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# International Journal of Organizational Innovation
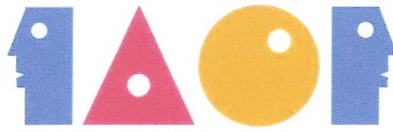
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# A STUDY OF TRANSFORMATION CHARACTERISTICS IN SOLVING THE MULTI OBJECTIVE LINEAR FRACTIONAL PROGRAMMING PROBLEMS

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## Abstract

In the optimization programming problems, some multiple objectives to be optimized rather than a single objective, and objectives can be expressed with ratio equations such as return/investment, operating profit/net-sales, cost/volume, and cost/benefit, etc. Naturally, there is a need for generalizing the simplex technique for linear programming to the ratio of linear functions. All these problems are fragments of a general class of optimization problems, termed in the literature as fractional programming problems. We proposed the transformation characteristics to solve the multi objective linear fractional programming (MOLFP) problems in this research. The transformation characteristics are proposed to solve MOLFP problems with both the numerators and the denominators of the objectives are linear functions and some technical linear restrictions are satisfied. The numerical example is presented.

Keywords: MOLFPP, Transformation Characteristics, Fuzzy Linear Programming

## Introduction

The multiple objective fractional programming models were first studied by Luhandjula (1984). Kornbluth and Steuer (1981) have presented an algorithm for solving the MOLFP by combining aspects of multiple objective, single objective fractional programming and goal programming. Bitran and Novaes (1973) method is used to solve this linear fractional program by solving a sequence of linear programs only re-computing the local gradient of the objective function. Hasan and Acharjee (2011) also develop a method for solving LFP by converting it into a single LP, but for the negative value of $\beta$, their method fails. Valipour et al. (2014) suggested an iterative parametric approach for solving MOLFP problems which only uses linear programming to obtain efficient solutions and converges to a solution. Nykowski and Zolkiewski (1985)

presented a compromise procedure for MOLFP problems. Mishra et al. (2014) presented a MOLFP approach for multi objective linear fuzzy goal programming problem. Saha et al. (2015) proposed an approach for solving linear fractional programing problem by converting it into a single linear programming problem, which can be solved by using any type of linear fractional programming technique.

Zimmermann (1976, 1978) applied fuzzy set theory concept with choices of membership functions and derived a fuzzy linear program which is identical to the maximum program. Luhandjula (1984) solved MOLFP by applying fuzzy approach to overcome the computational difficulties of using conventional fractional programming approaches to solve multiple objective fractional programming problems. Charnes and Cooper (1962) have shown that a linear fractional programming problem can be optimized by reducing it to two linear programs to solve MOLFP. Dutta et al (1992) modified the linguistic approach of Luhandjula (1984) by constructing the desirable membership functions. Chakraborty and Gupta (2002) stated that suitable transformation should have been applied to formulate an equivalent multi objective linear programming and the resulting multi objective linear programming could be solved based on fuzzy set theoretic approach.

The transformation characteristics are proposed to solve MOLFP problems with both the numerators and the denominators of the objectives are linear functions and some technical linear restrictions are satis-fied. The numerical example is presented.

## Method

## The Transformation Characteristics of MOLFPP

*Fuzzy Linear Programming*

The multi objective linear fractional programming problem can be considered as a vector optimizing problem. The first step is to assign two values $U_k$ and $L_k$ as upper and lower bounds for each objective function $Z_k$:

$U_k$ = Highest acceptable level of achievement for objective $k$

$L_k$ = Aspired level of achievement for objective $k$
Let

$d_k = U_k - L_k$ = the degradation allowance for objective $k$.

The range of the membership function $\mu_k(X)$ is $[0,1]$.

$$\mu_k(X) = \begin{cases} 1 & if \quad Z_k \leq L_k, \\ 1 - \dfrac{Z_k - L_k}{U_k - L_k} & if \quad L_k < Z_k < U_k, \\ 0 & if \quad Z_k \geq U_k. \end{cases}$$

*Linear Fractional Programming*

The general format of a classical linear fractional programming problem Charnes and Cooper(1962) can be stated as

$$Max \quad \frac{c^T x + \alpha}{d^T x + \beta}$$

s.t.
$$x \in X = \left\{ x \in R^n \middle| Ax \begin{pmatrix} \leq \\ = \\ \geq \end{pmatrix} b, x \geq 0, b \in R^m \right\} (1)$$

where $c, d \in R^n$; $\alpha, \beta \in R$, $X$ is nonempty and bounded.

The basic transformation characteristic of the original objective is proposed to solve the problem:

$$\underset{x \in \Delta}{Max} \frac{N(x)}{D(x)} \Leftrightarrow \underset{x \in \Delta}{Min} \frac{D(x)}{N(x)} \Leftrightarrow \underset{x \in \Delta}{Min} \frac{-D(x)}{-N(x)} (2)$$

## Multiple Objective Linear Fractional Programming Problem

The general format of maximizing MOLFP can be written as

$$Max \ Z(x) = \begin{cases} Z_1(x) = \dfrac{c_1^T x + \alpha_i}{d_1^T x + \beta_i} \\ Z_2(x) = \dfrac{c_2^T x + \alpha_i}{d_2^T x + \beta_i} \\ \quad . \\ \quad . \\ \quad . \\ Z_k(x) = \dfrac{c_k^T x + \alpha_i}{d_k^T x + \beta_i} \end{cases}$$

s.t.
$$x \in X = \left\{ x \in R^n \middle| Ax \begin{pmatrix} \leq \\ = \\ \geq \end{pmatrix} b, x \geq 0, b \in R^m \right\} (3)$$

where $c_i, d_i \in R^n$; $\alpha_i, \beta_i \in R$, $i = 1,2,...k$, $k \geq 2$, $X$ is nonempty and bounded.

Similarly, minimum problem can also be defined as

$$Min \quad Z(x) = [Z_1(x), Z_2(x), ... Z_k(x)]$$

s.t.
$$x \in X = \left\{ x \in R^n \middle| Ax \begin{pmatrix} \leq \\ = \\ \geq \end{pmatrix} b, x \geq 0, b \in R^m \right\} (4)$$

where $c_i, d_i \in R^n$; $\alpha_i, \beta_i \in R$, $i = 1,2,...k$, $k \geq 2$, $X$ is nonempty and bounded,
with

$$Z_i(x) = \frac{c_i^T x + \alpha_i}{d_i^T x + \beta_i} = \frac{N_i(x)}{D_i(x)}.$$

The general format of minimum MOLFP is as the following equivalent multi objective linear programming problem:

$$Min \quad c_i^T y + \alpha_i t,$$

s.t. $d_i^T y + \beta_i t = \gamma$
$A_i y - b_i t \leq 0$,
$y, t \geq 0$, $i = 1,2,...k$, $k \geq 2$.

The membership functions for $N_i(x)$ and $D_i(x)$ are as followed:

If $i \in I$, then
$$\mu_i(t N_i(y/t))$$
$$= \begin{cases} 0 & if \quad t N_i(y/t) \leq 0 \\ \dfrac{t N_i(y/t) - 0}{\bar{Z}_i - 0} & if \quad 0 < t N_i(y/t) < \bar{Z}_i \\ 1 & if \quad t N_i(y/t) \geq \bar{Z}_i \end{cases}$$

If $i \in I^c$, then
$$\mu_i(t D_i(y/t))$$
$$= \begin{cases} 0 & if \quad t D_i(y/t) \leq 0 \\ \dfrac{t D_i(y/t) - 0}{\bar{Z}_i - 0} & if \quad 0 < t D_i(y/t) < \bar{Z}_i \\ 1 & if \quad t D_i(y/t) \geq \bar{Z}_i \end{cases}$$

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The problem could be transformed into the crisp model as:

$$Max \ \lambda$$

$$\text{s.t. } \mu_i(tN_i(y/t)) \geq \lambda \text{ for } i \in I,$$

$$\mu_i(tD_i(y/t)) \geq \lambda \text{ for } i \in I^c,$$

$$tD_i(y/t) \leq 1 \quad \text{for } i \in I,$$

$$-tN_i(y/t) \leq 1 \quad \text{for } i \in I^c,$$

$$A(y/t) - b \leq 0,$$

$$t > 0, \ y \geq 0,$$

$$i = 1, 2, \dots k, \ k \geq 2.$$

$I$ is a set such that $I = \{i : N_i(x) \geq 0$ for some $x \in \Delta\}$ and $I^c = \{i : N_i(x) < 0$ for each $x \in \Delta\}$ where $I \bigcup I^c = \{1, 2, \dots, k\}$. The computing of $\overline{Z}_i$, is proceeded as "if $i \in I$, then it may assume the maximum aspiration level is $\overline{Z}_i = Z_i^*$, and if $i \in I^c$, then $\overline{Z}_i = -1/Z_i^*$ ." With $t = 0$, by Charnes and Cooper (1962) method, the problem could not be solved, the transformation characteristics can be used to solve the MOLFP.

Results and Discussion

The solution procedure is stated and numerical examples adopted from Chakraborty and Gupta (1973) are used to show the transformation characteristics.

Solution Procedure

The transformation characteristics are used to solve MOLFP when $t = 0$ from the original problems. The following procedure is developed:

Step 1. Solve the original MOLFPP by Charnes and Cooper (2002).

Step 2. Apply the proposed methodology if $t = 0$.

Step 3. Solve the problem by transform the equivalent multi objective linear programming problem into the crisp model.

Numerical Example

1. Let's consider a MOLFP with three objectives as follows:

$$Max \ Z(x) = \begin{pmatrix} Z_1(x) = \dfrac{-3x_1 + 2x_2}{x_1 + x_2 + 3}, \\ Z_2(x) = \dfrac{7x_1 + x_2}{5x_1 + 2x_2 + 1} \\ Z_3(x) = \dfrac{x_1 + 4x_2}{2x_1 + 3x_2 + 2} \end{pmatrix}$$

$$\text{s.t. } x_1 - x_2 \geq 1,$$

$$2x_1 + 3x_2 \leq 15,$$

$$x_1 + 9x_2 \geq 9,$$

$$x_1 \geq 3,$$

$$x_i \geq 0, \ i = 1, 2.$$

We obtain $t = 0$. The equivalent MOLFPP is:

$$Min \ Z(x) = \begin{pmatrix} Z_1(x) = \dfrac{-x_1 - x_2 - 3}{3x_1 - 2x_2}, \\ Z_2(x) = \dfrac{5x_1 + 2x_2 + 1}{7x_1 + x_2} \\ Z_3(x) = \dfrac{2x_1 + 3x_2 + 2}{x_1 + 4x_2} \end{pmatrix}$$

$$\text{s.t. } x_1 - x_2 \geq 1,$$

$$2x_1 + 3x_2 \leq 15,$$

$$x_1 + 9x_2 \geq 9,$$

$$x_1 \geq 3,$$

$$x_i \geq 0, \ i = 1, 2.$$

2. Reduce the MOLFPP into the following:

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$$Min \begin{pmatrix} f_1(y,t) = -y_1 - y_2 - 3t \\ f_2(y,t) = 5y_1 + 2y_2 + t \\ f_3(y,t) = 2y_1 + 3y_2 + 2t \end{pmatrix}$$

s.t. $3y_1 - 2y_2 \le 1$,

$\qquad 7y_1 + y_2 \le 1$,

$\qquad y_1 + 4y_2 \le 1$,

$\qquad y_1 - y_2 - t \ge 0$,

$\qquad 2y_1 + 3y_2 - 15t \le 0$,

$\qquad y_1 + 9y_2 - 9t \ge 0$,

$\qquad y_1 - 3t \ge 0$

$\qquad y_1 - 3t \ge 0$,

$\qquad y_i$, $i = 1,2$, $t \ge 0$.

3. The result value will be
   $(U_1, L_1) = (0, -0.32)$,
   $(U_2, L_2) = (0.8, 0)$, and
   $(U_3, L_3) = (0.56, 0)$. Transform the multi objective linear programming problem into the crisp model:

   $Min \ \lambda$

   s.t.

   $-y_1 - y_2 - 3t + 0.32 \le 0.32\lambda$,

   $\qquad 5y_1 + 2y_2 + t \le 0.8\lambda$,

   $\qquad 2y_1 + 3y_2 + 2t \le 0.56\lambda$,

   $\qquad 3y_1 - 2y_2 \le 1$,

   $\qquad 7y_1 + 2y_2 \le 1$,

   $\qquad y_1 + 4y_2 \le 1$,

   $\qquad y_1 - y_2 - t \ge 0$,

   $\qquad 2y_1 + 3y_2 - 15t \le 0$,

   $\qquad y_1 + 9y_2 - 9t \ge 0$,

   $\qquad y_1 - 3t \ge 0$,

   $\qquad y_i$, $i = 1,2$, $\lambda, t \ge 0$.

   The solution are: $\lambda = 0.5$, $y_1 = 0.6$, $y_2 = 0.04$, and $t = 0.02$. Therefore, the solution of the original

problem is: $x_1 = 3$, $x_2 = 2$,

$Z_1 = \dfrac{-5}{8}$, $Z_2 = \dfrac{23}{20}$, $Z_3 = \dfrac{11}{14}$.

## Conclusions

The transformation characteristics to solve MOLFPP based on fuzzy set theoretic approach is proposed in this research. The MOLFPP can be transformed into the equivalent appropriate multi objective linear programming problem by using the transformation characteristics. The resulting multi objective linear programming problem is solved using fuzzy set theoretic approach by membership functions and transform the multi objective linear programming problem into the crisp model. Numerical example is utilized to illustrate the proposed methodology.

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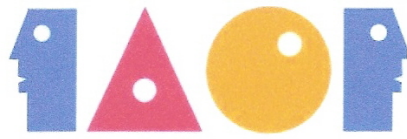
# AN EXPLORATORY STUDY OF ORGANIZATIONAL LEARNING NETWORKS: AN IDENTITY APPROACH

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## Abstract

This study adopts an identity perspective toward organizational learning to explore the patterns of learning networks in a healthcare organization. By considering learning subjects as heterogeneous, this study manages to connect individual perspective of organizational identity with organizational level of learning. The researcher conducted a qualitative study with stratified sampling involving four types of occupations. The software NodeXL was used for the descriptive network analysis and NVIVO 10 for analysis of the qualitative data. The findings are shown as follows: first, homogeneity in the learning networks preserve the distinctiveness of organizational identifications, which in turn, contributes to the performance of collaborative projects; second, heterogeneity in the learning networks is connected to adaptive identity, which is potential to shift the learning focus to the places outside the hospital; third, the structural dimension was the contextual variable that contributes to learning and identification. Facilitators of organizational learning should pay specific attention to patterns of learning networks in order to possibly intervene in the processes of identification construction.

Key Words: learning networks, an identity approach, healthcare organizations

## Introduction

Healthcare organizations are a knowledge intensive sector, and provide complex services, characterized by the interaction of multiple disciplines. A need for constant updating with the latest medical techniques drives healthcare

organizations to carry on continuous learning (Vassalou, 2001). Organizational learning influences individual employees and their perceptions over the organizations and leads to change in organizational identity (e.g. Child and Rodrigues, 2003). Therefore, the concept of identity is a key mechanism to examine the learning process occurring at the employee level; Wenger (1998) links the learning process with the identity: "Because learning transforms who we are and what we can do, it is an experience of identity (p. 215)." Nevertheless, some workplace learning may fail to consider the diversity of participants in learning programs, treating them as homogeneous (Poell et al., 2000).

The most powerful occupation within healthcare-the doctors-is associated with larger networks replete with diverse ties (Smith and Thompson, 2012) and are able to make their learning agenda depending on their own interest (Martin et al., 2006). In contrast, for the low-status staff, learning should be mainly relevant for better work performance (Poell et al., 2000). The power relations between learning actors construct a context of social interactions which function as basic mechanisms that support a mutually recursive relationship between organizational identity and organizational learning (Corley and Gioia, 2003).

This study considers the diversity of learning subjects in organizational learning, treating them as heterogeneous by investigating a healthcare organization. A learning network describes the way learning is organized in the context of work organizations and an identity approach on intra-organizational learning (Gioia et al., 2000; Doiron, 2013) offers insights on how to manage the organizational learning process and provides strategies on maintaining, refocus, or transform identity.

Literature Review

*Learning Networks*

The sociological discipline of organizational learning contends that social processes in the macro-structural conditions influence the organizational learning functions (Coopey, 1995). The paper extends this sociological view to the learning perspective and introduces the concepts of the learning network. Learning Network Theory (LNT) (Poell et al., 2000; Van der Krong, 1998) states that learning networks occur in every organization and describes the way learning is organized within the context of work organizations. LNT regards employees as the central actors of learning and employees have their own views and interests as to how and why they should learn. Therefore, LNT empha-

sizes employees as co-organizers of the learning process and recognizes learning as a commodity that gives rise to competing forces against mutual interests.

