Journal of Data Science 14(2016), 509-518

An evaluation of the Balance and Variation of DEMATELs by Using Liu's Integrated Validity Index

Hsiang-Chuan Liu[1], Wei-Sung Chen[2], Wei-Guang Tsaur[3], Hung-Ming Yeh[4], Chung-Ling Huh[5]
[1,3,4,5] *Graduate School of Business Administration*
[2] *Department of Computer Science and Information Engineering*
[3] *Department of Economics*
[4] *Department of Accounting*

Abstract: This paper, evaluates and compares the heterogeneous balance-variation order pair of any two decision-making trial and evaluation laboratory (DEMATEL) theories, in which one has a larger balance and a smaller variation. In contrast, the other one has a smaller balance and a larger variation. With this said, the first author proposed a useful integrated validity index to evaluate any DEMATEL theory presence by combining Liu's balanced coefficient and Liu's variation coefficient. Applying this new validity index, three DEMATELs kinds with a same direct relational matrix are compared that are: the traditional, shrinkage, and balance. Furthermore, conducted is a simple validity experiment Results. show that the balance DEMATEL has the best performance. And that, the shrinkage coefficient's performance is better than that of the traditional DEMATEL.

Key words: DEMATEL, indirect relational matrix, balance coefficient, variation coefficient, validity index.

1. Introduction

From 1972 to 1979, the decision Making Trial and Evaluation Laboratory (DEMATEL) was developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva [1]. DEMATEL can be used to resolve complex and difficult problems globally, and has been widely used as one of the best tools to solve the cause and effect relationship of various evaluation factors [1-4]. But a DEMATEL's indirect relation is always far greater than its direct relation, Especially, as the indirect relation matrix does not normalize as that of the direct relational matrix. Hence, the traditional DEMADEL is unfair and inaccurate [5-6]. Thus, two improved DEMATELs were proposed: the shrinkage, and balanced. Provided were both, the balanced and variation coefficients. The balanced coefficient can be used to evaluate the balance degree between both the DEMATEL's indirect influences and direct influences. If such influences are balanced, the variation coefficient can be used to evaluate the DEMATE relation prominence matrix's variation degree. We know that the traditional DEMATEL always has a smaller balance coefficient and a larger variation coefficient. Since the indirect influence is larger. Hence, we want to obtain both larger balance and larger variation coefficients. However, how to evaluate the heterogeneous balance-variation order pair of any two DEMATEL theories, in which one has a smaller balance and a larger variation. In contrast, the other one has a larger balance and a smaller variation -hence a critical issue. In this paper, the first author proposed a useful integrated validity index to evaluate any DEMATEL theory by combining Liu's balanced coefficient and Liu's variation coefficient. Particularly as the balance degree is more important than the variation one. When combining the balance coefficient and variation coefficient in the new validity index, we must give the larger weighted score to the balance coefficient than that of variation coefficient. Fortunately, as the balance coefficient is already more sensitive than the variation one. Hence, their average is possible to be computed.

This paper is organized as follows. Section 2 introduces the traditional DEMATEL. Section 3 introduces two improved DEMATELs: the shrinkage and balanced ones. Section 4 describes both Liu's balanced and variation coefficients, along with the proposed validity index. Section 5 describes by applying our validity index, the Experiment for comparing the three DEMATELs kinds. Section 6 concludes the paper with suggestions and what could possibly be expected in the future.

2. The traditional DEMATEL

Definition 1. The traditional DEMATEL
The procedure of the traditional DEMATEL method is briefly introduced below: [1-4]

2.1 Calculate the initial direct relation matrix Q

N experts are asked to evaluate the degree of direct influence between two factors based on a pair-wise comparison. The degree to which the expert e perceived factor i effects on factor j is denoted as

$$q_{ij}^{(e)},\ e=1,2,...,N,\ q_{ij}^{(e)} \in \{0,1,2,3,4\},\ i,j=1,2,...,n \tag{1}$$

For each expert e, an individual direct relation matrix is constructed as

$$Q_e = \left[q_{ij}^{(e)}\right]_{n\times n},\ e=1,2,..,N,\ q_{ii}^{(e)}=0,\ i=1,2,...,n \tag{2}$$

We can obtain their average direct relation matrix, called the initial direct relation matrix Q as follows:

$$Q=\left[q_{ij}\right]_{n\times n}=\frac{1}{N}\sum_{e=1}^{N}Q_e,\ q_{ij}=\frac{1}{N}\sum_{e=1}^{N}q_{ij}^{(e)},\ i,j=1,2,...,.n \tag{3}$$

