taiwan to analyze their performance. The empirical results show that the proposed approach of the two-stage slacks-based measure effectively improves the discriminative ability of performance evaluation using the traditional one-stage DEA method. This model can be extended to other service industry fields in the future.

Keywords: *Organizational performance measurement, Network slacks-based measure, Two-stage network data envelopment analysis, Bank performance evaluation, Domestic and Foreign Banks in Taiwan*

1. Introduction

There is a broad range of academic research on data envelopment analysis (DEA) starting from Charnes, Cooper and Rhodes (1978). We can particularly draw a distinction between single-stage and multi-stage analyses for bank efficiency analysis (Avkiran, 2011; Ho & Wu, 2009; Hsiao, Chang, Cianci, & Huang, 2010; Lo & Lu, 2009; Paradi, Rouatt, & Zhu, 2011; Sherman & Gold, 1985). The problem of multi-stage efficiency analysis has drawn much attention in recent literature (Cook, Liang, & Zhu, 2010). Seiford and Zhu (1999) employed a two-stage production performance measurement for the U.S. commercial banking system - namely, profitability and marketability efficiencies. They found a differential preference in banking at the operational scale and presented the identification of new information for improved bank performance using this new approach. Avkiran (2009) adopted the concept of network DEA to evaluate the profitability efficiency of UAE banks using a slacks-based measure approach, named network slacks-based measure (NSBM) or stage slacks-based measure (SSBM). Considering the divisional linkage within an organization, he pointed out that this innovative approach enables management to be aware of those profit centers' inefficiency. Kao and Hwang (2010) investigated the effect of network operational systems on performance measurement in a banking industry and reported that more information regarding inefficiency sources could be obtained. According to the above, evaluating multi-stage efficiency with multiple inputs and outputs in an organization or environment may be one managerial tool for identifying inefficiencies and opportunities so as to improve performance level and maintain a sustainable competitive advantage.

The purpose of this research is to verify whether the proposed two-stage SBM approach can effectively evaluate organizational performance as well as increase discriminative capability in today's dynamic and competitive business environment. In this context, we apply a dataset of Taiwan's domestic and foreign banks to evaluate the performance of the proposed approach in the bank performance model. The results obtained from this model provide sufficient information on efficiency to enhance performance and improve supervision direction. This two-stage approach is superior to the traditional one-stage SBM model. It is hoped that the information herein will be useful to those who are responsible for performance evaluation in the field of DEA publications.

The remainder of the paper is organized as follows. Section 2 provides a framework for bank performance evaluation. Section 3 illustrates the methodology and data. Section 4 presents the empirical results. The final section concludes the whole article.

2. A framework for bank performance evaluation

Most previous studies have advocated using DEA for performance evaluation in the banking industry (Berger & Humphrey, 1997; Chen, & Yeh, 2000; Cooper, Seiford, & Zhu, 2000; Fethi & Pasiouras, 2010; Seiford & Zhu, 1999; Luo, 2003). Since the organizational structure has rapidly expanded with profitable and efficient orientations, a single performance evaluation is not suitable for aggressive management insight. The multi-stage performance evaluation structures used by many in the literature appear to be a trend for further exploring inside information (Avkiran, 2011; Ho & Wu, 2009; Lo & Lu, 2009; Paradi et al., 2011). This research thus employs a two-stage performance evaluation structure with production efficiency and profitability efficiency measurements to evaluate the organizational performances of domestic and foreign banks in Taiwan.

Fig. 1 illustrates the framework. The production efficiency evaluation is set in the first stage of the organizational performance model, and the profitability efficiency evaluation is the second stage. Specifically, in the phase of production efficiency, the model follows a production approach used in the previous literature that aims to measure whether banks utilize input resources to generate relevant outputs as financial service capacities. We define fixed assets, operating expenses, and equities as specific inputs for the production efficiency measurement. For the selection of intermediate output variables, we use deposits and loans as

intermediate outputs from the first stage. If deposits and loans cannot be effectively exercised, then these financial service capacities may not maximize banks’ profits. The input-output variables for evaluating the profitability efficiency performance reflect that a bank manager’s objective is to pursue profit maximization, which depends on the financial service capacities from the view of production efficiency. We select interest revenues, fee revenues, and profits as final output variables for profitability efficiency evaluation. Thus, Table 1 presents the definitions of input, intermediate/2nd-stage input, and output variables selected for the two-stage performance evaluation in this research.