LNT assumes that an organization display characteristics of one, or of more in hybrid forms depending on both actor dynamics and work characteristics: (1)Liberal learning networks develop in organizations with loosely-coupled structure and with the notion of individual employee empowerment (Andrews and Herschel, 1996); (2)Vertical learning networks occur in many large organizations with centralized structure and dominated management; learning policies are developed by the management and translated into pre-designed learning programs by training staff; (3)Horizontal learning networks are characterized of egalitarian relationships among the actors, and open, thematic learning activities, therefore, gaining popularity in learning organizations with advocacy in team learning; (4)External learning networks exist in environments where employees have a strong orientation towards their professional field; on the one hand, professional employees are not easy to control and on the other hand, professions offer their members greater status and job security (Poell, et al. 2000).

## Organizational Identity and Learning Networks

Organizational identity is a process of self-definition based on social identity theory and self-categorization theory (e.g. Bergami & Bagozzi, 2000). Social identity theory highlights the construction of a shared self-definition in terms of ingroup-defining properties (Hogg and Terry, 2000). Social identification is the perception of belongingness to a group (Mael and Ashforth, 1992). Pratt (1998) contends that through social identification individuals feel "psychologically intertwined" with a group's destiny.

Corley et al. (2006) suggested two perspectives: the "essentialist" or the "social constructionist" in organizational identity research. The essentialist defines organizational identity as the central, enduring, and distinctive character of the organization (Elstak, 2008); a social constructionist describes organizational identity as being adaptive, unstable, and less enduring (Hatch and Schultz 2002). Barraquier (2013) in an ethnographic study on the incremental transformation of identity suggests "a claimed and institutionalized identity" and "adaptive identity." This study assumes that organizational identity is fluid, allowing organizational members to categorize their own attributes of

identity in a learning network with a set of internal relationships among individual members, and learning sources such as internal educational programs. An identity perspective to learning networks can help understand how characteristics of learning networks are constructed in relation to self-defining essence of collective's role.

Research Methods

In order to understand the relations and attributes in learning networks, the researcher conducted a social network analysis within a community hospital. Social networks analysis is diagrammed with nodes and links to present the complexity associated with social networking. The nodes in the network are the people and groups, while the links represent relationships or flows between the nodes.

*Context of the hospital case*: the study identifies SJ Hospital (not the real name), a non-profit organization located in a small town of Taiwan. In 1955, Reverend Georgia, Belgian missionary, founded JS. Currently, this hospital has 725 employees with 572 beds. This community teaching hospital had been the only medical resource in the small town since 1955. This hospital has its dominant culture derived from the religious motivation. The tenets underlying

Catholic hospital work is total sacrifice, true love constantly, and to transmit God's love through medical service. Religious stories regarding working experiences recounted by senior employees offer claimed, institutionalized identity.

Nevertheless, Joint Commission of Taiwan, established in 1999, and National Health Insurance, founded in 1995, set up new medical industrial regulations by opening up local medical markets to some other competitors. When compared with new competitors, JS has negative images: "slow development," "no advanced equipment and apparatus" and "the level of professional skills is not high." Progress may be more external than internal, not too much from the internal side, although many internal activities, many of the QCC, and a lot of reading sessions are internal stimulus, but those probably are not enough to make the hospital long-term progress.

*Data collection*: the researcher made semi-structured interviews, observations and a learning-network questionnaire to collect data. Following protocols in Poell et al. (2000), this study constructs guidelines for interviews. Examples are: "What in your unit you should learn?" "In what way you should learn it?" "What roles normally do you

have in the learning processes?" "Who are engaged in organizing learning?" "How these activities are decided?" The sampling strategy is stratified sampling with four groups of administrative staffs, medical technicians, nurses and physicians, whose numbers of samples, respectively, are 10, 5, 15, and 3. A Likert scale is used to measure respondents' attitudes to the five locations of learning: supervisors, peers, internal educational training, external training associations and others. The researcher also constructed identity questions, following guidelines by Brown et al. (2006), such as "Who are we as an organization?" "What are impressions around identity-related conversations in your work groups?" and "What are specific conceptual domains for organizational identity characterized by the CEOs?"

*Data analysis*: the researcher analyzes the interview transcripts by the use of the software NVIVO 10. Following coding techniques advanced by Corbin and Strauss (1990), the researcher organized open, axial and selective coding. The research found the corresponding concepts of components purposed by Poell et al. (2000), such as consensus camp, and 120 credits of learning activities. Little by little, emergent differences and similarities are observed and form particular patterns within the data. For example, patterns are subcategories of

learning policies, and learning climates that can be integrated connected. By systematically comparing and elaborating, this study eventually results in the identification of a small number of "core categories," such as "learning process," "learning structure," "adaptive identity" and "institutionalized identity."

The software used for the descriptive network analysis was NodeXL. The relation, represented by the arrow, means "learns from." Deep solid lines represent respondents agree/strongly agree with the learning places where they learn from; that is, the rating level is 4 or 5 in the Likert scale. Lighter transparent lines mean 3 or less than 3 in the Likert scale. Learning-network figures map internal learning relations within the hospital and confirm intimacy and alienation in the learning relationships.

Exploratory Analysis of the Learning Network

Technicians: As Figure 1 shows, technician members agree that they learn most from external locations. The probable reason for this situation was that the external locations, like the Association of Radiology, and Taiwan Society of Laboratory Medicine in Taipei, are places of granting the professional qualification by completing 150 learning

credits within six years. Comparatively, the internal educational training and supervisors play the second important places for medical technicians; internal learning system such as advanced system or mentoring system to train members were developed. Technicians learn from the most experienced in the ward, the supervisor or competent coworkers, but not for every technician. The least agreeable place is others, and the only one is indicated as the website.
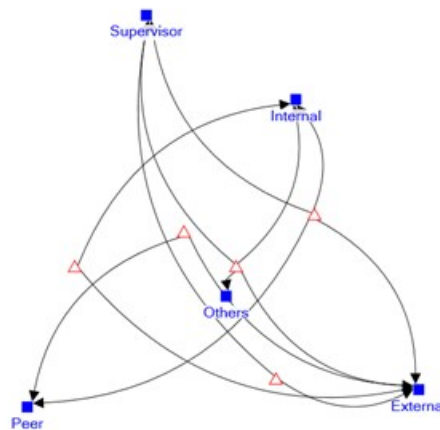


Figure 1: Learning Network for Technicians

Administrative Staff: Figure 2 shows that the administrative staffs learn more frequently within their own administrative units than between units. Learning is rather multidimensional, including knowledge of management, case studies, and meeting discussion. And peers are reciprocated relations, meaning learning is sometimes mutual. This situation might be explained by intensive contacts among supervisors and the job similarity of the employees. Collaborative learning with job-related contacts in other sectors plays the second significant important role. This situation could be partially explained by the fact that characteristics of administrative work are supporting, and for supervisors, crossing boundaries build parts of their learning networks.

Nurses: Due to the large size of numbers in the nursing department, this study obtains proportionally more samples. Nurses report to have intensive learning activities within certain sub-networks, such as supervisors, and internal education programs. Head nurses are the central employees that drive organizational learning in their business units. In the hospital, nurses are required to complete internal formal education (learning passport). The head nurses are experienced employees and are able to influence the general direction of the

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learning agenda. Supervisors (head nurses) are sources of knowledge and also are intermediaries (boundary spanners) to other valuable sources of knowledge. Supervisors are in alignment with internal education program to enhance closeness in the learning ties.
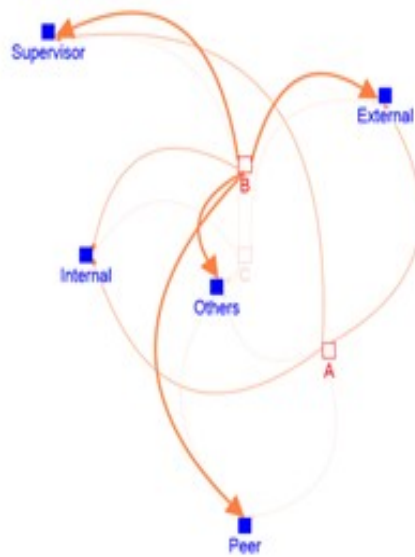


Figure 2: Learning Network for Administrative Staff
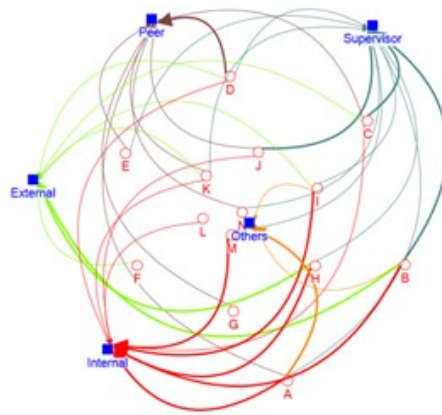


Figure 3: Learning Network for Nurses
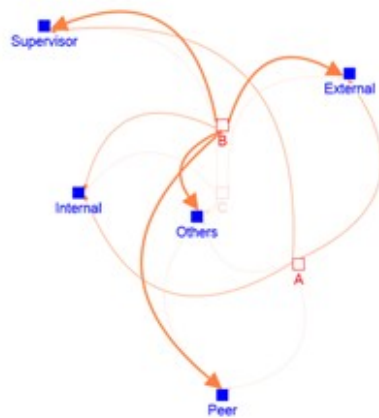
Figure 4: Learning Network for Physicians

Physicians: As physicians are proportionally less than the other three ocupations. This study has only three samples. The learning network for physicians is sparsely connected (Figure 4). A physician with an executive position (Respondent A and Respondent B) presents high strength of connections (the solid lines) with the sources of learning in the hospital; on the other hand, a physician without dealing administrative work might have weak connections (the lighter lines) with sources of learning, who is Respondent C.

Discussion

This study explores the learning networks in the case of the community hospital. Table 1 reveals differences and similarity between the four types of learning networks.

Goal-Directed and Homogeneous Learning Networks

Learning networks of nurses and administrators are based on homogeneous links and goal-directed type. Homogeneous are amongst actors who are similar. The learning relationships amongst members of a network who are similar in some form are like bonding social capital (Putnam, 2000). Bonding social capital provides network members emotional support and identity ownership through which they have access to new professional knowledge. Goal-directed learning networks mean that members share a common goal and most of their activities are focused on goal-attainment (Kilduff and Tsai, 2003).

To be specific, nurses are found to be the vertical type and administrative staffs a horizontal type. Hierarchical

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Table 1: Similarity and Differences between Learning Networks

| Network classification | Category | Network nucleus | Learning types |
|---|---|---|---|
| Goal-Directed homogeneous | Nurses | Internal training policy | Vertical |
| | Administrative Staffs | Supervisors | Horizontal |
| Serendipitous Heterogeneous | Technicians | External association | External |
| | Physicians | Counterparts | Liberal |

levels differentiate learning contents for nurses, and augmented levels makes the nurses' learning network as a vertical type. Collaborative learning with job-related contacts in other sectors play a significant factor to the horizontal learning network for administrative staffs. Lewis et al. (2005) suggest that an individual's attractiveness as a source of learning is related to the level of skills and expertise he/she possesses. Administrative supervisors have the expertise as the reason to be learning nucleus.

Serendipitous and Heterogeneous Learning Networks

Learning networks for technicians and physicians are heterogeneous, referring to different attributes and a weaker connection between the actors (McPherson et al., 2001). In this study, heterogeneous networks have relatively high external communications, and more independent operations; therefore, members in the networks are easy to separate from the organization. Paxton (1999) refers such ties as cross-cutting ties or bridging social capital. Unlike bonding, bridging ties are char-

acterized by exposure to and development of new ideas, values and perspectives (Woolcock, 2001). This study shows that physicians have high autonomy to make choices about who to connect with, and have less guidance from any central network agent concerning goals or strategy. This is what Kilduff and Tsai (2003: 90) call serendipitous network.

To be precise, medical technicians have external professional associations as the sources of learning. The external locations, like the Association of Radiology, and Taiwan Society of Laboratory Medicine in Taipei, are places of granting the professional qualification by completing 150 learning credits within six years: "*renewing professional certificates required learning credits in external associations,*" or "*professional learning should be mastered first and the next is management knowledge.*" On the other hand, physicians learn more with their counterparts in smaller, well-connected groups (liable to be the same field of experts outside of the hospital).

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Learning Networks and Identification

Organizational behaviors in the vertical learning networks are cohesive and submissive. In the vertical network, novice nurses often need operative and quick information and they get feedbacks from the immediate co-workers or seniors. Nurses develop a high-degree of trust and proximity. Proximity means geographic, organizational, and collaboration proximity (Sorensen et al., 2006). The perception of themselves is consistent with identity of organizations: *"when people need a lot of medical treatment, they must go out of the town. If you come here, you get more care. Our technology is not as good as others, but we give patients the feeling of family,...so many years things have been changed but we still give the public service and let patient feel at home.(Nurse Head in Patient Room)"*

Organizational behaviors in the horizontal learning networks are supportive and collaborative. In this study, supervisors who have the power status and expertise play as actor centrality of learning. Collaborative learning transmits the value of being "caring," which was learned, adhered and further reinforced in handling medical services: *"it is difficult to regard hospitals as profit-maximizing firms, as we receive patients who cannot pay hospitalization cost; among patients, there are some words spreading among the patients: 'as long as you cannot pay medical expenses, you can go to JS, the hospital will not drive you away' (Social Worker Director)."* Organizational behaviors in the external learning networks are independent and free. Learning ties of asymmetry means that advice and information seeking are not reciprocal. Industry counterparts in the external training programs are the subjects of comparison. Some respondents say they can have cross-boundary identity and learn that JS is rather conservative and honest: *"I am a supervisor supposed to attend hospital meetings where I observe JS does everything according to laws and regulations; sometimes JS reads too much into the new regulation and we will feel JS does more than what regulations expect us to do. (Lab Diagnosis Director)."*

Members in the liberal learning network are loosely-connected but with behavioral ethics in line with Catholic spirits. Respondents reported that meetings are the only channel of social interactions through which they can learn the values practiced within the working environment. Catholic doctrines transmit no-competition value and medical service is only a small part of its charity services. Therefore, the values doctors get from Catholic fathers is: *"we have no competitive relationship with those medical counterparts but we are in collaborative relationships; we exist for caring but not being competing with other hospitals (Doctor Hwang)."*

Conclusions

The findings suggest that learning networks have a relationship with organizational identification. Identification with a group can be tied to specific common practices, knowledge, and expertise. First, homogeneity in the learning networks preserves the distinctiveness of organizational identifications, which in turn, contributes to the performances of collaborative projects. This study finds that high close-

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Table 2: Learning Networks and Organizational Identity

| Category | Organizational behaviors | Attributes of learning networks | Organizational identity |
|---|---|---|---|
| Nurses | Cohesive and submissive | proximity | Feeling like home |
| Administrative Staffs | Supportive and collaboration | actor centrality | Caring and honest |
| Medical Technicians | Independent and free | asymmetry | Conservative and law-abiding |
| Physicians | line with Catholic spirits | small world | Caring but not being competing with other hospitals |

ness and frequency in contacts contribute to the accomplishments of complex collaborative projects in the vertical and horizontal learning networks. Moreover, those who are highly committed to the learning networks are motivated to preserve the distinctiveness. When the value of the hospital is threatened, those who are committed to the group display even stronger affiliation, expressing loyalty to the group and hospital as a whole (e.g. Khalifa and Shukla, 2014).

Second, heterogeneity in the learning networks is connected to adaptive identity, and in turn, the adaptive identity is potential to shift the learning focus to the places outside the hospital. The liberal and external learning networks transcend the borders of the hospital.

Adaptive identity is activated by the interactions with affiliated associations outside the organization. Credibility and authenticity in sources of learning affect the breeding of identification. Consequently, the adaptive identity enhances one's self-efficacy and expertise, which in turn, is potential to move the learning focus to the places that provide common value, knowledge and beliefs and distinguish them from others.

Third, the structural dimension was the contextual variable that contributes to learning and identification. An organizational structure is based on the division of labor and a hierarchical distribution of authority and responsibility. A healthcare organization has a hierarchical structure that enhances the diffusion of the existing organizational knowledge but encounters difficulties in creating new

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knowledge. Nurses from lower hierarchical levels have no choice on learning agenda and tend to be passive in receiving information translated from supervisors, thus resulting in more institutionalized identification and less adaptive ones. On the other hand, information flows for medical technicians, doctors, and administrative managers are not constrained by departments, units and hierarchical levels. The learning conditions of external, liberal and horizontal networks provide identification processes that allow cross-boundary interactions to absorb adaptive attributes.