2.2 Calculate the direct relation matrix A

$$A=\left[a_{ij}\right]_{n\times n}=\lambda^{-1}Q,\ \lambda=\max_{1\le i,j\le n}\left\{\sum_{j=1}^{n}q_{ij},\sum_{i=1}^{n}q_{ij}\right\} \tag{4}$$

$$a_{ii}=0,\ i=1,2,...,n,\quad 0\le a_{ij}\le 1,\ i\ne j,\ i,j=1,2,...,n,\quad 0\le\sum_{i=1}^{n}a_{ij},\sum_{j=1}^{n}a_{ij}\le 1,\ i,j=1,2,...,n \tag{5}$$

2.3 Calculate the indirect relation matrix B and the total relation matrix T

Based on Markov chain theory, we have $\lim_{n\to\infty} A^K = O_{n\times n}$ (6)

The indirect relation matrix

$$B = \left[b_{ij}\right]_{n\times n} = \lim_{k\to\infty}\left[A^2 + A^3 + ... + A^k\right] = A^2\left(I - A\right)^{-1} \tag{7}$$

The total relation matrix

$$T = \left[t_{ij}\right]_{n\times n} = A + B = \left[\left(a_{ij} + b_{ij}\right)\right]_{n\times n} \tag{8}$$

2.4 Calculate both the relation degree and the prominence degree of each factor

$$r_i = \sum_{j=1}^{n} t_{ij},\ \ c_i = \sum_{k=1}^{n} t_{ki},\quad i = 1, 2, ..., n \tag{9}$$

The value of γ_i indicates the total dispatch is direct and indirect effects, the effect of factor i on the other factors, and the value of c_i which indicates the total receive from both the direct and indirect effects, and the effects factor i has on the other factors.

The relation degree of factor i is denoted as

$$x_i = r_i - c_i,\quad i = 1, 2, ..., n \tag{10}$$

The prominence degree of factor i is denoted as

$$y_i = r_i + c_i,\ \ i = 1, 2, ..., n \tag{11}$$

Relation prominence matrix is denoted as

$$\left(x_i, y_i\right)_{i=1}^{n} \tag{12}$$

2.5 Set the threshold value (α)

For eliminating some minor effects elements in matrix T to find the impact-relations map, Yang et al. [3] has suggested the threshold value below:

$$\alpha_Y = \frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n} t_{ij} \tag{13}$$

Lia and Tzeng [4] suggested a more information threshold value, $\propto_M$, based on their maximum mean de-entropy (MMDE) algorithm.

2.6 Build a cause and effect relationship diagram

If $t_{ij} > \propto_\gamma$ or $t_{ij} > \propto_M$, then factor i is a net dispatch node of factor j, and factor j is a net receive node of factor i, and is denoted as

$$\left(x_i, y_i\right) \to \left(x_j, y_j\right),\ or\ \left(x_i, y_i\right) \leftarrow \left(x_j, y_j\right) \tag{14}$$

The graph of $(x_i, y_i)_{i=1}^{n}$ including the net direct edges can present a cause and effect relationship diagram.

3. The improved DEMATELs

Two improved DEMATELs: the shrinkage DEMATEL and the balanced DEMATEL are briefly introduced below: [5-6]

3.1 The shrinkage DEMATEL

Our previous paper [2] pointed out that the indirect relation of a traditional DEMATEL is always far greater than its direct relation. This relation is unbalanced and unfair, because the indirect relation matrix is not as normalized as the direct relation matrix.

For overcoming this drawback, an external shrinkage coefficient of the indirect relation matrix, d, was provided to construct a better indirect relation matrix, and a generalized DEMATEL theory is obtained below:

Definition 2. The shrinkage DEMATEL [5]

Let $A = \left[a_{ij}\right]_{n\times n}$ and $B = \left[b_{ij}\right]_{n\times n}$ are defined as Definition 1. The indirect relation matrix with shrinkage coefficient d

$$B_d = \left[b_{ij}^{(d)}\right]_{n\times n} = dA^2\left(I - dA\right)^{-1},\ d \in \left[\frac{1}{2}, 1\right] \tag{15}$$