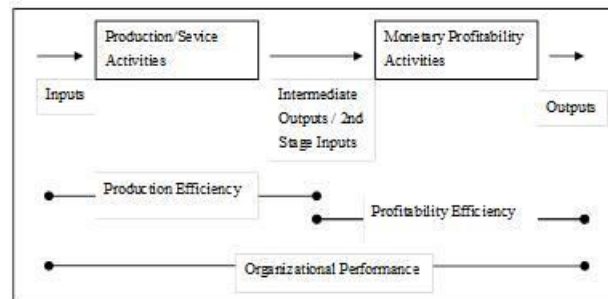


Fig 1: A framework for bank performance evaluation.

Table 1: Variables and Definitions

| Variables | | Definitions |
|---|--------------------|--|
| Input Variables | Fixed assets | Any tangible and intangible assets that are capable of being owned or controlled by the company at year-end. |
| | Operating expenses | The sum of a business’ operating expenses for a specific year. |
| | Equities | The value of an ownership interest in property, including shareholders’ equity in a business. |
| Intermediate Variables/2 nd -Stage Input Variables | Deposits | They are recorded as a liability for the bank, representing the amount owed by the bank to customers for a specific year. |
| | Loans | Loans are recorded by the amount of outstanding principal, with unearned income excluded. |
| Output Variables | Interest revenues | The interest earned by a company during the period indicated in the heading of the income statement under the accrual method. |
| | Fee revenues | They are mainly derived from service and penalty charges and, to a much lesser extent, from asset sales and property leasing. Examples are deposit and transaction fees. |
| | Profits | The residual income of a firm after adding total revenue and gains and subtracting all expenses and losses for the reporting period, i.e. earnings before income tax. |

3. Methodology and dataset

The methodology utilized herein for performance evaluation in the banking industry is based on the two-stage slacks-based measure in order to create more discriminative capabilities for the DEA performance evaluation. Ever since Tone and Tsutsui (2009; 2010; 2014) introduced NSBM or SSBM, it has been used to construct the bank performance evaluation model with a two-stage framework.

3.1 Network data envelopment analysis

Network data envelopment analysis (DEA) is a concept by which intermediate measures are imposed on the specification of the efficient frontier (Lo & Lu, 2009). Tone and Tsutsui (2009) developed the slacks-based measure approach of the network DEA model that can deal with intermediate measures directly in a single evaluation procedure. Therefore, we use the network DEA model to evaluate the organizational performance of domestic and foreign banks in Taiwan, which includes production efficiency and profitability efficiency evaluation in two stages.

This paper adopts the non-oriented approach of SSBM for bank performance model construction, where n DMUs (banks) ($j = 1, 2, \dots, n$) consist of K stages ($k = 1, 2, \dots, K$). Let m_k and r_k be the number of inputs and outputs to stage k , respectively. Moreover, we denote the link leading from stage k to stage h by (k, h) and the input (output) slacks to stage k by s^{k-} (s^{k+}) and define the objective function of operational performance evaluation, ρ^{NSBM} , below (Tone & Tsutsui, 2009):

$$\rho^{NSBM} = \min \frac{\sum_{k=1}^K w^k \left[1 - \frac{1}{m_k} \left(\sum_{i=1}^{m_k} \frac{s^{k-}}{x_{io}^k} \right) \right]}{\sum_{k=1}^K w^k \left[1 + \frac{1}{r_k} \left(\sum_{r=1}^{r_k} \frac{s^{k+}}{y_{ro}^k} \right) \right]} \tag{1}$$

Subject to:

$$\sum_{j=1}^n \lambda^P X^P = X^P - S^{P-} \tag{1.1}$$

$$\sum_{j=1}^n \lambda^P Z^{(P,M)} = \sum_{j=1}^n \lambda^M Z^{(P,M)} \tag{1.2}$$

$$\sum_{j=1}^n \lambda^P = 1 ; \lambda^P, S^{P-} \geq 0 \tag{1.3}$$

$$\sum_{j=1}^n \lambda^M Y^M = Y^M + S^{M+} \tag{1.4}$$

$$\sum_{j=1}^n \lambda^M = 1 ; \lambda^M, S^{M+} \geq 0 \tag{1.5}$$

$$w^P + w^M = 1, w^k \geq 0 \tag{1.6}$$

With regard to the free linking constraints (1.2) imposed on this model, we assume that the output of the previous stage is the same as the following stage input. Because w_k is a user-specified weight for each stages, one can observe the specific contribution of each stage in the organizational performance. This research sets the weight of the production efficiency and the profitability efficiency stages at 0.5, respectively.