This study has the following contributions: (1) this study offers a summary of the relationship between learning networks and the organizational identity. Attributes of learning networks influence the diffusion of information and further shape organizational identity. (2) Learning networks shape identities by interactions. In essence, identification reinforces the stability of learning networks. This study has the practical implications. Practitioners should pay specific attention to patterns of learning networks in order to possibly intervene in the processes of knowledge sharing and identification construction. Then, knowing the dynamic process of learning networks is a useful tool to facilitate learning and give solutions to competitive advantage of organizations. However, the findings are limited to hospital with similar learning networks. Future directions of research should clarify the cause-and-effect relationship between learning networks and identification.

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# FACTORS TO STUDENT SATISFACTION TOWARDS
# THE EDUCATIONAL ACTIVITIES – A CASE STUDY IN VIETNAM

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## Abstract

With the ever-increasing competition environment in the higher education system of Vietnam, it is crucial for universities to constantly recognize the factors influencing students' satisfaction to have a better understanding of their opinions, improve the quality of their programs, and ensure the sustainable development. The purpose of this study is to identify the factors having the effects on the satisfaction of students of a university in Ho Chi Minh City. The results showed that all the five factors, education programs, lecturer quality, service competence, university policies and infrastructure, had significant influences on the student satisfaction. Among these factors, lecturer quality and education programs are the two major factors to the student's satisfaction.

Keywords: higher education, student satisfaction, education programs, lecturer quality, service competence, university policies, infrastructure

## Introduction

Education is an essential task for developing human resources of a country. Within the education system, higher education plays the role of the main source of high quality human resources training. The mission of higher education is to provide suitable education and training for students to transform them into practitioners with proper ethics to engage to both professional career and civic activities. Due to the fundamental challenges, modern higher education has to reconsider the learning and teaching strategies in the global competitive environment (Bernhard 2012).

It is important for any higher education institute to implement an effective management on its education and training activities so that students can acquire knowledge and skills necessary for their career and life. The pressures of enhancing the higher education can be traced everywhere (McRoy and Gibbs 2009). Failing to satisfy the demand of students would put an end to that education or-

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ganization. It is crucial for the education institute to obtain the accurate and adequate information from the students and the feedback from the students' evaluation can be regarded as one of the most significant educational management tool (Stukalina 2014). Thus, it is essential to constantly study the student satisfaction to understand their needs and have proper solutions to enhance the quality of a higher education organization for the existence and development.

The case university was founded in 1976 in Ho Chi Minh City. It is the leading university in the field of banking - finance in Vietnam and has been providing the society with tens of thousands of graduate students. Many of the alumni of the university are holding important positions in the government and organizations in Vietnam.

Literature Review

Education is one of the service sectors. One of its most critical characteristics in the service sectors is the service encounter, the interactions between the customer and service provider. The service encounter quality is also the core of the service-providing activities (Bitner *et al.* 1990). During the process of service encounter, customer obtains the service of the whole organization (Bitner, 1992). Bitnier (1992) also mentioned that the service physical surrounding and atmosphere has significant impacts on the service satisfaction and stated how the physical surroundings affect both the customers and employees. Thus, management of the physical facilities is vital to the student satisfaction as well. This argument was included in the study of Gruber *et al.* (2010) and Janardhana and Rajasekhar (2012) where the factors like infrastructure and atmosphere were selected as the independent variables in the model. The

study also mentioned that satisfaction should be viewed from both the customers' and service providers' sides.

Satisfaction and service quality has caught the great attention of both academicians and managers over the past decades. It is one of the most important notions of service marketing (Ma *et al.* 2005). Regarding the definition of satisfaction, several concepts had been proposed (Oliver 1997, Hansemark and Albinsson 2004, Panda and Das 2014). Among all of the definitions, some certain ideas such as "consumers' response", "person's feelings", "customer's attitude", or "perception" are always mentioned. That implies that when the service is provided, the customers' emotional reactions have to be noticed carefully. Several studies also believed that students' satisfaction refers to their perception and experience with their study at school (Alves and Raposo 2009, Gruber *et al.* 2010, Zineldin *et al.* 2011, Nell and Cant 2014).

According to Zeithaml (2000), customers' satisfaction is the consideration of whether a service or product satisfies their needs and expectations or not. Hence, satisfaction refers to the comparison between perceptions and expectations (Alves and Raposo 2009). In a study on student's satisfaction on education, Palacio *et al.* (2002) suggested that students' expectations are formed before going to universities, and identifying these expectations are very important to clearly understand their real needs and fulfill them. In 2010, Gruber *et al.* measured 15 dimensions of student satisfaction from student's perspective such as administration, atmosphere, course, library lecture, infrastructure etc. Zineldin *et al.* (2011) included five major factors to assess students' perception of satisfaction. The factors are technical, functional, infrastructure, interaction and

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atmosphere of higher education institutions. Their study also mentioned that the student feedback, survey and measurements are the important information resources of quality improvement and satisfaction. Nell and Cant (2014) applied the SERVQUAL model to education system and determine the overall student satisfaction. Their work transformed five items of empathy, reliability, responsiveness, tangibility and assurance into service, service outcome, prompt reaction, physical facilities and required skills and knowledge. Lecturing quality also has impacts on the satisfaction. Xiao and Wilkins (2015) examined the effects of lecturer commitment on student perceptions of teaching quality and satisfaction. Their study showed that lecturer commitment to student's academic achievement and lecturer commitment to the social integration of students are both positively related to student satisfaction.

Many factors could have potential impacts on the student satisfaction according to the literature mentioned above. In the past decades, many studies had been conducted to analyze the relationship between these factors and satisfaction. However, the associated literature is quite rare in Vietnam. Besides, the relationship between these factors and student satisfaction have to be explored because the service quality and satisfaction vary with the industries, service type, country and development level (Sultan and Wong 2010).

In this study, five potential factors, education program, infrastructure, lectures quality, service competence, and university policies, are selected to examine the relationship between them and the student satisfaction. The research framework is shown below in Figure 1.
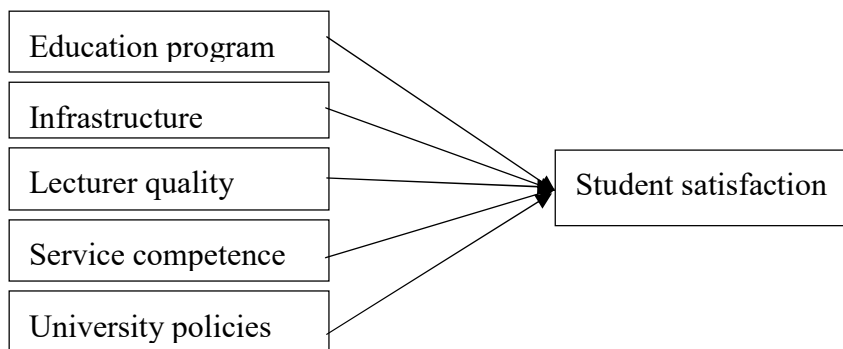


Figure 1. Research Framework

Research Process and Hypotheses

The survey questionnaires were distributed at a higher education institution in Ho Chi Minh City in Vietnam either handed directly to students or sent to them via the school's email network. After collecting data, the author analyzed them using the statistical software PASW-SPSS 20th edition. Statistical

method used in this study included basic descriptive statistics, reliability test, correlation analysis, and regression model. The regression model between the dependent variable (Satisfaction) and the five independent factors was established to explore the causation relationship and influences among variables and the significance test was tested in the final stage.

Based on the proposed research model, five hypotheses are listed:

**H1:** There is a positive relationship between the education program and the student satisfaction

**H2:** There is a positive relationship between the infrastructure facilities and the student satisfaction

**H3:** There is a positive relationship between the lecturer quality and the student satisfaction

**H4:** There is a positive relationship between the service competence and the student satisfaction

**H5:** There is a positive relationship between the university policies and the student satisfaction

### Questionnaire Design

The observed variables of the study were drawn from the review of previous studies and theories on the customer satisfaction. Besides, several new items were added into the questionnaire to fit the case of students of the university in Ho Chi Minh City. To ensure all the items of the questionnaire are fully understood, the authors first conducted a pilot test on 30 students. Through the Cronbach's Alpha value, the reliability of the observed variable in the questionnaire was determined. At this stage, the opinions from the participants helped the authors to adjust the content of the questionnaire to make the content clear for the participants. After correction and adjustment, the official questionnaire was modified and the distribution of the survey on students can be started.

Two major parts are included in the questionnaire: (1): demographic information, (2): survey on student satisfaction (Table 1). In the first part of the questionnaire, the nominal scale was used to categorize the students into groups (gender, year and major). In the second part of the questionnaire, 5-point Likert scale was used to measure the observed variables. (1 – Mostly Disagree, 2 – Disagree, 3 – Neutral, 4 – Agree, 5 – Mostly Agree).

### Research Results and Analysis

With 250 questionnaires delivered, 240 of them were collected. After screening, 200 samples were accepted. The result of the descriptive statistics shows that the percentage of each group is quite balanced.

### Reliability Test and Factor Analysis

The results of reliability test showed Cronbach's Alpha values are larger than 0.6 in all factors. They are 0.750 for EP, 0.641 for IF, 0.799 for LQ, 0.808 for SC, 0.758 for PO and 0.809 for SAT. However, in the factor of Service Competence, the analytical result shows that the Cronbach's Alpha coefficient can be increased from 0.808 to 0.860 if the observed variable SC4 is deleted. Besides, the items IF1 and IF2 have the Item-Total Correlation less than 0.3. Thus, they violated the condition of the reliability and were removed from the scale as well. After removing these items from the scale, the reliability test was conducted again. The result of the second reliability test showed that no observed variable in the scale has the Item-Total Correlation coefficient less than 0.3 while the Cronbach's Alpha for IF is increased to 0.708, and for SC, it is increased to 0.860. The rest of the Cronbach's alphas remained the same. Thus, the scale is reliable and can be used for the survey.

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Twenty one items on student satisfaction were conducted in the factor nalysis (Table 2). The top contribution of student's satisfaction goes to education program (EP), explained by 38.98% of the total variance with an eigenvalue of 9.355. The lecturer quality (LC) is the second largest contribution which accounts 9.111% of the total variance with an eigenvalue of 2.187, following by the service competences (SC), university policy, (PO) and infrastructure facilities (IF). The SC explains 7.124% of the total variance with an eigenvalue of 1.710; the PO explains 5.939% of the total variance with an eigenvalue of 1.425 and the IF explains 5.052% of the total variance with an eigenvalue of 1.212. These five components account for 71.479% of the model. The factor loading ranged from 0.682 to 0.832 across all items which also exceeded the requirement of 0.4 or more. In the analysis of extracting factors, the Bartlett's test of sphericity was conducted and found at $\chi^2 = 4993.393$, p = 0.000.

Table 1. Factors survey on student satisfaction

| No. | Code | Description |
|---|---|---|
| Education Program (EP) | | |
| 1 | EP1 | The education programs of the Banking University of Ho Chi Minh City are frequently updated to match the social demand |
| 2 | EP2 | The education program of the Banking University of Ho Chi Minh City provides students with necessary knowledge to work in my related fields |
| 3 | EP3 | The education programs have clear output standard |
| 4 | EP4 | The detail of the education program is clearly informed to student |
| 5 | EP5 | The education programs satisfy students' need for future career development |
| Infrastructure facilities (IF) | | |
| 6 | IF1 | The classrooms are good enough for teaching and studying |
| 7 | IF2 | The university provides adequate equipment to support teaching and learning activities |
| 8 | IF3 | The library has abundant learning reference material |
| 9 | IF4 | The university infrastructure is good enough extra-curricular activities |
| 10 | IF5 | The classrooms are good enough for teaching and studying |
| Lecturer Quality (LQ) | | |
| 11 | LQ1 | Lecturers possess in-depth knowledge in the courses they teach |
| 12 | LQ2 | Lecturers have good teaching methods |
| 13 | LQ3 | Lecturers frequently apply technology to support their lectures |
| 14 | LQ4 | Lecturers are fair in evaluating students' results |
| 15 | LQ5 | Lecturers are kind and friendly |
| 16 | LQ6 | Lecturers possess in-depth knowledge in the courses they teach |
| Service Competence (SC) | | |
| 17 | SC1 | The university's administrative staff are friendly to students |
| 18 | SC2 | The university's administrative staff are enthusiastic to help solving students' problems |
| 19 | SC3 | The university's administrative staff provide good solutions for students' problems |
| 20 | SC4 | The university frequently provides career information and orientation to students |
| University Policies (PO) | | |

| 21 | PO1 | The university always provides scholarships to students with good results |
| 22 | PO2 | The value of scholarships allow students to focus on studying |
| 23 | PO3 | The university has good policies to encourage students to engage in learning |
| 24 | PO4 | The university has good policies to encourage students to engage in extra-curricular activities |

Student Satisfaction (SAT)

| 25 | SAT1 | I feel satisfied with studying in the Banking University of Ho Chi Minh City |
| 26 | SAT2 | I will advise others to choose to study in the Banking University of Ho Chi Minh City |
| 27 | SAT3 | I intend to pursuit further study in the Banking University of Ho Chi Minh City |

Table 2. Factor analysis of students' satisfaction toward education

| Factors | Factor Loadings | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| EP1 | .816 | | | | |
| EP2 | .795 | | | | |
| EP3 | .778 | | | | |
| EP4 | .746 | | | | |
| EP5 | .726 | | | | |
| LQ1 | | .832 | | | |
| LQ2 | | .814 | | | |
| LQ3 | | .763 | | | |
| LQ4 | | .743 | | | |
| LQ5 | | .703 | | | |
| LQ6 | | .682 | | | |
| SC1 | | | .808 | | |
| SC2 | | | .750 | | |
| SC3 | | | .754 | | |
| PO1 | | | | .770 | |
| PO2 | | | | .760 | |
| PO3 | | | | .744 | |
| PO4 | | | | .697 | |
| IF3 | | | | | .782 |
| IF4 | | | | | .780 |
| IF5 | | | | | .767 |
| Eigenvalues | 9.355 | 2.187 | 1.710 | 1.425 | 1.212 |
| Variance (%) | 38.980 | 9.111 | 7.124 | 5.939 | 5.052 |
| Cumulative variance (%) | 38.980 | 48.091 | 55.215 | 61.155 | 71.479 |
| Cronbach's alpha | 0.750 | 0.799 | 0.860 | 0.758 | 0.708 |

Table 3. Summary of student's satisfaction regression analysis

|  | B | Std. Error | . | Sig. | VIF |
|---|---|---|---|---|---|
| Constants | .378 | .222 |  | .048 |  |
| Education Program | .285 | .051 | .218 | .000 | 1.387 |
| Lecturer Quality | .312 | .035 | .297 | .001 | 1.258 |
| Service Competence | .231 | .057 | .178 | .018 | 1.353 |
| University Policy | .139 | .037 | .097 | .010 | 1.469 |
| Infrastructure | .194 | .045 | .133 | .022 | 1.521 |
| R square |  |  | .695 |  |  |
| Adjusted R square |  |  | .682 |  |  |
| F(p-value) |  |  | 28.691 (.000) |  |  |

In addition, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was found at 0.895, suggesting appropriateness of the factor analysis.

*Regression Analysis*

The correlation analysis shows that the dependent variable was correlated with all the independent variables. In addition, the independent variables were also correlated to one another. Hence, it is important to check whether the collinearity (VIF) occurs in the regression analysis.

According to the regression analysis results (Table 3), all the factors proposed in this research have significant effects on the students' satisfaction. Among them, the standardized coefficients of these factors are as following: lecturer quality ($\cdot$ =.297), education program ($\cdot$ =.218), service competence ($\cdot$ =.178), infrastructure ($\cdot$ =.133) and university policies ($\cdot$ =.097). This indicates that better

lecturing quality an instructor can provide, the more comprehensive program a university has, the more friendly service the university offers, the more adequate equipment the university provides, the more considerate policy a university can supply, the students' satisfaction will therefore be higher.

The VIF of all independent variables shows that the collinearity doesn't happen in this research. It indicates that the collinearity relationship between the independent variables doesn't have significant impact one the regression model.

As shown in Table 3, all the independent variables influence the dependent variable as their p-values (Sig.) were smaller than 0.05. Based on the Beta coefficients, it can be said that the independent variables positively influence the dependent variable and the factor "Lecturers' Quality" has the highest influence level on the dependent variable, followed by Education Program and Service Competence. The university policies factor has the lowest influence level on the student's satisfaction. The regression formula can be written as the following:

$$SAT = 0.378 + 0.285*EP + 0.312*LQ + 0.231*SC + 0.139*PO + 0.194*IF$$

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Conclusion and Implications

The present study highlighted the influence of five factors on student satisfaction. Significantly, it is focused on the higher education and, especially, it used sample from Vietnam, where little previous research has been reported. The analysis pointed out that all the five proposed factors influence the satisfaction of students in the case university. The results support the notion that the academic environment and service activities can affect the level of student satisfaction (Smart and Umbach 2007). Among the factors, Lecturer Quality and Education Program are the two factors that influence student satisfaction the most. This is reasonable since the first priority of students coming to the university is to study, especially in a famous school with high pressure on learning like the case university.