The total relation matrix with shrinkage coefficient d

$$T_d = \left[t_{ij}^{(d)}\right]_{n\times n} = A + B_d = \left[\left(a_{ij} + b_{ij}^{(d)}\right)\right],\ d \in \left[\frac{1}{2}, 1\right] \tag{16}$$

The Relation-Prominence of the DEMATEL (A, B_d) with shrinkage coefficient d is defined as

$$R(A, B_d) = \left(x_i^{(d)}, y_i^{(d)}\right)_{i=1}^{n} = \left(r_i^{(d)} - c_i^{(d)}, r_i^{(d)} + c_i^{(d)}\right)_{i=1}^{n} \tag{17}$$

where

$$r_i^{(d)} = \sum_{j=1}^{n} t_{ij}^{(d)},\ c_i^{(d)} = \sum_{k=1}^{n} t_{ij}^{(d)},\quad i = 1, 2, ..., n \tag{18}$$

If d=1, the new DEMATEL(A, B_d) is just the traditional DEMATEL(A, B). If d=0.5, then $\max_{1\le i,j\le n}\left\{\sum_{j=1}^{n} b_{ij}^{(d)}, \sum_{i=1}^{n} b_{ij}^{(d)},\right\} \le 1$,

and the new DEMATEL(A, B_d) is feasible, since its indirect relation influence is no longer greater than its direct relation influence.

3.2 The balanced DEMATEL L

Definition 3. The balanced DEMATEL [6]

Let $A = \left[a_{ij}\right]_{n\times n}$ and $B = \left[b_{ij}\right]_{n\times n}$ are defined as Definition 1.

$$\mu = \max_{1\le i,j\le n}\left\{\sum_{j=1}^{n} b_{ij}, \sum_{i=1}^{n} b_{ij}\right\} \tag{19}$$

The normalized indirect relation matrix, B_N is defined by

$$B_N = \left[b_{ij}^{(N)} \right]_{n\times n} = \mu^{-1} B = \left[\left(\mu^{-1} b_{ij} \right) \right]_{n\times n} \quad (20)$$

Normalized total relation matrix is defined as

$$T_N = \left[t_{ij}^{(N)} \right]_{n\times n} = A + B_N = \left[\left(a_{ij} + \mu^{-1} b_{ij} \right) \right]_{n\times n} \quad (21)$$

The Relation-Prominence of the DEMATEL(A, B_N) is defined as

$$R(A, B_N) = \left(x_i^{(N)}, y_i^{(N)} \right)_{i=1}^{n} = \left(r_i^{(N)} - c_i^{(N)}, r_i^{(N)} + c_i^{(N)} \right)_{i=1}^{n} \quad (22)$$

where

$$r_i^{(N)} = \sum\nolimits_{j=1}^{n} t_{ij}^{(N)}, \; c_i^{(N)} = \sum\nolimits_{i=1}^{n} t_{ij}^{(N)} \quad (23)$$

4. The validity index of DEMATELS

Liu's balanced coefficient, Liu's variation coefficient and the proposed validity index may be briefly introduced as follows.

4.1 Liu's balanced coefficient,

Definition 4. The balanced coefficient [6]

Let $A = \left[a_{ij}\right]_{n\times n}$, $B = \left[b_{ij}\right]_{n\times n}$ and $\mu = \max_{1\le i,j\le n} \{\sum_{j=1}^{n} b_{ij} \sum_{i=1}^{n} b_{ij}\}$ be defined as above; therefore the balanced coefficient is defined as follows

$$\beta\left(A, B\right) = \frac{2\sqrt{\mu}}{1+\mu}, \quad 0 \le \beta\left(A, B\right) \le 1 \quad (24)$$

Note that

$$\mu = 1 \Leftrightarrow \beta\left(A, B\right) = 1, \; \mu \ne 1 \Leftrightarrow \beta\left(A, B\right) < 1 \quad (25)$$

4.2 Liu's variation coefficient

Definition 5. The variation coefficient [5-6]

Let $A = \left[a_{ij}\right]_{n\times n}$, $B = \left[b_{ij}\right]_{n\times n}$, $\mu = \max_{1\le i,j\le n} \{\sum_{j=1}^{n} b_{ij} \sum_{i=1}^{n} b_{ij}\}$ $T = \left[t_{ij}\right]_{n\times n}$ =A+B , $r_i = \sum_{j=1}^{n} t_{ij}, \; c_i = \sum_{k=1}^{n} t_{ki}, \; i = 1, 2, ..., n$ and $\left(x_i, y_i\right)_{i=1}^{n} = \left(r_i - c_i, r_i + c_i\right)_{i=1}^{n}$ are defined as above.