In addition to the organizational performance measurement, Tone and Tsutsui (2009) also defined the objective function of stage efficiency as:

$$\rho_k^{NSBM} = \frac{1 - \frac{1}{m_k} \left(\sum_{i=1}^{m_k} \frac{s_i^{k-*}}{x_{io}^k} \right)}{1 - \frac{1}{r_k} \left(\sum_{r=1}^{r_k} \frac{s_r^{k+*}}{y_{ro}^k} \right)} \quad (2)$$

Here, s^{k-*} and s^{k+*} are the optimal input and output slacks for equation (1), respectively.

We use the SSBM model to measure the organizational performance as well as to estimate the stage efficiency. It is also important that we provide specific managerial insights and directions to improve the performance level in the end.

3.2 Dataset

As to the dataset we collect samples of domestic and foreign banks from the banking industry in Taiwan for 2013. All banks are regulated under Taiwan’s Financial Supervisory Commission. The dataset is taken from banks’ annual reports and Taiwan Economic Journal databases. We delete samples with incomplete, zero, or negative data.

According to Lo and Lu (2009), the correlation between input and output variables must have a positive relationship under the basic assumption of data envelopment analysis. Tables 2 to 4 presents the correlation analysis of input, intermediate, and output variables.

Table 2: Correlation coefficients for input variables and intermediate variables

| | Fixed assets | Operating expenses | Equities | Deposits | Loans |
|--------------------|--------------|--------------------|----------|----------|-------|
| Fixed assets | 1 | | | | |
| Operating expenses | 0.9 | 1 | | | |
| Equities | 0.84 | 0.82 | 1 | | |
| Deposits | 0.91 | 0.84 | 0.94 | 1 | |
| Loans | 0.85 | 0.77 | 0.92 | 0.99 | 1 |

Table 3: Correlation coefficients for intermediate variables/2nd-stage input variables

| | Deposits | Loans |
|----------|----------|-------|
| Deposits | 1 | |
| Loans | 0.99 | 1 |

Table 4: Correlation coefficients for intermediate and output variables

| | Deposits | Loans | Interest revenues | Fee revenues | Profits |
|-------------------|----------|-------|-------------------|--------------|---------|
| Deposits | 1 | | | | |
| Loans | 0.99 | 1 | | | |
| Interest revenues | 0.99 | 0.99 | 1 | | |
| Fee revenues | 0.63 | 0.62 | 0.69 | 1 | |
| Profits | 0.77 | 0.78 | 0.84 | 0.88 | 1 |

4. Empirical analyses and results

4.1 Efficiency analyses applying the two-stage SBM model

Table 5 summarized the organizational performance of Taiwan’s banking industry based on the non-oriented two-stage SBM model, proposed by Tone and Tsutusi (2009). As can be seen from the table, the average scores for the profitability efficiency in the three categories of the sample dataset were 0.27, 0.17, and 0.47. These results showed that domestic banks have very bad profitability efficiency. The average score of organizational performance was 0.61 in the foreign banks category. This result showed that foreign banks have more efficient ways to deploy their assets and resources.

Table 6 listed the detailed organizational performance scores and ranks derived from the two-stage SBM model. Three domestic banks and seven foreign banks had a score of 1 and outperform the other banks. For production efficiency, one domestic bank and seven foreign banks had a score of 1, showing their superiority. For profitability efficiency, zero domestic banks and six foreign banks had a score of 1. In Table 6, the average score of profitability efficiency in Taiwan’s banking industry was 0.2747, which is lower than the average production efficiency score and the average organizational performance score. This result suggested that bank managers have to launch new profitability maximization plans as soon as possible.