Thus, constantly improving the quality of lecturers and education program should be the top priority in the development strategy of the university. The service quality of the university should also be another indicator that should be reviewed and improved frequently as well. One of the biggest flaws of public universities in Vietnam is their weakness in delivering services to students. Aspects such as school employees' attitude, information delivery, or complaints response are usually lowly ranked in public university.

Nevertheless, as more participants joining the higher education market with good service quality, students are becoming increasingly more aware of the service quality of a school. That could be a reason why Service Competence is the third highest ranked factor in this study. Thus, improving service competence should

also be a priority in the development strategy of the case university. As the case university is a public school, its policies must closely follow the education regulation of the Ministry of Education and Training. Thus, it may be more difficult for the university to quickly issue new policies to meet the demand of the market.

However, as the autonomy trend has been increasingly promoted in the education system of Vietnam, the university could soon have more space to adapt its policies. Regarding the infrastructure, the position of being a long-established public school means that the university has the advantage on this matter. For example, the university has a very good location in the city and annually receives budget from the Ministry. However, as the university will soon receive financial autonomy, it should have good preparation to make good use of this status.

As mentioned previously, Lecturer Quality and Education Program are two factors that contribute to the satisfaction of students the most in case university. Thus, ensuring the high quality of lecturers and education programs will be an advantage of the university in the current and future context. To keep the high quality of lecturers, the university should first keep a high standard in the recruitment of lecturers. As the international integration trend is visible in Vietnam, new lecturers should be able to adapt to this trend.

In other words, the school may consider setting its recruitment standard based on the internationalization criteria such as foreign language ability, research ability, or technology application ability. Recruiting competent lecturers with ability to quickly update

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and adapt to knowledge will be a considerable improvement for the training quality of the university. However, if the university is able to hire competent lecturers, it is very important to have policies that match their contributions and demands. Meanwhile, the university will soon be granted the autonomy to operate on its own, thus, the policies for lecturers should be able to attract and retain them as this is the main workforce that brings the success of a school. The policies should cover not only the tangible benefit such as salary or bonus but also intangibles such as recognitions.

Regarding the education program, although the education programs of a university still have to base on the fundamental higher education program issued by the Ministry of Education and Training, universities are actually granted a bigger room to apply their own content and teaching methods into their programs. Thus, the education program of the case university should be built on two rules: (1) it should focus on providing students with competence and skills truly required for their jobs in the future (2) the program should be internationally oriented. This is especially important as Vietnam has entered many international economic ties in 2015 such as ASEAN Economic Community. This means Vietnamese students will see a lot opportunities to work abroad or work with foreigners even in Vietnam. Thus, internationally oriented program will help students to catch up with this trend and more likely to be successful in their careers.

Regarding the infrastructure, while the university has already had a strong base of infrastructure thanks to the support of the government, it will have to constantly improve its infrastructure to meet the increasing demand of the market, especially when more foreign universities are coming to Vietnam with strong background of knowledge and finance. Besides, as the authors suggested previously on the international orientation of the school, the infrastructure will also have to be improved to support this trend. Thus, a solution to this matter is applying and setting international standard on every aspect of the university. As it will cost the university a lot of money to fully adopt the international standard, the school may first focus on lecturer standard, education program standard, service policies and teaching and learning support equipment standard first. These aspects are the core values that greatly contribute to the growth of a university. Thus, they should be the priority in the development strategy of a university.

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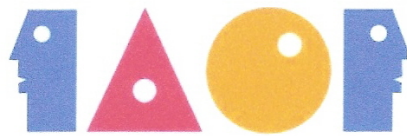
# A STUDY OF AIRBNB USE BEHAVIOR IN THE SHARING ECONOMY

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## Abstract

This study analyzed Airbnb use behavior using the UTAUT2 model and further elucidated whether the UTAUT2 model is appropriate for explaining such behavior. Using a designed questionnaire as the research instrument and Airbnb users as the potential respondents, a total of 408 valid samples were obtained and subject to analysis and testing of causal relationships between potential variables in the structural model using the Smart PLS 3 software. The results reveal the following: (1)Behavioral intention is positively affected by hedonic motivation, price value and habit. (2)Use behavior is positively affected by habit, facilitating conditions and behavioral intention. (3)This research model has explanatory power of 68% for behavioral intention and of 51% for use behavior.

Keywords: Sharing Economy, Airbnb, Unified Theory of Acceptance and Use of Technology 2, Behavioral Intention, Use Behavior

## Introduction

In the past, most consumers were accustomed to owning what they used. Today, more and more consumers enjoy sharing and renting things instead of owing them. This shift has driven the rapid growth and firm presence of the SE around the world. In addition, IT advancement has made interpersonal relationships closer and enabled people to leverage the features and benefits brought by the internet and thus create more efficient social activities. This has given rise to online platforms that have changed people's lifestyles and operating models in the business world.

In the SE framework, owners (lessors) share their cars, houses, clothes, toys, knowledge, skills and products with others at reasonable prices through leasing and sharing. This is not different from a 'transactional' relationship in trading, but more like 'sharing'. The SE trend did not spring from nothing in a blink of time. Its rapid rise has been driven primarily by factors such as economic recession, increased environmental awareness, internet technology advancement and widespread use of social media. The SE enables a three wins operating model for owners (lessors), users (renters) and platform operators and has considerable room for future growth with diversifying categories. In Fortune's Global Top 10 Unicorns 2016, SE companies have taken three places. They are Uber, China's Didi and Airbnb, which have ranked first, third and fourth, respectively. Particularly, Airbnb has reached a market value of US$30 billion by 2016 in less than eight years since its startup in August, 2008 and expects to become a listed company in 2018.

The purpose of this study is to understand: key factors that affect the use of Airbnb by users; to what extent the UTAUT2 model is able to explain the intention to use Airbnb and Airbnb use behavior, and whether intervening variables (gender, age, experience) in the UTAUT2 model affect the intention to use Airbnb and Airbnb use behavior.

## Literature Review

This study incorporated the UTAUT2 model, i.e. UTAUT, to investigate Airbnb use behavior in the SE. The following provides descriptions of SE, Airbnb and UTAUT2.

## Sharing Economy

SE means organizations or individuals who own idle resources transfer the right to use such resources to others with charge and thus transferors gain rewards while sharers create value by sharing idle resources from others. However, the SE is a phenomenon that has become popular only in the last few years and its main feature is an IT-based third party marketplace platform in which the third party can be a commercial institution, an organization or a government. Individuals, with the help of such platforms, can exchange their idle items, share their knowledge and experiences, or raise funds from companies for specific innovative projects.

Sharing is very common in life on the internet and is ubiquitous from text, images to videos and software. As social networking is becoming mature,

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shared content today is no longer limited to virtual resources, but has extended to physical consumables such as housing and cars, thus forming a new generation business model called 'sharing economy'. The SE exists in three forms: (1) based on sharing and renting of products and services; (2) based on recirculation of transferred secondhand products, which is in essence successively realized transfer of ownership of the same item among people with different needs; and (3) based on collaborative lifestyles of asset and skill sharing, which are in essence sharing of intangible assets such as time, knowledge and skills.

## Airbnb

Airbnb is a website that offers accommodation rentals for the public. Users of the website have to register and create personal profiles on the website. Each accommodation object is linked to one landlord. A landlord's personal profile includes information such as recommendations from other users, reviews from previous customers, responsiveness rating and a private messaging system. Travelers can publish, discover and book accommodations from unique sources around the world. All of these have made Airbnb a well-known recent representative of the SE.

Founded in August, 2008, Airbnb is a private company headquartered in San Francisco, California, USA and run by Airbnb, Inc. It has over in 60,000,000 renters across 34,000 cities in 191 countries and 12 subsidiaries in Barcelona, Spain, Berlin, Germany, Copenhagen, Denmark, Dublin, Ireland, London, UK, Milan, Italy, Moscow, Russia, Paris, France, San Fran-

cisco, USA, Sao Paulo, Brazil, Singapore, and Sydney Australia.

## UTAUT2

Based on the theoretical framework UTAUT, Venkatesh et al. (2012) developed a new theoretical framework called UTAUT2 in the context of user environment, highlighting the use of different IT specific background environments and the ability to recognize relevant dimensions and mechanisms. They further introduced 3 new dimensions of variables, i.e. hedonic motivation, price value and habit, to the UTAUT foundation. The results of their study have significant implications for the applicability of the UTAUT2 theory and user acceptance of information technology.

The UTAUT model is expanded and extended by introducing hedonic motivation, price value and habit. Research shows that UTAUT2 has improved behavioral intention by 18% and use of technology by 12% by Venkatesh et al. (2012).

## Methods

### Conceptual Framework

This study investigated Airbnb use behavior in the sharing economy with the UTAUT2 introduced by Venkatesh et al. (2012) as the foundation. Compared to the UTAUT, the UTAUT2 has three additional variables, i.e. hedonic motivation, price value and habit, as well as one additional intervening variable, experience, which refers to experience with the use of an online platform for accommodation booking. The theoretical framework is shown in Figure 1.

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## Hypothesis

This study was based on the UTAUT2 model, which included seven dimensions, i.e. performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), hedonic motivation (HM), price value (PV) and habit (HT), as well as three intervening variables, i.e. gender, age, experience with the use of an online platform for accommodation booking for the analysis of Airbnb use behavior. Based on this, the following hypotheses were developed for this study:

- Gender and age intervene the effect of PE on BI.
  H1: PE has a positive effect on BI among Airbnb users.
  H1a: Gender intervenes the effect of PE on BI.
  H1b: Age intervenes the effect of PE on BI.

- Gender, age and experience intervene the effect of EE on BI.
  H2: EE has a positive effect on BI among Airbnb users.
  H2a: Gender intervenes the effect of EE on BI.
  H2b: Age intervenes the effect of EE on BI.
  H2c: Experience intervenes the effect of EE on BI.

- Gender, age and experience intervene the effect of SI on BI.
  H3: SI has a positive effect on BI among Airbnb users.
  H3a: Gender intervenes the effect of SI on BI.
  H3b: Age intervenes the effect of SI on BI.

H3c: Experience intervenes the effect of SI on BI.

- Gender, age and experience intervene the effect of FC on BI and UB.
  H4: FC have a positive effect on BI among Airbnb users.
  H4a: Gender intervenes the effect of FC on BI.
  H4b: Age intervenes the effect of FC on BI.
  H4c: Experience intervenes the effect of FC on BI.

- Gender, age and experience intervene the effect of HM on BI.
  H5: HM has a positive effect on BI among Airbnb users.
  H5a: Gender intervenes the effect of HM on BI.
  H5b: Age intervenes the effect of HM on BI.
  H5c: Experience intervenes the effect of HM on BI.

- Gender and age intervene the effect of PV on BI.
  H6: PV has a positive effect on BI among Airbnb users.
  H6a: Gender intervenes the effect of PV on BI.
  H6b: Age intervenes the effect of PV on BI.

- Gender, age and experience intervene the effect of HT on BI.
  H7: HT has a positive effect on BI among Airbnb users.
  H7a: Gender intervenes the effect of HT on BI. H7b: Age intervenes the effect of HT on BI.
  H7c: Experience intervenes the effect of HT on BI.
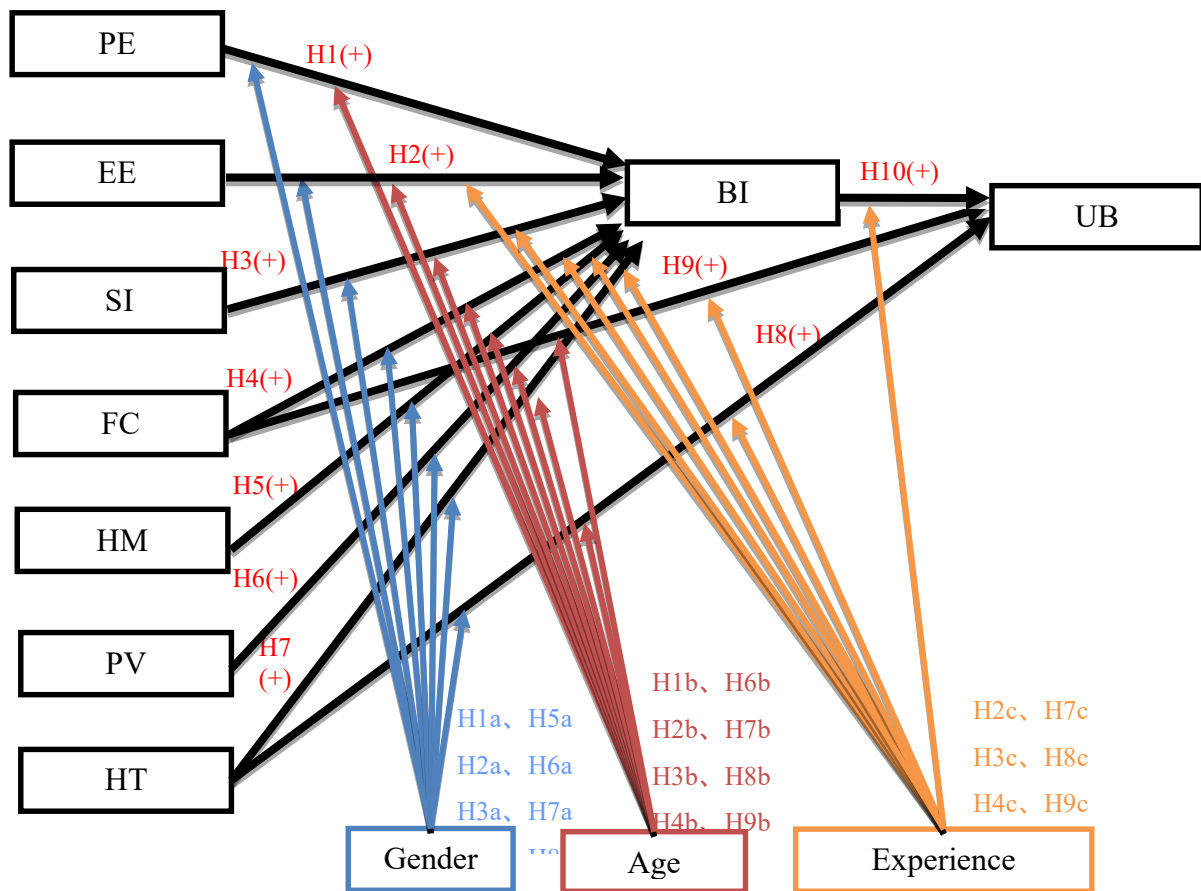
Figure 1. Conceptual Framework

- Gender, age and experience intervene the effect of HT on UB.
  H8: HT has a positive effect on Airbnb UB.
  H8a: Gender intervenes the effect of HT on UB.
  H8b: Age intervenes the effect of HT on UB.
  H8c: Experience intervenes the effect of HT on UB.

- Age and experience intervene the effect of FC on UB.
  H9: FC have a positive effect on Airbnb UB.
  H9b: Age intervenes the effect of FC on UB.

H9c: Experience intervenes the effect of FC on UB.
- Experience intervenes the effect of BI on UB.
  H10: BI has a positive effect on Airbnb UB.
  H10c: Experience intervenes the effect of BI on UB.

Operational Definition

PE: This variable represents how much the user expects the use of Airbnb to improve accommodation and travel.

EE: This variable represents how easy the user finds the use of Airbnb.

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SI: This variable represents how important the user perceives others' thinking that he or she should use Airbnb.

FC: This variable represents to what extent the user perceives to have received resources and support while using Airbnb.

HM: This variable represents how much enjoyment or pleasure the user feels while using Airbnb.

PV: This variable represents how in proportion the user perceives the amount paid is to the benefits gained.

HT: This variable represents the driver of behavioral intention that leads the user to continued use out of habit.

BI: This variable represents the subjective probability or likelihood of the intention to use Airbnb in the user.

UB: This variable represents the willingness to use Airbnb in the user and is measured by the frequency of use.

## Object of Study

The subjects of this study were selected by sampling users who have used the Airbnb platform for accommodation booking as well as via convenient sampling of well-known travel and accommodation forums (e.g. Backpackers, PTT and Facebook community pages). The subjects were asked to complete the questionnaire online via Google Forms and invite exchange students from Hong Kong, Korea and Japan that they knew to complete the questionnaire. The collected data was analyzed using the Smart PLS 3.0 packaged software and the SPSS 12.0 statistical software. The questionnaire survey took place from August 1 to 31, 2016. Having eliminated 7 invalid questionnaires from the

415 completed ones, 408 valid questionnaires were obtained.