Then Liu's variation coefficient of the Relation prominence matrix of (A, B) is defined as:

$$\sigma_L\left(A, B\right) = 1 - \frac{1}{1 + 5\sqrt{\sum_{i=1}^{n} \sqrt{\left(x_i - \bar{x}_d\right)^2 + \left(y_i - \bar{y}_d\right)^2}}} \quad (26)$$

where

$$\bar{x}_d = \frac{1}{n} \sum\nolimits_{j=1}^{n} x_i \, , \; \bar{y}_d = \frac{1}{n} \sum\nolimits_{j=1}^{n} y_i \quad (27)$$

4.3 Liu's validity coefficient,

Definition 6. The variation coefficient [5-6]

If $A = [a_{ij}]_{n\times n}$, is the direct relation matrix, $B = [b_{ij}]_{n\times n}$ is the indirect relation matrix, $\beta(A,B)$ is Liu's balance coefficient and $\sigma_L(A,B)$ is the variation coefficient, then the variation coefficient is defined as

$$V_L(A,B) = \frac{1}{2}\left[\beta_L(A,B) + \sigma_L(A,B)\right] \tag{28}$$

5. Experiment

An experiment for Comparing three DEMATELs, by using the validity index is conducted as follows:

Suppose 10 experts are asked to evaluate the degree of the direct influence between two factors based on pair-wise comparison. The degree to which the expert e perceived factor i effects on factor j is denoted as

$$q_{ij}^{(e)}, e = 1, 2, .., 10 \ . \ q_{ij}^{(e)} \in \{0, 1, 2, 3, 4\} \ , \ i, j = 1, 2, 3, 4 \tag{29}$$

For each expert e, an individual direct relation matrix is constructed as

$$Q_e = \left[q_{ij}^{(e)}\right]_{n\times n}, e = 1, 2, .., 10, \ q_{ii}^{(e)} = 0, i = 1, 2, 3, 4 \tag{30}$$

then we can obtain the initial direct relation matrix Q as follows:

$$Q = \left[q_{ij}\right]_{4\times 4} = \frac{1}{10}\sum_{e=1}^{10} Q_e, \ q_{ij} = \frac{1}{10}\sum_{e=1}^{10} q_{ij}^{(e)}, i, j = 1, 2, 3, 4 \tag{31}$$

The direct relation matrix A:

$$A = \left[a_{ij}\right]_{4\times 4} = \lambda^{-1} Q, \lambda = \max_{1\le i, j\le 4}\left\{\sum_{j=1}^{4} q_{ij}, \sum_{i=1}^{4} q_{ij}\right\} \tag{32}$$

$$A = \left[a_{ij}\right]_{4\times 4} = \begin{bmatrix} 0 & 0.36 & 0.32 & 0.32 \\ 0.32 & 0 & 0.34 & 0.30 \\ 0.34 & 0.30 & 0 & 0.30 \\ 0.28 & 0.28 & 0.30 & 0 \end{bmatrix} \tag{33}$$

5.1 DATA for traditional DEMATEL

The indirect relation matrix, total relation matrix, relation-prominence matrix, balance coefficient, variation coefficient and validity index are listed as follows.

The indirect relation matrix B:

$$B=\left[b_{ij}\right]_{4\times4}=A^2\left(I-A\right)^{-1}=\begin{bmatrix}3.9448 & 3.8483 & 3.9290 & 3.7995\\ 3.7483 & 3.8237 & 3.7991 & 3.6907\\ 3.6807 & 3.6963 & 3.8253 & 3.6331\\ 3.4499 & 3.4478 & 3.4963 & 3.4508\end{bmatrix} \tag{34}$$

The maximum row and column value of indirect relation matrix:

$$\mu=\max_{1\le i,j\le n}\left\{\sum\nolimits_{j=1}^{n} b_{ij},\sum\nolimits_{i=1}^{n} b_{ij}\right\}=15.5215 \gg \max_{1\le i,j\le n}\left\{\sum\nolimits_{j=1}^{n} a_{ij},\sum\nolimits_{i=1}^{n} a_{ij},\right\}=1 \tag{35}$$