Table 5: Results of the two-stage SBM model

| | Organizational Performance | Production Efficiency | Profitability Efficiency |
|-----------------------|----------------------------|-----------------------|--------------------------|
| <i>All samples</i> | | | |
| No. of efficient DMUs | 10 | 8 | 6 |
| Mean | 0.45 | 0.45 | 0.27 |
| Std. Dev. | 0.31 | 0.28 | 0.29 |

| <i>Domestic</i> | | | |
|-----------------------|------|------|------|
| <i>Banks</i> | | | |
| No. of efficient DMUs | 3 | 1 | 0 |
| Mean | 0.36 | 0.41 | 0.17 |
| Std. Dev. | 0.23 | 0.16 | 0.09 |
| <i>Foreign</i> | | | |
| <i>Banks</i> | | | |
| No. of efficient DMUs | 7 | 7 | 6 |
| Mean | 0.61 | 0.53 | 0.47 |
| Std. Dev. | 0.38 | 0.41 | 0.40 |

Table 6: Results of two-stage SBM for domestic and foreign banks in Taiwan

| Decision Making Units | Organizational Performance | | Production Efficiency | | Profitability Efficiency | |
|-----------------------|----------------------------|------|-----------------------|------|--------------------------|------|
| | Score | Rank | Score | Rank | Score | Rank |
| <i>Domestic</i> | | | | | | |
| <i>Banks</i> | | | | | | |
| D01 | 0.3321 | 28 | 0.4658 | 17 | 0.1091 | 40 |
| D02 | 0.2596 | 37 | 0.3822 | 25 | 0.1213 | 36 |
| D03 | 0.2886 | 33 | 0.4503 | 18 | 0.1095 | 39 |
| D04 | 0.041 | 50 | 0.0552 | 49 | 0.1647 | 27 |
| D05 | 0.5933 | 13 | 0.6306 | 9 | 0.15 | 31 |
| D06 | 1 | 1 | 0.3177 | 34 | 0.3373 | 10 |
| D07 | 0.4285 | 18 | 0.5539 | 14 | 0.1157 | 38 |
| D08 | 1 | 1 | 0.3501 | 28 | 0.3221 | 11 |
| D09 | 0.3102 | 32 | 0.2919 | 39 | 0.2401 | 15 |
| D10 | 0.2639 | 36 | 0.2933 | 38 | 0.2186 | 20 |
| D11 | 0.2354 | 39 | 0.596 | 11 | 0.0703 | 44 |
| D12 | 0.1931 | 43 | 0.5722 | 13 | 0.0641 | 48 |
| D13 | 1 | 1 | 0.283 | 41 | 0.386 | 9 |

| | | | | | | |
|-----|--------|----|--------|----|--------|----|
| D14 | 0.4124 | 19 | 0.3566 | 26 | 0.2086 | 22 |
| D15 | 0.2466 | 38 | 0.2935 | 37 | 0.1742 | 25 |
| D16 | 0.3211 | 30 | 0.3301 | 33 | 0.2197 | 19 |
| D17 | 0.1897 | 44 | 0.3341 | 32 | 0.1278 | 33 |
| D18 | 0.4331 | 16 | 0.295 | 36 | 0.3077 | 12 |
| D19 | 0.3568 | 26 | 0.3859 | 24 | 0.2239 | 18 |
| D20 | 0.2231 | 40 | 0.2888 | 40 | 0.2047 | 23 |
| D21 | 0.4546 | 15 | 0.4214 | 23 | 0.2397 | 16 |
| D22 | 0.3669 | 24 | 0.4375 | 21 | 0.1821 | 24 |
| D23 | 0.3903 | 22 | 0.508 | 15 | 0.1177 | 37 |
| D24 | 0.1626 | 46 | 0.17 | 45 | 0.1583 | 28 |
| D25 | 0.2719 | 34 | 0.3393 | 31 | 0.1714 | 26 |
| D26 | 0.2703 | 35 | 0.4469 | 19 | 0.1073 | 41 |
| D27 | 0.3313 | 29 | 0.5735 | 12 | 0.0659 | 45 |
| D28 | 0.2228 | 41 | 0.4863 | 16 | 0.0761 | 42 |
| D29 | 0.3553 | 27 | 1 | 1 | 0.0545 | 50 |
| D30 | 0.0812 | 47 | 0.2525 | 43 | 0.0651 | 46 |
| D31 | 0.3943 | 20 | 0.4315 | 22 | 0.1532 | 30 |
| D32 | 0.1716 | 45 | 0.4438 | 20 | 0.0556 | 49 |
| D33 | 0.3806 | 23 | 0.3428 | 30 | 0.1559 | 29 |