## Data Analysis

All the dimensions in this study have a Cronbach's alpha (α) over 0.78, higher than 0.7 suggested by scholars, indicating excellent reliability of this study. In terms of validity, the survey response scales in this study have theoretical bases that refer to relevant local and international literature and have been modified based on a pretest, giving excellent validity to this study. Composite reliability (CR) takes into account factor loading differences between measures. Average variance extracted (AVE) is a measure that assesses the convergent validity of a construct. It is defined as the total of the mean squared factor loadings of all the measures in a construct (i.e. adding squared factor loadings and divided by the number of measures). Hair et al. (2006) and Fornell and Larcker (1981) suggest CR and AVE need to be greater than 0.7 and 0.5, respectively. The potential variables in this study all have CR over 0.86, greater than the suggested 0.7, and AVE between 0.60 and 0.87, all greater than the suggested 0.5, indicating the CR and convergent validity of this study are within reasonable ranges. See Table 1 for detailed data.

Hair et al. (2006) suggests the square root of the AVEs for potential variables needs to be greater than the correlations between variables. The diagonal value of each variable in this study is the square root of the AVE for each potential variable and is greater than the correlations between all the potential variables in all cases, indicating the potential variables in this

Table 1. Reliability and validity analysis for potential variables

| Research Facets | Question | Mean | | Factor Loadings | Cronbach's α | Construct Reliability (CR) | Average Variance Extracted |
|---|---|---|---|---|---|---|---|
| PE | PE1 | 4.19 | 4.06 | 0.70 | 0.88 | 0.93 | 0.81 |
| | PE2 | 4.04 | | 0.71 | | | |
| | PE3 | 3.94 | | 0.76 | | | |
| EE | EE1 | 4.17 | 4.09 | 0.65 | 0.91 | 0.94 | 0.79 |
| | EE2 | 4.15 | | 0.69 | | | |
| | EE3 | 4.04 | | 0.69 | | | |
| | EE4 | 4.00 | | 0.71 | | | |
| SI | SI1 | 3.50 | 3.42 | 0.67 | 0.85 | 0.91 | 0.77 |
| | SI2 | 3.385 | | 0.66 | | | |
| | SI3 | 3.37 | | 0.60 | | | |
| FC | FC1 | 4.11 | 3.94 | 0.69 | 0.78 | 0.86 | 0.60 |
| | FC2 | 4.05 | | 0.59 | | | |
| | FC3 | 3.57 | | 0.54 | | | |
| | FC4 | 4.04 | | 0.62 | | | |
| HM | HM1 | 3.80 | 3.87 | 0.80 | 0.87 | 0.92 | 0.79 |
| | HM2 | 3.94 | | 0.71 | | | |
| | HM3 | 3.86 | | 0.65 | | | |
| PV | PV1 | 3.91 | 3.93 | 0.71 | 0.90 | 0.94 | 0.84 |
| | PV2 | 3.94 | | 0.78 | | | |
| | PV3 | 3.95 | | 0.75 | | | |
| HT | H1 | 3.38 | 2.92 | 0.75 | 0.87 | 0.92 | 0.79 |
| | H2 | 2.93 | | 0.66 | | | |
| | H3 | 2.45 | | 0.58 | | | |
| BI | BI1 | 3.88 | 3.79 | 0.80 | 0.87 | 0.92 | 0.87 |
| | BI2 | 3.82 | | 0.80 | | | |
| | BI3 | 3.67 | | 0.77 | | | |
| UB | UB1 | 3.00 | 2.92 | 0.72 | 0.87 | 0.92 | 0.80 |
| | UB2 | 2.68 | | 0.59 | | | |
| | UB3 | 3.08 | | 0.57 | | | |

study are clearing distinct and have excellent discriminant validity. See Table 2 for detailed data.

This study uses the Smart PLS 3 software in SEM for analysis that combines the techniques of principal component analysis and multiple regression analysis and can test both the measurement model and the structural model formed by all the dimensions. The data from the analysis shows that the $R^2$ is 0.66 for BI and 0.48 for UB, indicating the variance explained by the exogenous variables in this research model reaches a certain level.

The fact that hypotheses H5, H6, H7, H8, H9 and H10 reach the significance level indicates behavioral inten-

tion to use the Airbnb platform and use behavior are positively affected by

factors including hedonic motivation, price value and habit as well as habit,

Table 2. The square roots of AVE for individual potential variables and the matrix of correlation coefficients between potential variables

|      | BI   | EE   | FC   | HM   | HT   | PE   | PV   | SI   | UB   |
|------|------|------|------|------|------|------|------|------|------|
| BI   | 0.93 |      |      |      |      |      |      |      |      |
| EE   | 0.55 | 0.89 |      |      |      |      |      |      |      |
| FC   | 0.59 | 0.66 | 0.78 |      |      |      |      |      |      |
| HM   | 0.64 | 0.57 | 0.65 | 0.89 |      |      |      |      |      |
| HT   | 0.69 | 0.39 | 0.46 | 0.53 | 0.89 |      |      |      |      |
| PE   | 0.62 | 0.66 | 0.61 | 0.61 | 0.51 | 0.90 |      |      |      |
| PV   | 0.70 | 0.56 | 0.61 | 0.67 | 0.56 | 0.66 | 0.91 |      |      |
| SI   | 0.56 | 0.46 | 0.50 | 0.59 | 0.60 | 0.52 | 0.52 | 0.88 |      |
| UB   | 0.63 | 0.46 | 0.47 | 0.48 | 0.64 | 0.47 | 0.47 | 0.51 | 0.89 |

Note.1. The diagonal block values represent the square roots of AVE for individual potential variables.
2. The non-diagonal values represent the correlation coefficients between potential variables.

facilitating conditions and behavioral intention, respectively. The fact that hypotheses H1, H2, H3 and H4 do not reach the significance level indicates performance expectancy, effort expectancy, social influence and facilitating conditions do not have direct connections with behavioral intention to use the Airbnb platform.

The addition of the three intervening variables, gender, age and experience, has improved the explanatory power of the overall model with slight improvement in explaining both behavioral Intention and use behavior as well as positive changes in the path coefficient for each of the dimensions, indicating gender, age and experience indeed have intervention effects. The fact that hypotheses H6 and H7 reach the significance level indicates that

behavioral intention to use Airbnb is positively affects by the two factors, price value and habit while the significance of H8 and H10 indicates use behavior is positively affected by habit and behavioral intention. All the three intervening variables, gender, age and experience, have a T-value less than 1.96 and a P-value less than 0.05, indicating no significance.

From the perspective of statistical significance, four out of the ten hypotheses in this study are supported. This has two implications. First, price value perceived by and habits among Airbnb users in the UTAUT2 model both have positive effects on behavioral intention among them, with a t-value of 5.00 and 1.99 in the test statistics. Second, habits and behavioral intention among Airbnb users in the

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model both have positive effects on their use behavior, with a t-value of 3.35 and 2.47 in the test statistics. The remaining six hypotheses all have a T-value less than 1.96 and a P-value less than 0.05, indicating performance expectancy, effort expectancy, social influence, facilitating conditions and hedonic motivation all have no significant effects on behavioral intention and use behavior.

## Results

As shown by the results of this study, hedonic motivation, price value and habit all have positive effects on behavioral intention; the addition of the three intervening variables, gender, age and experience with the use of the platform for accommodating booking, has significantly improved the explanatory power of the research model from 66% to 68%; and the improvement not only has practical value, but also reduce the effect of hedonic motivation. In terms of the intervening variables, gender, age and experience, the results of this study show they have no significant effects.

In addition, although habit, facilitating conditions and behavioral intention have significant positive effects on use behavior, the model is able to explain only 48.0% of them. Even the addition of the three intervening variables, gender, age and experience, has only slightly improved its explanatory power to 51% while reducing the effect of facilitating conditions on behavioral intention. As for the intervening variables, gender, age and experience, the results of this study show they have no significant effects. The results of this study show the two dimensions, price value and habit, have positive

effects on behavioral intention. Finally, although the results of this study are consistent with Venkatesh et al. (2012), the four dimensions, performance expectancy, effort expectancy, social influence and facilitating conditions, have no effects on behavioral intention.

The results of this study can serve as references for platform operators in the sharing economy and help these operators understand important factors for owners (lessors) and users (renters) as well as what these people think needs improvement while using these platforms. Given that performance expectancy, effort expectancy and social influence have no significant effects on the Airbnb platform, some improvement may be made in platform design by adding games for social interaction and content about cultures in different countries. Such games can help users understand cultures in different countries and encourage them to play the games with their friends. In this way, users can become more diversified instead of restricting to those who tend to use these platforms only when they need to. By inviting their friends to play the games, users can get travel credits that can be used to pay fees while booking accommodations. This can further encourages users to use these platforms.

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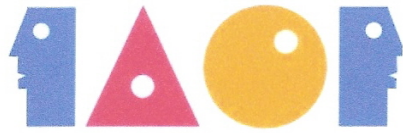
# A MOST ADVANTAGEOUS BID EVALUATION MODEL BASED ON FUZZY ANALYTIC HIERARCHY PROCESS FOR SUPPLIER SELECTION

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Abstract

Numerous professional exhibition organizers (PEO) use the lowest bid that meets project specifications as the sole criterion to award bids. This approach frequently causes competitive price-centered bidding that focuses on the lowest price. Consequently, purchasers or contractors might not receive products that meet their requirements. To address this issue, the most advantageous bid (MAB) method can be employed. However, during the process of MAB evaluations, the selection or formulation of weights for evaluation criteria and sub-criteria are often problematic for PEO calling for bids. Therefore, this study examines extant literature and expert interviews to establish the criteria and sub-criteria of MAB awarding evaluations. We employ a fuzzy analytic hierarchy process to analyze the MAB evaluation criteria and sub-criteria weights. The research results are a suitable reference for PEO conducting MAB evaluations.

Keywords: Professional Exhibition Organizers, Most Advantageous Bid, Fuzzy Analytic Hierarchy Process

Introduction

During procurement or purchase processes, awarding contracts to the lowest bid , a process in which suppliers quote prices below their minimum or base price, frequently leads suppliers or vendors to prioritize winning the right to supply at unreasonably low prices, after which they attempt to deliver inferior quality products when fulfilling the contract (Wang and Chen, 2010). Regardless of whether this type of fraudulent behavior is exposed, the professional exhibition organizer (PEO) inviting bids is unable to obtain products that meet their requirements. To address this issue, the most advantageous bid (MAB) method can act as a suitable bid-awarding criterion (Wang and Chen,

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2010; Chen et al., 2008). This method allows parties awarding a bid to conduct comprehensive evaluations of prospective contractors based on technical quality, function, commercial terms, or prices by considering pre-specified evaluation criteria. They can then award the contract to the most suitable bidder (Tserng et al., 2008; Huang, 2012a; Tsai and Lee, 2010; Guo and Zhu, 2010; PCO, 2016). The MAB method selects the supplier that is most suitable to the contractor's requirements and advantageous to the contractor or purchaser by developing a total score for all criteria and sub-criteria as given by the established evaluation committee. Therefore, a fair evaluation committee and the appropriate selection of evaluation criteria are the most crucial preliminary preparations(Tsai and Lee, 2010). This study reviews extant literature and uses findings from expert interviews to estab-lish suitable MAB evaluation criteria and sub-criteria. The weights of these criteria and sub-criteria are then anal-yzed using a fuzzy analytic hierarchy process (FAHP). The results of this study offer a suitable reference for constructing MAB evaluation models.

Research Method

*Establishing The Hierarchical Framework For The Evaluation Model*

The goal of this study is to construct a MAB evaluation model. We review extant literature (Chen et al., 2008; Tserng et al., 2008; Huang, 2012; Liou et al., 2005; Dickson, 1966; Huang, 2013; Sun et al., 2012) to determine pre-liminary evaluation criteria and sub-criteria. Close- and open-ended questionnaires were designed and evaluated by five experts based on their experiences and perceptions. The opinions and recommendations of these experts regarding questionnaire items that should added or deleted were cross-examined by these experts to gradually determine the evaluation criteria and sub-criteria. This process was repeated until all experts reached consensus.

We then establish the following three hierarchy levels for the proposed evaluation model: (1) goals; (2) evaluation criteria, comprising seven factors (technological capabilities, management systems, price and cost, cooperative abilities, performance of prior contract fulfillment, delivery and warranty, and quality control capabilities); and (3) sub-criteria, comprising 34 indicators (Figure 1). We then employ a questionnaire survey to elicit responses from people who have been responsible for MAB evaluations for PEO. We obtained a total of 15 responses, 11 of which are valid.

*Establishing the Evaluation Model*

A consistency test should be performed prior to the FAHP analysis. The basis of the test is the consistency index (C.I.) and consistency ratio (C.R.) (Saaty, 1980; Saaty, 1985).

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| Goal | criterion | Sub-criterion |
|---|---|---|

| | F1: Technological Capabilities | F1-1:Technical skills and human resources |
| | | F1-2:Service capacity |
| | | F1-3:Production technology or job practice |
| | | F1-4:Equipment resources |
| | | F1-5:Expandability, compatibility, diversity |

| | F2: Management System | F2-1:Personnel quality and training |
| | | F2-2:Labor relations |
| | | F2-3:Organizational structure |
| | | F2-4:Service attitude, customer complaint handling |
| | | F2-5:After-sales services |
| | | F2-6:Internal management systems |

| | F3: Price and Cost | F3-1:Terms of payment |
| | | F3-2:Total bidding price |
| | | F3-3:Cost for end-of-life disposal or handling |
| | | F3-4:Financial system |

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| | F4: Cooperative Abilities | F4-1:Technological cooperation |
| | | F4-2:Geographical location |
| | | F4-3:Information exchange |

| | F5: Performance of Prior Contract Fulfillment | F5-1:Experience or actual performance |
| | | F5-2:Reputation |
| | | F5-3:Accreditation of special performance in prior contract fulfillment |
| | | F5-4:Compliance, default history |

| | F6: Delivery and Warranty | F6-1:Delivery deadline |
| | | F6-2:Delivery accuracy |
| | | F6-3:Follow-up service time |
| | | F6-4: Schedule management |
| | | F6-5:Warranty |

| | F7: Quality Control Capabilities | F7-1:Environmentprotection capabilities |
| | | F7-2:Quality control capabilities |
| | | F7-3:Failure rate or life span |
| | | F7-4:Stability, reliability |
| | | F7-5:Ease of operation |
| | | F7-6:Ease of self-maintenance |
| | | F7-7:Aesthetics and comfort |

Figure 1. Hierarchy of the proposed MAB evaluation model

$$C.I. = \frac{\lambda_{\max} - n}{n-1} \tag{1}$$

$$C.R. = \frac{C.I.}{R.I.} \tag{2}$$

where $n$ represents the number of hierarchical factors, $\lambda_{\max}$ is the eigenvalue of the comparison matrix, R.I. represents the random consistency index obtained from numerous simulations and varying according is to the order of the matrix (Saaty, 1980; Saaty, 1985).

The steps of the FAHP operation are as follows (Huang, 2013; Huang, 2012b; Huang, 2012c; Huang and Shen, 2012; Buckley, 1985; Chang, 1996; Huang and Yang, 2016a; Hu et al., 2012):

Step 1 -- Development of the hierarchical framework.

Step 2 -- Questionnaire design: In accordance with the discussed hierarchical framework, the questionnaire is designed to contain pairs of comparable indicators so the relative opinions on the paired indicators can be obtained from respondents. A 9-point scale was adopted to describe the relativity, as shown in Table 1.

Table 1. The relative importance of fuzzy ratio scales (Huang, 2012b; Huang and Shen, 2012)

| Relative Importance | Linguistic Variables | Triangular Fuzzy Number |
|---|---|---|
| $C_{ij} = \tilde{9}$ | Absolute Importance | (8,9,9) |
| $C_{ij} = \tilde{8}$ | Intermediate value | (7,8,9) |
| $C_{ij} = \tilde{7}$ | Very Strong Importance | (6,7,8) |
| $C_{ij} = \tilde{6}$ | Intermediate value | (5,6,7) |
| $C_{ij} = \tilde{5}$ | Essential Importance | (4,5,6) |
| $C_{ij} = \tilde{4}$ | Intermediate value | (3,4,5) |
| $C_{ij} = \tilde{3}$ | Weak Importance | (2,3,4) |
| $C_{ij} = \tilde{2}$ | Intermediate value | (1,2,3) |
| $C_{ij} = \tilde{1}$ | Equal Importance | (1,1,2) |

Step 3 -- Establish a fuzzy positive reciprocal matrix (Huang and Yang, 2016a; Huang and Yang, 2016b)

$$A = [\tilde{a}_{ij}]\qquad(3)$$

where $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ QUOTE $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ , $l_{ij}, m_{ij}, u_{ij}$ are the lower limit, peak, and upper limit of the triangular fuzzy number. $\tilde{a}_{ij} = 1/\tilde{a}_{ij}, \quad \forall i, j = 1,2,\cdots\cdots, n.$ QUOTE $\tilde{a}_{ij} = \frac{1}{\tilde{a}_{ij}}, \forall i, j = 1, 2, 1, n$ .