The balance coefficient is

$$\beta_L\left(A,B\right)=\frac{2\sqrt{\mu}}{1+\mu}=0.4769 \tag{36}$$

The total relation matrix T:

$$T=\left[t_{ij}\right]_{4\times4}=\begin{bmatrix}3.9448 & 4.2083 & 4.2490 & 4.1195\\ 4.0683 & 3.8237 & 4.1391 & 3.9907\\ 4.0207 & 3.9963 & 3.8253 & 3.9331\\ 3.7299 & 3.7278 & 3.7963 & 3.4508\end{bmatrix} \tag{37}$$

The Relation-Prominence matrix of (A,B):

$$R(A,B)=\left(x_i\,,y_i\right)_{i=1}^{n}=\begin{bmatrix}0.7579 & 32.2851\\ 0.2658 & 31.7781\\ -0.2344 & 31.7850\\ -0.7893 & 30.1989\end{bmatrix} \tag{38}$$

The variation coefficient of $R(A,B)$ is: $\sigma_L\left(A,B\right)=0.9015$ (39)

The validity index of (A,B) is: $V_L\left(A,B\right)=0.6892$ (40)

5.2 DATA shrinkage DEMATEL with shrinkage coefficient 0.5

The indirect relation matrix, the total relation matrix, the relation-prominence matrix with shrinkage coefficient 0.5, the balance coefficient, the variation coefficient and the validity index are listed as follows:

The indirect relation matrix with the shrinkage coefficient of 0.5:

$$B_{0.5}=\begin{bmatrix}0.2538 & 0.1993 & 0.2144 & 0.2047\\ 0.2012 & 0.2450 & 0.2002 & 0.2012\\ 0.1916 & 0.2020 & 0.2450 & 0.1971\\ 0.1882 & 0.1879 & 0.1872 & 0.2182\end{bmatrix} \tag{41}$$

The maximum row and column value of indirect relation matrix with the shrinkage 0.5:

$$\mu_{0.5}=\max_{1\le i,j\le n}\left\{\sum\nolimits_{j=1}^{n} b_{ij}^{(0.5)},\sum\nolimits_{i=1}^{n} b_{ij}^{(0.5)}\right\}=0.8721<1 \tag{42}$$

The balance coefficient is:

$$\beta\left(A,B_{0.5}\right)=\frac{2\sqrt{\mu_{0.5}}}{1+\mu_{o.5}}=0.9977 \tag{43}$$

The total relation matrix with the shrinkage coefficient 0.5:

$$T_{0,5}=\begin{bmatrix} 0.2538 & 0.5593 & 0.5344 & 0.5247 \\ 0.5212 & 0.2450 & 0.5402 & 0.5012 \\ 0.5316 & 0.5020 & 0.2450 & 0.4971 \\ 0.4682 & 0.4679 & 0.4872 & 0.2182 \end{bmatrix} \tag{44}$$

The Relation-Prominence matrix of $\left(A,B_{0.5}\right)$:

$$R(A,B_{0.5})=\left(x_i^{(0.5)},y_i^{(0.5)}\right)_{i=1}^{n}=\begin{bmatrix} 0.0973 & 3.6469 \\ 0.0334 & 3.5818 \\ -0.0311 & 3.5824 \\ -0.0996 & 3.3826 \end{bmatrix} \tag{45}$$

The variation coefficient of $R(A,B_{0.5})$: $\sigma_L\left(A,B_{0.5}\right)=0.7653$ (46)

The validity index of $\left(A,B_{0.5}\right)$:

$$V_L\left(A,B_{0.5}\right)=0.8815>V_L\left(A,B\right)=0.6892 \tag{47}$$

5.3 DATA of the balanced DEMATEL

The indirect normalized relation matrix, the total normalized relation matrix, the normalized relation-prominence matrix, the balance coefficient, the variation coefficient and the validity index are listed as follows:

The normalized indirect relation matrix:

$$B_N=\mu^{-1}B=\begin{bmatrix} 0.2541 & 0.2479 & 0.2531 & 0.2448 \\ 0.2415 & 0.2464 & 0.2448 & 0.2378 \\ 0.2371 & 0.2381 & 0.2464 & 0.2341 \\ 0.2223 & 0.2221 & 0.2253 & 0.2223 \end{bmatrix} \tag{48}$$

The maximum row and column value of the normalized indirect relation matrix:

$$\mu_N=\max_{1\le i,j\le n}\left\{\sum\nolimits_{j=1}^{n}b_{ij}^{(N)},\sum\nolimits_{i=1}^{n}b_{ij}^{(N)}\right\}=1 \tag{49}$$