Foreign

Banks

| | | | | | | |
|-----|--------|----|--------|----|--------|----|
| F01 | 0.0194 | 51 | 0.0022 | 51 | 1 | 1 |
| F02 | 0.3126 | 31 | 0.0819 | 48 | 1 | 1 |
| F03 | 0.4305 | 17 | 0.5968 | 10 | 0.1249 | 34 |
| F04 | 0.0666 | 48 | 0.3029 | 35 | 0.0467 | 51 |
| F05 | 0.0439 | 49 | 0.0432 | 50 | 0.1352 | 32 |
| F06 | 1 | 1 | 1 | 1 | 1 | 1 |
| F07 | 0.7017 | 12 | 0.3525 | 27 | 0.4291 | 8 |
| F08 | 1 | 1 | 1 | 1 | 0.2158 | 21 |
| F09 | 0.3667 | 25 | 0.3461 | 29 | 0.2427 | 14 |
| F10 | 1 | 1 | 0.2221 | 44 | 1 | 1 |
| F11 | 0.4844 | 14 | 0.163 | 46 | 1 | 1 |
| F12 | 1 | 1 | 1 | 1 | 0.0709 | 43 |
| F13 | 1 | 1 | 1 | 1 | 0.5841 | 7 |

| | | | | | | |
|---------|--------|----|--------|----|--------|----|
| F14 | 0.8833 | 11 | 0.1394 | 47 | 1 | 1 |
| F15 | 0.2187 | 42 | 0.2571 | 42 | 0.1232 | 35 |
| F16 | 1 | 1 | 1 | 1 | 0.2607 | 13 |
| F17 | 0.3934 | 21 | 1 | 1 | 0.0646 | 47 |
| F18 | 1 | 1 | 1 | 1 | 0.2342 | 17 |
| Average | 0.4491 | | 0.4488 | | 0.2747 | |

We observed in Fig. 2 that foreign banks have a higher average score than domestic banks in overall organizational performance. Foreign banks were very good at profitability efficiency and had the highest average score of 0.47. Thus, domestic bank managers have to try harder at the profitability stage.

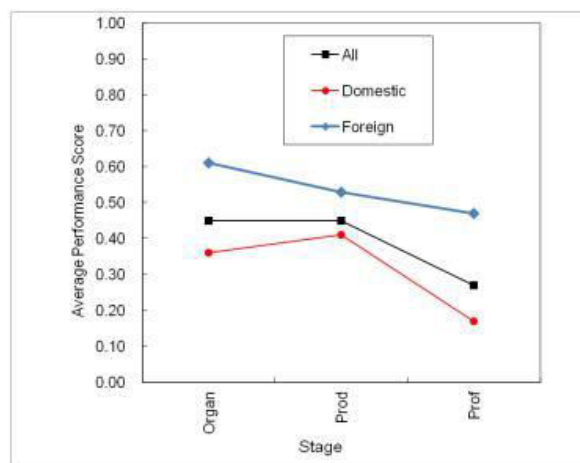


Fig. 2: Average performance score comparisons among all samples, domestic banks, and foreign banks across stages.

4.2 Comparisons between one-stage SBM and two-stage SBM models

In the scatter plot of Fig. 3, we observed the points of the two-stage SBM model and compared the two categories of domestic and foreign banks in detailed efficiencies rather than overall efficiency.

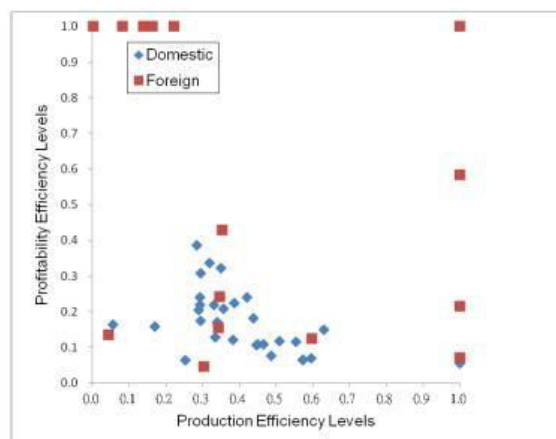


Fig. 3: Scores' scatter plot by production efficiency and profitability efficiency for two-stage SBM.