Step 4 -- Use the geometric means method to integrate the opinions of respondents.

$$\tilde{a}_{ij} = (\tilde{a}_{ij}^1 \otimes \tilde{a}_{ij}^2 \otimes \cdots\cdots \otimes \tilde{a}_{ij}^n)^{\frac{1}{n}}$$
(4)

where $\tilde{a}_{ij}$ is the triangular fuzzy number in the ith column and jth row of the fuzzy positive reciprocal matrix and $\tilde{a}_{ij}^n$ is the assessment value of respondent n.

Step 5 -- Calculate the fuzzy weight:

(1) Method 1: Column geometric mean method(CGM method) (Buckley, 1985)

$$\tilde{w}_i = r_i \otimes (r_1 \otimes r_2 \otimes \cdots\cdots \otimes r_n)^{-1}\qquad(5)$$

$$r_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \cdots \otimes \tilde{a}_{in})^{\frac{1}{n}}\qquad(6)$$

where $\tilde{w}_i$ represents the fuzzy weight value of each column in the fuzzy positive reciprocal matrix, and $r_i$ represents the geometric mean value of the triangular fuzzy number.

(2) Method 2: Extent analysis method(EA method) (Chang, 1996)

$$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes [\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j]^{-1}\qquad(7)$$

$$\sum_{j=1}^{m} M_{gi}^j = [\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j]\qquad(8)$$

$$[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j]^{-1} = [\frac{1}{\sum_{i=1}^{m} u_i}, \frac{1}{\sum_{i=1}^{m} m_i}, \frac{1}{\sum_{i=1}^{m} l_i}]\qquad(9)$$

where $S_i$ represents the ith fuzzy weight of matrix m and $M_{gi}^j$ represents the calculated triangular fuzzy number obtained after the questionnaire underwent relative omparison.Following the comparison of each indicator, each group produced a minimum value (Eq. 10). Assume d'(A_i) is the minimum of each group (Eq. 11), and then form a set from the minimum value from each group (Eq. 12).

$$V(M \ge M_1, M_2, \cdots\cdots, M_k) = \min V(M \ge M_i), i = 1, 2, \cdots\cdots, k. \qquad (10)$$

$$d^*(A_i) = \min V(S_i \ge S_k) \qquad (11)$$

$$W' = (d'(A_1), d'(A_2), \cdots\cdots, d'(A_n))^T \qquad (12)$$

Thereafter, use the minimum value following the comparison and standardize it to obtain the defuzzified weight of each indicator (Eq. 13)

$$W = (d(A_1), d(A_2), \cdots\cdots, d(A_n))^T \qquad (13)$$

Step 6 -- Defuzzification: Convert the fuzzy weights into non-fuzzy values (Eq. 14).

$$DF_{ij} = \frac{a + b + c}{3} \qquad (14)$$

a, b, and c are the lower limit ($l_{ij}$), the peak ($m_{ij}$), and the upper limit ($u_{ij}$) of the triangular fuzzy number.

Step 7 -- Perform normalization (Eq. 15) to obtain the weights for each criterion and sub-criterion.

$$NW_i = \frac{DF_{ij}}{\sum DF_{ij}} \qquad (15)$$

Step 8 -- Perform hierarchical tandem to calculate the global weights of all indictors.

Empirical Results

We used the consistency ratio (CR) to assess the reliability and credibility of the questionnaire. When CR $\leqq 0.1$, it indicates that the deviation in the respondents' estimation of each factor's weight when constructing the paired-comparison matrix was acceptable, verifying the consistency. All CR values were lower than 0.1; therefore, all the judgments are consistent.

Tables 2 and Table 3 show that the local criteria weights[b] for CGM method and EA method weighting calculating methods are different, although the factors are ranked identically. (F7:Quality Control Capabilities > F5:Performance of Prior Contract Fulfillment > F3:Price and Cost > F1:Technological Capabilities > F6:Delivery and Warranty > F2:Management System > F4:Cooperative Abilities , based on highest to lowest weighting size); thus, the performance of both methods in determining the significance of criteria is identical. The total weight of the top five evaluation criteria achieved 85.28% (CGM method) and 85.01% (EA method). This shows that the five most crucial criteria the supplier provides

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regarding purchase evaluation are product quality or quality control capbailities, delivery and warranty, price and cost, production technology or technological capabilities, and performance of prior contract fulfillment. The management systems and cooperative abilities criteriahave a combined weight of only 14.72% (CGM method) and 14.99%(EA method), showing that they have low importance.

Among all evaluation criteria, quality control capabilities has a weight of 23.48% (CGM method) and 24.13% (EA method), whereas the price and cost criteria has a weight of 18.97% (CGM method) and 14.87%(EA method). This shows that the MAB purchasing method can shift the bid awarding criteria from lowest bid oriented and place significant major emphasis on quality with secondary condiderations on price, which enables purchasers to acquire the highest quality products within a pre-determined budget.

Regarding the ranking of local sub-criteria weights[b], the ranking of sub-criteria determined CGM and EA methods differ for F7-1 to F7-7. The ranking of sub-criteria based on weight (highest to lowest) obtained using CGM method is F7-4(Stability, reliability) > F7-2(Quality control capabilities) > F7-1(Environment protection capabilities) > F7-3(Failure rate or life span) > F7-5(Ease of operation) > F7-6(Ease of self-maintenance) > F7-7(Aesthetics and comfort), whereas that obtained using EA method is F7-5(Ease of operation) > F7-2(Quality control capabilities) > F7-1(Environment protection capabilities) > F7-3(Failure rate or life span) > F7-4(Stability, reliability) > F7-6(Ease of self-maintenance) > F7-7(Aesthetics and comfort).

Table 2. Local weight and global weight for each criterion (CGM method)

| Criterion[a] | Local Weights[b] | Ranking | Sub-criterion[a] | Local Weights[b] | Ranking | Global Weights[c] | Ranking |
|---|---|---|---|---|---|---|---|
| | | | F1-1 | 0.2015 | 3 | 0.0241 | 22 |
| | | | F1-2 | 0.2647 | 2 | 0.0317 | 13 |
| F1 | 0.1196 | 4 | F1-3 | 0.2899 | 1 | 0.0347 | 8 |
| | | | F1-4 | 0.0952 | 5 | 0.0114 | 30 |
| | | | F1-5 | 0.1487 | 4 | 0.0178 | 29 |
| | | | F2-1 | 0.1324 | 3 | 0.0115 | 31 |
| | | | F2-2 | 0.0897 | 6 | 0.0078 | 34 |
| F2 | 0.0871 | 6 | F2-3 | 0.1126 | 4 | 0.0098 | 32 |
| | | | F2-4 | 0.2854 | 1 | 0.0249 | 19 |
| | | | F2-5 | 0.2812 | 2 | 0.0245 | 21 |
| | | | F2-6 | 0.0987 | 5 | 0.0086 | 33 |
| F3 | 0.1897 | 3 | F3-1 | 0.2958 | 2 | 0.0561 | 4 |

| Criterion[a] | Local Weights[b] | Ranking | Sub-criterion[a] | Local Weights[b] | Ranking | Global Weights[c] | Ranking |
|---|---|---|---|---|---|---|---|
| | | | F3-2 | 0.3333 | 1 | 0.0632 | 2 |
| | | | F3-3 | 0.1321 | 4 | 0.0251 | 14 |
| | | | F3-4 | 0.2388 | 3 | 0.0453 | 7 |
| F4 | 0.0601 | 7 | F4-1 | 0.3742 | 1 | 0.0225 | 20 |
| | | | F4-2 | 0.3039 | 3 | 0.0183 | 27 |
| | | | F4-3 | 0.3219 | 2 | 0.0193 | 25 |
| F5 | 0.1985 | 2 | F5-1 | 0.3015 | 2 | 0.0332 | 11 |
| | | | F5-2 | 0.1847 | 4 | 0.0204 | 24 |
| | | | F5-3 | 0.3211 | 1 | 0.0354 | 9 |
| | | | F5-4 | 0.1927 | 3 | 0.0212 | 23 |
| F6 | 0.1102 | 5 | F6-1 | 0.1443 | 5 | 0.0286 | 17 |
| | | | F6-2 | 0.3079 | 1 | 0.0611 | 3 |
| | | | F6-3 | 0.1611 | 4 | 0.0320 | 16 |
| | | | F6-4 | 0.1856 | 3 | 0.0368 | 12 |
| | | | F6-5 | 0.2011 | 2 | 0.0399 | 5 |
| F7 | 0.2348 | 1 | F7-1 | 0.1235 | 4 | 0.0290 | 18 |
| | | | F7-2 | 0.1477 | 2 | 0.0347 | 6 |
| | | | F7-3 | 0.2918 | 1 | 0.0685 | 1 |
| | | | F7-4 | 0.1472 | 3 | 0.0346 | 10 |
| | | | F7-5 | 0.1135 | 5 | 0.0267 | 15 |
| | | | F7-6 | 0.0899 | 6 | 0.0211 | 26 |
| | | | F7-7 | 0.0864 | 7 | 0.0203 | 28 |

a. For An Explanation of the Codes, Please Refer to Fig. 1.

b. Local Weight is Determined based on Judgments of a Single Criterion.

c. Global Weight is Determined by Multiplying the Weight of the Criteria.

Table 3. Local weight and global weight for each criterion (EA method)

| Criterion[a] | Local Weights[b] | Ranking | Sub-criterion[a] | Local Weights[b] | Ranking | Global Weights[c] | Ranking |
|---|---|---|---|---|---|---|---|
| F1 | 0.1367 | 4 | F1-1 | 0.1847 | 3 | 0.0221 | 21 |
| | | | F1-2 | 0.2769 | 2 | 0.0331 | 14 |
| | | | F1-3 | 0.3013 | 1 | 0.0360 | 10 |
| | | | F1-4 | 0.1046 | 5 | 0.0125 | 31 |
| | | | F1-5 | 0.1325 | 4 | 0.0158 | 29 |
| F2 | 0.0899 | 6 | F2-1 | 0.1432 | 3 | 0.0125 | 30 |
| | | | F2-2 | 0.0785 | 6 | 0.0068 | 34 |

| Criterion[a] | Local Weights[b] | Ranking | Sub-criterion[a] | Local Weights[b] | Ranking | Global Weights[c] | Ranking |
|---|---|---|---|---|---|---|---|
| | | | F2-3 | 0.1216 | 4 | 0.0106 | 32 |
| | | | F2-4 | 0.2764 | 1 | 0.0241 | 19 |
| | | | F2-5 | 0.2695 | 2 | 0.0235 | 20 |
| | | | F2-6 | 0.1108 | 5 | 0.0097 | 33 |
| F3 | 0.1487 | 3 | F3-1 | 0.3088 | 2 | 0.0586 | 4 |
| | | | F3-2 | 0.3201 | 1 | 0.0607 | 2 |
| | | | F3-3 | 0.1735 | 4 | 0.0329 | 18 |
| | | | F3-4 | 0.1976 | 3 | 0.0375 | 5 |
| F4 | 0.0600 | 7 | F4-1 | 0.3968 | 1 | 0.0238 | 22 |
| | | | F4-2 | 0.2887 | 3 | 0.0174 | 28 |
| | | | F4-3 | 0.3145 | 2 | 0.0189 | 27 |
| F5 | 0.1897 | 2 | F5-1 | 0.3105 | 2 | 0.0342 | 12 |
| | | | F5-2 | 0.1784 | 4 | 0.0197 | 25 |
| | | | F5-3 | 0.3121 | 1 | 0.0344 | 8 |
| | | | F5-4 | 0.1990 | 3 | 0.0219 | 23 |
| F6 | 0.1337 | 5 | F6-1 | 0.1538 | 5 | 0.0305 | 16 |
| | | | F6-2 | 0.2987 | 1 | 0.0593 | 3 |
| | | | F6-3 | 0.1594 | 4 | 0.0316 | 13 |
| | | | F6-4 | 0.1685 | 3 | 0.0334 | 7 |
| | | | F6-5 | 0.2196 | 2 | 0.0436 | 6 |
| F7 | 0.2413 | 1 | F7-1 | 0.1094 | 5 | 0.0257 | 15 |
| | | | F7-2 | 0.1743 | 2 | 0.0409 | 9 |
| | | | F7-3 | 0.2835 | 1 | 0.0666 | 1 |
| | | | F7-4 | 0.1462 | 3 | 0.0343 | 11 |
| | | | F7-5 | 0.1355 | 4 | 0.0318 | 17 |
| | | | F7-6 | 0.0796 | 6 | 0.0187 | 24 |
| | | | F7-7 | 0.0715 | 7 | 0.0168 | 26 |

a. For An Explanation of the Codes, Please Refer to Fig. 1.

b. Local Weight is Determined based on Judgments of a Single Criterion.

c. Global Weight is Determined by Multiplying the Weight of the Criteria.

Additionally, the ranking for the local sub-criteria weights[b] are identical (F1-1 to F1-5, F2-1 to F2-6, F3-1 to F3-4, F4-1 to F4-3, F5-1 to F5-4, and F6-1 to F6-5). This shows that the CGM method and EA method methods possess a certain level of performance when determining the importance of sub-criteria.

For the ranking of global sub-criteria weights[c], the four most crucial sub-criteria are identical for both of the

discussed methods (F7-3:Failure rate or life span > F3-2: Total bidding price > F6-2: Delivery accuracy > F3-1: Terms of payment). The three least critical sub-Conclusion

Based on supplier evaluation theories, this study reviewed extant literature and conducted expert interviews to establish evaluation criteria and sub-criteria when using MAB to award bids. The seven evaluation criteria and 34 sub-criteria are a suitable reference for PEO engaging in MAB evaluations. The study also employed FAHP to determine the weighting of the criteria and sub-criteria, and the analysis results in this study indicate that among the discussed evaluation criteria, the total weight of quality

criteria are F2-2(Labor relations), F2-6(Internal management systems), and F2-3(Organizational structure).

control capabilities, delivery and warranty, price and cost, technological capability, as well as performance of previous contract fulfillment exceeds 85%. The total weight of management system and cooperative abilities criteria is less than 15%. When determining the relative scoring of evaluation criteria and sub-criteria, PEO in need of MAB evaluations can use the weights obtained in this research as the basis. The methodology and processes detailed in this study can also be used to establish MAB evaluation models, to improve the accuracy of supplier selection.

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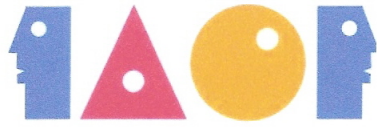
# A STUDY OF CREATIVE TEACHING AND TECHNOLOGICAL CREATIVITY USING HIERARCHICAL LINEAR MODELS

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## Abstract

Introduction: One of the sports community's current issues that deserves more academic attention and development is how athletic coaches can use creative teaching methods to engage their trainees in various ways of thinking with regard to technological creativity to help distinguish them, technologically, from other athletes, thus enhancing their performance in athletic events. Accordingly, this study aims to explore how creative teaching and self-efficacy impact technological creativity among athletes, as well as to understand the role of creative teaching as a moderator between self-efficacy and technological creativity.

Methodology: This study selects a number of coaches and athletes from various sports teams as respondents to a questionnaire survey. The questionnaire is comprised of items on creative coaching, athletes' technological creativity, and athletes' self-efficacy. We collect a total of 230 valid responses: 30 from coaches, and 200 from athletes in various athletic disciplines in university and high school teams. The collected data is analyzed using hierarchical linear modeling.

Results: 1. We find significant differences in technological creativity among athletes from different team sports. 2. We also find significant correlations between athletes' self-efficacy and technological creativity. 3. Coaches' creative teaching has a significant effect on athletes' technological creativity. 4. Coaches' creative teaching has no moderating effect on the relationship between athletes' self-efficacy and technological creativity.

Conclusion: Athletes with higher self-efficacy are more capable of demonstrating their technological creativity in their athletic performance. With regard to the apparent failure of creative teaching to produce a positive effect on technological creativity, it may be argued that the concept and application of creative coaching in Taiwan's athletic disciplines have not reached maturity, with most coaches lacking sufficient command of creative teaching to provide athletes with effective instruction. Overall, this study indicates that the quality of creative teaching has no impact on the self-efficacy and technological creativity of athletes in Taiwan. While creative teaching is not an important factor in this work, athletes' self-efficacy is a crucial factor with regard to enhancing technological creativity.