The balance coefficient is: $\beta\left(A,B_N\right)=\dfrac{2\sqrt{\mu_N}}{1+\mu_N}=1$ (50)

The normalized Relation-Prominence matrix of $\left(A,B_N\right)$ is:

$$RP_N=\left(x_i^{(N)},y_i^{(N)}\right)_{i=1}^{n}=\begin{pmatrix} 0.1050 & 3.8950 \\ 0.0358 & 3.8249 \\ -0.0338 & 3.8254 \\ -0.1070 & 3.6109 \end{pmatrix} \tag{51}$$

The variation coefficient of $R(A,B_N)$ is:

$$\sigma_L(A, B_N) = 0.7717 > \sigma_L(A, B_{0.5}) = 0.7653 \tag{52}$$

The validity index of (A, B_N) is:

$$V_L(A, B_N) = 0.8859 > V_L(A, B_{0.5}) = 0.8815 > V_L(A, B) = 0.6892 \tag{53}$$

The results of all of the validity indexes show that the balanced DEMATEL has the best performance, and the performance of the shrinkage DEMATEL with the shrinkage coefficient 0.5 is better than that of the traditional DEMATEL.

6. Conclusion

This paper, evaluates and compares the heterogeneous balance-variation order pair of any two DEMATEL theories, in which one has a larger balance and a smaller variation. In contrast, the other one has a smaller balance and a larger variation. With this said, the first author proposed a useful integrated validity index to evaluate any DEMATEL theory presence by the average of Liu's balanced coefficient and Liu's variation coefficient. Using this new validity index, three DEMATELs kinds with a same direct relational matrix are compared including the traditional, shrinkage, and balance. Furthermore, conducted is a simple validity experiment Results. show that the balance DEMATEL has the best performance. And that, the shrinkage coefficient's performance is better than that of the traditional DEMATEL.

References

[1]. S. Detcharat & A. Pongpun, "Using DEMATEL Method to Analyze the Causal Relations on Technological Innovation Capability Evaluation Factors in Thai Technology-Based Firms," International Transaction Journal of Engineering, 81-103, 2013.

[2]. G.H. Tzeng, C.H. Chiang, & C.W. Li, "Evaluating intertwined effects in e-learning programs:A Novel Hybrid MCDM Model Based on Factor Analysis and DEMATEL," Expert Systems with Applications, vol. 32: 1028-1044, 2007.

[3]. Y.P. Yang, H.M. Shieh, J.D. Leu & G.H. Tzeng, "A novel hybrid MCDM model combined with DEMATEL and ANP with applications," International Journal Operational Research, vol. 5, no. 3:160-168, 2008.

[4]. C.W. Lia, G.H. Tzeng, "Identification of a threshold value for the DEMATEL method using the maximum mean de-entropy algorithm to find critical services provided by a semiconductor intellectual property mall," Expert Systems with Applications, vol. 36:9891–9898, 2009.

[5]. H.-C. Liu, B.-C. Shia, Y.-C. Ou, H.-W. Su, "A generalized DEMATEL theory with a shrinkage coefficient of indirect relation matrix," IMETI 2015, Kaohsiung Taiwan, 2015.

[6]. H.-C. Liu, Y.-C. Ou, H.-C. Tsai, B.-C. Shia, J.-M. Ju, "A balanced DEMATEL theory with normalized indirect relation matrix, " ICICIC 2015, Dalian, China, 2015.

Hsiang-Chuan Liu
Graduate School of Business Administration
Fu Jen Catholic University. New Taipei, Taiwan, ROC
Tel : +886-2-29096938; Fax: +886-4-2213520
lhc@asia.edu.tw

Wei-Sung Chen
Department of Computer Science and Information Engineering
Asia University, Taichung, Taiwan, ROC
james@asia.edu.tw

Wei-Guang Tsaur
Department of Economics
Graduate School of Business Administration
Fu Jen Catholic University. New Taipei, Taiwan, ROC

Hung-Ming Yeh
Department of Accounting
Graduate School of Business Administration
Fu Jen Catholic University. New Taipei, Taiwan, ROC
012939@mail.fju.edu.tw

Chung-Ling Huh
Graduate School of Business Administration
Fu Jen Catholic University. New Taipei, Taiwan, ROC
402088143@mail.fju.edu.tw.