4.3 Managerial implications

We combined the results of the production efficiency and the profitability efficiency to create a managerial matrix in a two-dimensional scatter plot. We observed that it is easy to compare all bank datapoints with the average operating benchmarks in the industry and go a step further to provide direction to improve organizational performance. This matrix can be divided into four quadrants with the relative efficiency of the production and profitability stages serving as the horizontal and vertical axes of the managerial matrix. The average operating benchmarks had scores of 0.4488 and 0.2747, which are derived from the two-stage SBM model respectively. One important suggestion was that almost all banks in Taiwan should pay more attention on the stage of resource allocations and find out their competitive advantages. Bank managers and government officers can find directions for improvement in organizational performance from this matrix, as shown in Fig. 4.

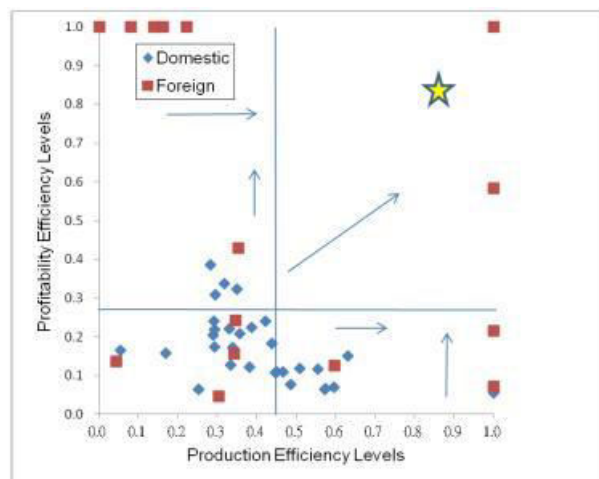


Fig. 4: A matrix for managerial improvements.

5. Conclusion

We integrated the concept of intermediate output for the stage performance evaluation and a slacks-based measure to create a two-stage SBM model for evaluating the whole organizational performance and the detailed stage performance, including both production efficiency and profitability efficiency, in Taiwan for both domestic and foreign banks.

We summarized the empirical results as follows. First, foreign banks had a higher organizational performance than the domestic banks, and the foreign banks operated much better than the domestic banks in profitability efficiency. It can be interpreted that domestic banks have benefited in terms of bank size, fund assets, and intermediate functions, but foreign banks have focused on specific service functions like wealth management and fund portfolio management for senior clients. Second, the information provided by the two-stage SBM model can help bank managers and government officers allocate the appropriate resources to the correct stages in order to improve overall performances.

As to future research, we would like to suggest that it could focus on the weights of sub-structural evaluations by using analytic network processes. Studies could give significant parameters on data envelopment analysis. It is also valuable to practical applications. Research can consider a structure of performance evaluation that includes more precise dimensions and variables like uncontrollable or environmental variables.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Authors' Biography

Chiun-Sin Lin is a Professor of the Department of Business and Entrepreneurial Management, Kainan University, Taiwan. Previously he was a Professor and Chairman of the Department of Management Science, National Chiao Tung University, Taiwan. He received Bachelor and Master Degrees in Business Administration from the National Taiwan University, Taiwan and a Ph.D. in Business Administration from the University of Houston, USA. His researches have been published in various journals including *Management Science*, *European Journal of Operational Research*, *Communications in Statistics*, *International Journal of Services Technology and Management*, *Electronic Library*, *Expert Systems with Applications*, *Applied Energy*, *Economic Modelling*, *Journal of Testing and Evaluation*, and *Cyberpsychology, Behavior, and Social Networking*. His current research interests include performance evaluation, internet marketing, and electronic commerce.

Hsin-Yi Lin is currently a Doctoral Candidate of Department of Management Science, National Chiao Tung University, Taiwan. Simultaneously she works at the Service Systems Technology Center, Industrial Technology Research Institute in Taiwan. She received her Master degree in Div. Transportation Engineering of Department of Civil Engineering from National Central University, Taiwan, R.O.C. Her current research focuses on area of performance evaluation, international business, supply chain management, logistics management and intelligent performance management system.