Keywords: Self-Efficacy, Technological Creativity, Creative Teaching, Hierarchical Linear Models (HLM)

## Introduction

### Research Background

The concept of creativity has undergone progressive development and has been extensively applied to various disciplines around the world, including the field of sports education. Nowadays a growing number of schools has managed to provide a creative educational environment for their athletic curriculum. Most sports instructors or coaches consider it an instructional priority to integrate the notion of creativity or creative ways of thinking into their courses to help students cultivate creativity, and en

hance their efficiency in athletic performance (Swartz, 2003). This development is likely to affect how athletic students behave or perform to achieve excellence in sports. How are they able to adjust themselves in this regard? According to the social cognitive theory proposed by Bandura (1982), self-efficacy refers to the self-perceived confidence one has in one's ability to perform in a specific situation. Self-efficacy allows learners to formulate a specific model of personal thinking, feeling and motivation that affects their personal behavior and choice of activity (Bandura, 1982). Therefore, we consider it worthwhile to research the issue of how self-efficacy can help athletes improve their performance,

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creativity and technology as a result of their coaches' creative teaching.

The relevant literature has suggested that self-efficacy, be it positive or negative, affects an individual's decision to perform in a certain environment. People with higher self-efficacy are likely to work more proactively to overcome their difficulties, while those with lower self-efficacy may simply imagine a situation worse than the real one, and thus feel more pressure and less confidence. Theoretically, high self-efficacy may result in positive ways of thinking and emotional responses. People with higher self-efficacy are more capable of effectively concentrating their attention and thus exert more effort to overcome challenges (Bandura, 1981).

Most athletes work to challenge their physical limitations in the training process in order to improve their performance. Those who have reached their current level of proficiency by pushing to the physical extremes can still further enhance their athletic performance from a mental perspective (Lin, 2007). Chiu and Yeh (1998) considered technological creativity to be a successful implementation of creative technol-ogy. Technological creativity is also a synthesis of knowledge development in a specific discipline, as well as a thinking process for solving creative problems, one that can result in creative ideas. In terms of sports, the athletic operating process in which athletes create or apply any appropriate, original, practically valuable technology can be referred to as "athletic technology creativity." The extant literature has seldom mentioned the concept of sports-related technology creativity as a factor in evaluations of athletic performance. Recently, however, dedicated athletes have continued to advance their professional skills, making it more common for sports coaches to employ diverse models in their athletic training sessions. Athletic instructors use creative ways of thinking through creative instruction, and with the aid of technological creativity, they train their athletes to become exceptionally successful in sports contests. Coaches are essential to any training program and have significant influence on athletes with regard to training and performance. They play the roles of both leader and trainer (Wang and Zhang, 2012; Huang, 1990). Tierney, Farmer and Grean (1999) argued that creativity is a practical, unique, results-oriented

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way of performing a certain activity. Coaches and athletes have an inter-dependent relationship: athletes expect their coaches to pass on experience, skills and knowledge, and coaches desire to do exactly that. In light of the current gaps in the relevant literature, the relationship between athletic instructors and trainees deserves to be further addressed. Therefore, this study explores the influence of coaches' creative teaching on athlete's self-efficacy and technological creativity.

*Relationships Among Constructs*

Amabile (1996) placed special emphasis on self-efficacy and considered it a driving force behind technological creativity. She argued that the creative process involves many setbacks, and requires long-term effort and investments of energy and resources. Without strong self- efficacy, activities related to technological creativity fail to persist or succeed. As such, self-efficacy is a crucial factor for technological creativity. Ford (1996) also held that self-efficacy is a major factor for individual creativity and affects future creative behaviors and performance. Bandura (1997) observed that self- efficacy is a prerequisite for

creative production and knowledge discovery. According to these earlier studies, self-efficacy plays a crucial role in the development of creativity. Bandura argued further that high self- efficacy is a requirement for new knowledge discovery or innovative production. Accordingly, this study hypothesizes that self-efficacy has a significant positive influence on technological creativity.

Amabile (1988) proposed that both domain-relevant and creativity-relevant skills are necessary for individual creative performance. Amabile (1996) viewed an individual's creative performance as the result of the interactions between the individual and the working environment. Creativity will thus vary in different social contexts. According to King and Anderson (1990), creativity works to help team members solve problems and make decisions. It allows people to provide various skills, knowledge and experience to generate more creative results. Mao and et al. (2000) also mentioned that if all members work together creatively, the team should be able to achieve both greater creativity and effectiveness. Hoegl (2007) held that both domain-relevant skills and creativity-relevant skills affect a team's

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effectiveness and efficiency. Chang (2011) thus proposed that instructors should include creativity practice into their creative instruction, and encourage innovative or unconventional ways of thinking. Students should be taught to see themselves as creative producers, who thus need to learn to appreciate or accept creative concepts, innovation, game-playing ideas, and notions of overturn or reversal. Accordingly, this study proposes its second hypothesis: that creative teaching has a significant positive influence on technological creativity.

Amabile (1983) considered domain-relevant skills to be an important element in the expression or exercise of creativity. Therefore, whether or not it is easy to acquire or internalize domain knowledge or cultural products is a crucial factor affecting creative instruction. Easy acquisition or internalization of domain knowledge will help teachers to improve their self-efficacy and performance in creative instruction. Meanwhile, apart from creative teaching and self-efficacy—both of which predict behavior in creative teaching—intrinsic motivation should not be overlooked as one of the factors affecting the expression

of creativity. Tierney and Farmer (2002) point out that while self-efficacy has a significant influence on a person's performance, creative self-efficacy may be an important driving force for the individual to perform creativity and persist in this regard. People may encounter setbacks and obstacles which must be overcome in the creative process, and strong self-efficacy is required for them to persist with their creative activities rather than giving up. Relevant studies conducted by Amabile (1996), Csikszentmihaly (1996) and Sternberg and Lubart (1995) all emphasize that intrinsic motivation is an important driving force that helps individuals to perform creatively and continue their efforts. Accordingly, this study proposes its third hypothesis: creative teaching has a significant moderating effect on the relationship between self-efficacy and technological creativity.

Purposes of the Study
(1) To explore the influence of coaches' creative teaching and athletes' self-efficacy on athletes' technological creativity.
(2) To determine whether coaches' creative teaching has a moderating effect on the relationship between

athletes' self-efficacy and their technological creativity.

(3)  To make suggestions for follow-up research and practical applications based on the research results.

## Methodology

### *Research Framework and Hypotheses*

This study intends to examine the following three hypotheses, and our empirical investigation of the multilevel model consists of two stages as shown in Figure 1.

**H1:** There is a significant influence of athletes' self-efficacy on their technological creativity.

**H2:** There is a significant positive influence of coaches' creative teaching on athletes' technological creativity.

**H3:** Coaches' creative teaching has a significant moderating effect on the relationship between athletes' self-efficacy and their technological creativity.
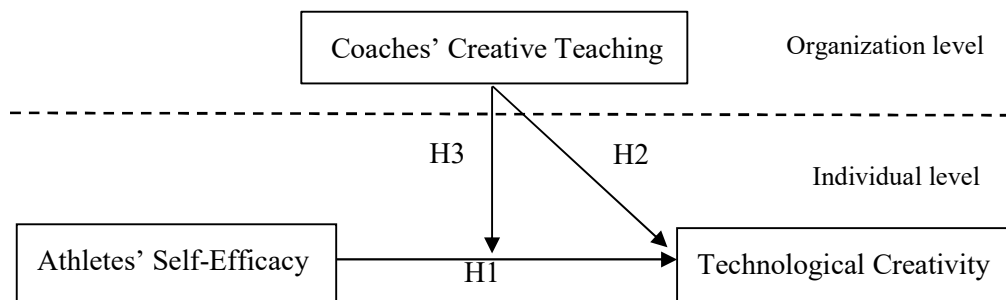


*Figure 1. Research Framework*

*Research Subjects and Instruments*

Using a random sampling approach, this study selected athletes and coaches from various sports teams to undergo a questionnaire survey. A total of 30 coaches and 285 athletes on school teams in various athletic disciplines from universities and high schools were surveyed. Valid responses were collected from 30 coaches and 200 athletes. This study employed a Likert scale in the various questions on creative teaching for coaches and self-efficacy and technological creativity for athletes, as follows.

(1) Coaches' creative teaching: measured by a Likert scale for ath-

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letes' descriptions of their coaches' creative teaching, as modified from the Innovative Behavior Scale developed by Scott and Bruce (1994) for superiors' evaluation of subordinates.

(2) Athletic self-efficacy: measured using items on athletic self-efficacy modified from the corresponding instrument developed by Sallis et al. (1988), Hu (2003), and Chiu (2008).

(3) Technological creativity: measured by the scale on technological creativity developed by Wu (2007).

Data Analysis

The collected data was analyzed using hierarchical linear modeling (HLM). HLM is a statistical analysis that takes into account the relationships between independent and dependent variables at different levels. This measurement of variables at various levels distinguishes HLM from hierarchical regression analysis.

This study adopted HLM to measure four models: the Null model, the Random-Coefficients-Regression model, the Intercepts-as-Outcomes model, and the Slopes-as-Outcomes model. The Null model was examined to measure internal within-group consistency and be-

tween-group variances. The Random-Coefficients-Regression model was tested to determine the effect of self-efficacy on creative teaching, and whether intercepts and slopes differ for different groups. The Intercepts-as-Outcomes model was used to measure the effect of coaches' creative teaching. The Slopes-as-Outcomes model was applied to assess the moderating effect of creative teaching on the relationship between self-efficacy and technological creativity.

Results

*Reliability and Validity Analyses*

The reliability analysis indicated that the Cronbach's Alpha coefficient for each scale was greater than 0.9, suggesting high reliability. Meanwhile the factor analysis showed a KMO value of 0.869 for athletes' self-efficacy and 0.946 for technological creativity, indicating high construct validity.

*HLM Analysis*

(1)   Null model
Level-1: technological creativity=$\beta_{0j}$+$r_i$
Level-2: $\beta_{0j}$=$\gamma_{00}$+$u_{0j}$

The results of the data analysis show estimates of the variance components for athletes' self-efficacy ($\chi 2 = 56.40745$, df $= 16$, p<0.0001) with the within-group variance component $\tau 00 = 3.813$ (e.g., 38.1%), indicating that the relationship between the variables reached the level of significance (p<0.0001). This also indicates a significant correlation between athletes' self-efficacy and technological creativity. Accordingly, this study rejected the null hypothesis and proceeded to conduct a cross-level HLM analysis.

*Cross-Level Analysis*

Cross-level analysis was conducted in two parts. We first used the Intercepts-as-Outcomes model to predict how the variables of coaches' creative teaching and athletes' self-efficacy affect technological creativity, and we then applied the Slopes-as-Outcomes model to examine whether coaches' creative teaching has a moderating effect on the relationship between athletes' self-efficacy and technological creativity.

Two-level hierarchical linear models were used to test the moderating effect of coaches' creative teaching on the relationship between athletes' self-efficacy and technological creativity:

Level 1: $\beta 0j+\beta 1j$*(athletes' self-efficacy)+rij.
Level 2: technological creativity ij=$\gamma 00+\gamma 01$*creative teaching j+$\gamma 10$* athletes' self-efficacy ij+ u0j+u1j* athletes' self-efficacy ij+ rij

As shown in Table 1, the results indicate that athletes' self-efficacy and technological creativity are significantly correlated. Thus, Hypothesis 1 is supported. Coaches' creative teaching has a negative effect on athletes' technological creativity ($\gamma 01 = -0.207224$, p $= 0.019$;

$\gamma 10 = 0.539632$, p<0.001).

Thus, Hypothesis 2 is not supported. Coaches' creative teaching has no moderating effect on the relationship between athletes' self-efficacy and technological creativity. Thus, Hypothesis 3 is not supported.

Table 1. HLM Analysis

| Effect | coefficient | SD | T-test | Approx. d.f. | P-test |
|---|---|---|---|---|---|
| For INTRCPT1, $\beta_0$ | | | | | |
| INTRCPT2, $\gamma_{00}$ | 2.763594 | 0.409999 | 6.740 | 15 | <0.001 |
| Creative teaching, $\gamma_{01}$ | -0.207224 | 0.078722 | -2.632 | 15 | 0.019 |
| For self-efficacy slope, $\beta_1$ | | | | | |
| INTRCPT2, $\gamma_{10}$ | 0.539632 | 0.045538 | 11.850 | 16 | <0.001 |

Discussion and Recommendations

*Discussion*

(1) Athletes' self-efficacy and technological creativity

According to Bandura (1982), high self-efficacy is a requirement for new knowledge discovery or creative production, highlighting the importance of self-efficacy in the implementation of creativity. Relevant research has also suggested that the best indicator of success for students is no longer their ability, but their belief in their ability to succeed (Amabile, 1996). The results of this study indicate that athletes with higher self-efficacy demonstrate higher technological creativity, which is consistent with Hypothesis 1. Meanwhile, athletes over 16 years of age have been found to be more likely to increase their self- confi

dence in an effective manner. The participants in this study could comprehend the questions and complete the survey accurately, indicating that athletes over 16 years of age are mentally mature and have high self-confidence. Accordingly, athletes' self-efficacy has a significant effect on their technological creativity.

(2) Coaches' creative teaching and athletes' technological creativity
The results of this study show a negative influence of coaches' creative teaching on technological creativity. One of the possible reasons for this is that creative teaching was not emphasized in sports education in Taiwan until rather recently, and thus current athletic trainees have been given little creative instruction or relevant information. Athletic coaches who received a conventional sports education mostly tend to follow the same style when teaching

their young athletes. Nowadays, however, based on scientific research, experience and knowledge in this regard, a growing number of athletic educators has called for a change requiring coaches to become more conscious of creative teaching in their work.

However, the promotion of creative teaching in the field of sports education is still at an early stage in Taiwan. Lacking proficiency in creative teaching, most coaches still fail to enable trainees to effectively receive and understand messages in a creative teaching process. The data obtained in this study shows that athletic coaches in Taiwan are, on average, between 30 and 39 years of age. Their thinking regarding creative teaching also varies significantly depending on their age, which is consistent with the findings of relevant studies (e.g., Chen, Gully and Eden, 2001; Yang, 2000; Lin, 2002). We found that coaches under the age of 39 had higher levels of intrinsic motivation and more diverse forms of innovative instruction. It can thus be argued that if coaches are able to enjoy themselves and willing to take on challenges with an open attitude in their instruction, then their creative teaching behavior will have

a significant influence on athletes' technological creativity.

(3)    The moderating effect of coaches' creative teaching on the relationship between athletes' self-efficacy and technological creativity According to Amabile (1996) and Woodman, Sawyer and Griffin (1993), the concept of creativity is an integration of the concepts of self-efficacy and technological creativity. An athlete's self-efficacy level represents that athlete's subjective belief in or perception of his or her ability to achieve a result. However, this study sought to understand whether coaches' creative teaching has a moderating effect on the relationship between athletes' self- efficacy and technological creativity. In regards to this finding, it should be noted that Taiwan has seen few creative teaching activities in athletic education, which is important as it applies to the role of creative teaching as a moderating factor in this study. The data obtained in this study shows that most athletic coaches in Taiwan have not carried out sports education abroad, which may explain why they have engaged in fewer creative teaching activities in their instruction. This highlights the need to further explore the issue of communica-

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tion between athletic students and coaches. Overall, the results of this study indicate that while athletes' self-efficacy has a significant influence on their technological creativity, coaches' creative teaching has no moderating effect on the relationship between the athletes' self-efficacy and technological creativity. Accordingly, in Taiwan where coaches' creative teaching has not reached a mature level, athletes' self-efficacy remains a major factor for breakthroughs in their technological creativity.

## Recommendations

Most athletes are able to cultivate their technological creativity through a long period of training and accumulated experience in competitions and matches. While athletes' self-efficacy is an indispensable factor in the promotion of their technological creativity, creative training can work to enhance their self- efficacy. This study thus recommends that all Taiwanese sports associations or federations regularly organize sporting events and long-term training projects for athletes at various levels, enabling them to increase their knowledge and experience of innovative technology, so as to facilitate their communication with coaches in terms of creative instruction. All schools offering sports education should promote creative teaching as an advanced means for athletic instructors and students to improve their performance. We also recommend that coaches should stay informed regarding the latest relevant information. Chia (1976) also encouraged coaches to adjust their teaching approaches to different situations. Accordingly, we suggest that follow-up research be conducted to explore the interactions between coaches and athletes, in order to enable trainees to efficiently cultivate their creativity and enhance their performance (Swartz, 2003).

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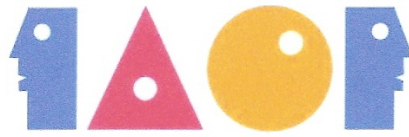
# A CASE STUDY ON INNOVATION AND ENTREPRENEURIAL VALUE OF GREEN FOOD: PINEAPPLE PRODUCTS AS AN EXAMPLE

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Abstract

In 2012, the United Nations Environmental Program, UNEP, defined the green products to be used in food products known as green food. The pursuit of healthy and nutritious diet concept has become a hot topic in recent years. Mr. Yu-fan Yang (hereinafter referred to as "the producer") for the cultivation of non-toxic pineapples in Guanmiao District, Tainan City, Taiwan who paid attention to the natural law and the product of no-added pineapple processing products. In this study, the immersion/ crystallization analysis style was used to collect and analyze the textual information of the social interaction with the online shoppers from the community website such as FB and blog between 2011 and 2016 of the producer and then with the semi-structured interviews to explore the green food concept of operating pineapple industry which brought the long-term benefits for the producer, moreover, provide more favorable ecological sustainable management. The producer was used to the community website; he sold out 12,000 kilograms of pineapple fruit and other processed products quickly on online shopping within 12 hours in 2016. The producer knew to seek support from government and academic groups to solve his problems, and knew the concept of customer-oriented green consumption to create a new value of the product, that is, the entrepreneurial value of the producer.

Key Words: Green Food, Innovation, Entrepreneurial Value, Immersion / Crystallization Analysis Style

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## Introduction

Nowadays, many companies are actively developing and manufacturing green-related food, and use the products, service packaging or advertising marketing to consumers a message which will like to inform the public that green food to the Earth's environment friendly. Green food consumption could guarantee the life quality of consumers.

However, green food consumption is not an easy task; it needs from government policy, so that consumers are more receptive (Zhu, Li, Geng, & Qi, 2013). The Environmental Protection Department, Taiwan, (2013) proposed the so-called green store can be divided into physical green stores and virtual green stores. Green store is to facilitate consumers to give priority to the procurement of green goods, and leading the green consuming of corporate social responsibility. The so-called green goods refers to the recyclable, low pollution, provincial resources and other functions or concepts of the product from the raw material acquisition, product manufacturing, sales, usage and disposal process.

This study has studied a small producer marketing of pineapple fruit and processed product on social network, without physical store, since 2011, to explore the quality of his control to pineapple-related products and to examine the entrepreneurial value of marketing his product. The purpose of this study is as follows:
1. To explore the producer concerning of pineapple product management.

2. To explore the producer concerning of service innovation and entrepreneurial value of pineapple product.

## Literature Review

### Green Food

Many studies have pointed out that consumers are increasingly concerned about the environment, food quality and safety concerns, the development of green food market have more expectations. The definition of green products, including food, is mainly to prevent environmental pollution.

According to definition of the United Nations Environmental Program, UNEP, the so-called green products, also known as cleaner production, are strategies that continually apply integration and prevent environmental pollution in processes, products and services to increase ecological benefits and reduce human and environmental hazards" which be used in food production is known as green products food (UNEP 2012).

Akgüngör, Miran and Abay (2010) argued that green food refers to food that are harmless, non-polluting, safe and nutritious to consumers' health, and can minimize the harm to the Earth during the production, manufacture and sale. They defined green food as fresh and nutrient product which can increase the ecological benefits and reduce the harm to humans and the environment. In 2015, Britain practiced of zero carbon food policy to reduce the delivery mileage of local agricultural products which do not have to be

through the wholesale and shorten the distance between the origin and the customer. This will not only reduce the carbon emissions of transport, but also provide the freshest crops.

Lu (2016) pointed out that some special regulations were formed to enhance the agro-processed food by the Council of Agriculture. The processed agricultural products including self-produce and commissioned OEM. The use of agricultural raw materials of the processed food production should be produced with traceability products such as GAP, Certified Agricultural Standards, produce resume or organic verification as the priority. The Environmental Protection Department, Taiwan (2016) has applied for the "Label for Carbon Footprint of Products" (hereinafter referred to as Carbon Label) since May 2010. Till now, there are 95 manufacturers, 422 products to obtain carbon label use rights in Taiwan and many of which have the characteristics of Taiwan's gifts. The government called on the public to give priority purchasing of carbon label products to support environmental products. Huang, We, Tsai and Lin (2013) studied that New Taipei City consumers reflected the product's positive reputation after purchasing the organic agricultural products.

*Innovation and Entrepreneurship*

The term of "innovation" was first proposed by Schumpeter, emphasizing that innovation and invention are not the same. Invention is for scientific activities, and innovation belongs to economic need. Innovation is the effective use of enterprise resources to meet the needs of the market via new production methods; it is the driving force of economic growth. In the ordinary sense, innovation is "to make better by change and to create profits" or a kind of "process of turning creativity into dollar" (Chen & Liu 2011).

Hung and Kao (2012) considered the concept of innovation could be applied to many aspects such as process innovation, product innovation, service innovation which could make the original value up. From the view of technological process innovation, all are technical process innovation whatever to improve the manufacturing method, put the new elements into the old manufacturing process, or make the production efficiency or output increase. About product or service innovation, it added new function in the original product or through the integration of services to improve the quality of the original service. It could create the added value of the enterprise competition as a niche through the service innovation. "Service innovation" is a key element in promoting the sustainable growth of the service section, which comes from the concern of consumers and the orientation of customer value (Lu, 2011).

Chen (2013) pointed out that entrepreneurship is one of the acts of business areas focus on new products, new technologies, new raw materials, new organizational structure or management model, through a certain degree of transformation, to create the economic value of the product, to achieve the goal of business and profit from them. The essence of entrepreneurial behavior is

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to identify opportunities and put useful ideas into practice. The tasks required for entrepreneurial mission could be done by individual, also by the group, and the need for creativity, driving force and the willingness to take risks (Barringer & Ireland 2008). In this way, "entrepreneurship", innovation and creative activities, is in the condition of risk and uncertain environment, and through the discovery, assessment and entrepreneurial opportunities to establish a new economic organization, and bring benefits for entrepreneur (Kuo, 2013).

Study Method

The essence of case study is that it tries to clarify one or a group of decision: Why they will be adopted, how to implement, and what kind of results will be. This definition therefore raised the subject of "decision making", which is considered to be the main focus of case study (Yin, 1994). Chang (2010) pointed out the immersion/ crystallization analysis style. Chang said that a researcher likes an explorer or a thinker, long-term study in the text in order to master, through continuous review of relevant experience into the overall analysis coupled with insight into the experience gained by the new insights, and the correlation between each other, and finally extract the report of the social reality of the paper.

This study had collected the producer's interact through community website such as FB and blog with

friends from 2011 to 2016, then sorting out and analyzing its discussion topics, finally, ended the research by semi-structured interviews. The official interview time was 2 hours held on January 7, 2017, supplemented by three telephone interviews to determine the correctness of the information.

Researchers use broader research questions as the basis for interviews, through the concept and management of green food, to guide the conduct of interviews. Interview guide or interview table as the interview structure. The type of problem or discussion was carried out in a more flexible manner, showing the immersion/crystallization analysis style. Figure 1 showed the framework of the study to show the main object of the producer, with semi- structured design interviews based on the literature reference to explore the management, innovation and entrepreneurial value of producer's pineapple and the processed pineapple.

Data Analysis

*Introduction of Case Study*

This study was collected and analyzed the textual information of the social interaction with the online shoppers from the community website such as FB and blog between 2011 and 2016 of the producer as follows:
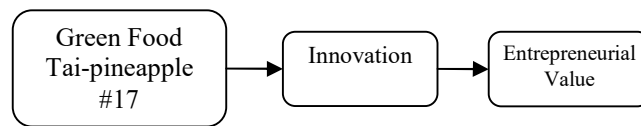
Figure 1. Study Framework

1.     The producer returned to his hometown using of organic fertilization soil to plant the Tai-pineapple #17 in 2011, however, the sunburned fruit was too small and the fruit was split after planted 18 months. The producer decided to donate all the pineapple to the local elementary school, and he decided to pay 1% of the surplus return to his primary school alma mater. He shared his pineapple story in community website which opened the network marketing business model.

2.     The producer purchased a large number of pineapple seedlings, to plant 2700 strains of pineapple seedlings within 8 hours in a day, planted a strain per 10 seconds, in 2012 and the remaining pineapple seedlings to act as fertilizer, the producer adjusted the concept of planting techniques by natural agriculture.

3.     For the first time, the producer accepted the pre-order pineapple in the community site in 2013, but it was redesigned due to the pre-purchase order was bad.

4.     Due to weather factors lead to excessive burst of fruit, delayed the pre-purchase order, harvest and delivery in 2014. The producer used the dried pineapple fruit as compensation, and to take advantage of this condition to promote this new product. The producer continued to develop the dried

pineapple and pineapple jam sold during New Year and Mid-autumn Festival.

5.     In 2015, pineapple immature caused by the lack of rain during the growing up period, but encountered the consecutive heavy rain on the harvest days, so the producer returned money to the consumers. In the early 2016, the weather was still uncertain such as more rainfall, high temperature and humidity which increased the fruit disease. The producer moved all the secondary pineapple turning to jam and ice cream to reduce the loss.

The producer has issued his pineapple information such as production resume, market experience and sale places etc., through the community website to communicate with consumers, and adjust their sales model since 2013. In 2016, the producer allowed the regular customers a week in advance to pre-order pineapple, and then open to the new customers which could effectively control the orders amount. Table 1 referred to the sale of pineapple from 2013 to 2016.

*Green Food Management*

Guanmiao accounted for 43% out of 1,125 hectares in Tainan total planting area, and the producer only occupied 0.18% of 484 hectares in this area. There are 18 product and marketing

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Table 1. The Sale of Pineapple of the Producer's Community Network
from 2013 to 2016

| Events \ Year | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|
| Harvest Time | April-May | May-June | April-May | April-May |
| Fresh Pineapple Sales | First Preorder from Network：Due to July | Due to July | Due to July | Due to July |
| Dried Pineapple Sales | | September | February, September | September |
| Sales Pineapple Products | Fresh Pineapple | Fresh Pineapple Dried Pineapple Pineapple Jam | Fresh Pineapple Dried Pineapple Pineapple Jam Pineapple Ice Cream | Fresh Pineapple Dried Pineapple Pineapple Jam Pineapple Ice Cream |
| Sales Time for Regular Customers | March 19 | 1. Fresh Pineapple：March 16 2.Dried Pineapple：August 29-September 06 3. Pineapple Jam：August 29-September 06 | 1. Fresh Pineapple：May 18-20 2. Dried Pineapple：February 02-10、September 14-16 3. Pineapple Jam：February 02-10、September 14-16 4. Pineapple Jam：September 02 (Sold out within 2 hours ) | 1. Fresh Pineapple：March 13 2. Dried Pineapple：September 01 (Sold out within 12 hours ) 3. Pineapple Jam：September 01 (Sold out within 12 hours ) 4. Pineapple Cream：September 21 |
| Sales Time for New Customers | March 19 | The same time as the regular customers | The same time as the regular customers | 1. Fresh Pineapple：May 12 2. Dried Pineapple：September 03 (Sold out within 30 minutes ) 3. Pineapple Jam：September 03 (Sold out within 30 minutes ) 4. Pineapple Cream：October 02 |

Remarks: This table excluded the pineapple amount in 2012 which donated to an elementary school.

classes at Guanmiao area out of 42 classes of Tainan City, organic farm 1 (miscellaneous), this ratio for the green pineapple industry is quite rare, and organic product and marketing class for 0. The producer used the seedling cultivation of non-toxic agricultural practices. The producer shared his usual method of planting to cyber mates on Internet from the beginning in 2013. He will also advise the harvest period of pineapple, and real record the work of a small farmer in the community website.

For example, pineapple is easy to ferment due to it is the high moisture fruit. Usually, the producer delivered the half -mature pineapple to the processing plant with low temperature, low humidity and drying method to dry, the fruit color would be better after dry, it needed 35 to 38 hours for drying process. The drying process did not add any sugar, the dried fruit, then, into a freezer after vacuum packaging. The producer will inform consumers about the process of his products on the Internet or explain what was the difference of pineapple taste either April or June and the latter is sweeter. The producer considered that his product quality was unstable; he tried to let his consumers know about the characteristics of agricultural products.

The producer.

"Though pineapple output was high on unit area, but the yield was not so high after the average harvest of two years. However, But I think a lot of benefits of pineapple, pineapple can do a lot of different processed products, can also be used in multiple function."

The producer insisted on providing the green food to consumers, hence, he must speed up the logistics path from farm to consumer hands and he believed that he fitted to be the media of the platform. And his personal face book can be opened to consumers such as planted process, manufacturing process, product resume, validation information and others. The producer believed that the most suitable sales channel came from quickly communicating with consumers about product information.

The producer.

"I used the face book to operate my pineapple products business. Initially, face book provided the free resources to fans, but received money later. But, my individual face book group has never received money, so I decided to continue to use my own face book to operate."

*Innovation and Entrepreneurial Value*

The producer emphasized that the increasing customers mean the successful operation in network, and the regular customers are still the major power of business, he tried to pay more attention on new customers. However, how to keep the regular customers is still his most important service innovation business model.

The producer.
"I gave the priority, usually a week in advance, to send text messages to the regular customers, I think the regular customers are the root, and I need to take care of them. From the beginning, the regular customers still keep supporting me, so the regular customers are very important. And I did not care the amount of money from the regular customers, but was if or not ordered with me."

The customer-oriented producer considered that the regular customers are important sales objects. In 2016, the producer gave the priority, usually a week in advance, to send text messages to inform the regular customers sharing with the information about pre-order fresh pineapple or dry pineapple and the remaining to the new customers. The producer took advantage of network smoothly to enhance the value of his pineapple product, so he could

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complete the pre-order activities within 12 hours. The producer does believe that the product features could be the right choice for the customers.

The producer.

    "To force the correct approaches and meet the problems face to face and solve it. I have obtained the certification of credibility, such as MOA, of my products from the related department of National Cheng Kung University and the multiple residual analysis method -310 items from National Pingtung University of Science and Technology. Now my products have a stable quality, and also accumulated a group of loyal fans, but the related verifications still need to do, even if the overall cost is increased, I think it is necessary to create your own value and create new value for your

product.″

    The producer could share his pineapple cultivation process, product validation information, product resume and other information, which could enhance the support from the increasing consumer for his green food, through the network marketing. The producer does not intend to expand the cultivate area, therefore, to upgrade the product quality, to have a services innovation, and to have a stable quality are his major efforts.

## Conclusion

    The producer runs his business through the community website to order the products and deliver to consumers from the origin. He knows how to use the current media to build his business reputation without the physical stores. The producer uses the good quality pineapple to process for the

dried pineapple and pay his attention on process and health management, processing technology, preservation, transportation and packaging. The producer's pineapple business can bring benefits for him and more favorable ecological sustainable management.

    From Internet operation, the producer quickly sold out 12,000 kilograms of pineapple fruit and other processed products within 12 hours in September 2016 to his regular and new customers. The producer promotes the green food via informing consumers about his pineapple resume and qualified certificates. The producer actively establishes the mutual trust with customers in order to increase revenue performance.

    The producer's customer-oriented consumption creates the new value of the product, that is, the entrepreneurial value of the producer. In addition to, the producer knows how to seek technical support from government and academic groups to solve his problem. The studied showed that the constantly learning and applied the modern technology can solve the dilemma; green consumption can naturally become the mainstream of the future industry.

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# CREATING LOGISTICS ASSESSMENT FOR LOGISTICS BUSINESS BY USING A HYBRID MCDM MODEL

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## Abstract

Few studies have presented a holistic approach to evaluating complex performance assessment of logistics companies and proposed an improvement model. Therefore, the purpose of this article is to focus on strategies to reduce the gaps in performance caused by interdependence and feedback problems among dimensions and criteria to achieve the aspiration level. This study addresses this problem using the method of hybrid MCDM (multiple criteria decision making), including DEMATEL (decision-making trial and evaluation laboratory), DANP (the DEMATEL-based analytic network process) and VIKOR (VIšekriterijumsko KOmpromisno Rangiranje), to examine the influential relationships among dimensions and criteria of the empirical case and to ultimately present the best improvement schemes.

Key Words:  MCDM, DEMATEL, DANP, VIKOR, Balanced Scorecard

## Introduction

As freight volume grows and transportation becomes more complicated, the demand for logistics management rises. Meeting customer's

requirements demand and providing better service is one of the most important benefits of good logistics management. Superior logistics management is increasingly becoming a key factor in the success of any company's operations.

Logistics is the practice of moving resources from origin to destination as efficiently as possible. With the growing complexity of logistics management, companies need more expertise and advanced technology to improve processes. Improving customer service can bring a good commercial reputation, create process optimization, and cost saving in operations.

A hybrid Multiple Criteria Decision-Making (MCDM) can consider the methodology of multiple decision-attributes simultaneously with priority ranking and evaluation according to the feature/attribute of each alternative, thus helping decision-makers resolve practical problems when faced with limited feasible alternatives (Kleijnen, 2005). An empirical case of logistic company is presented to demonstrate the proposed model for improvement.

This study is different from previously research (Tzeng & Huang, 2011) to evaluate and improve the performance of logistics business's dimensions and criteria, which are interdependent for achieving the best alternative. The purpose is to develop a model that proposes a strategy for improving logistics policy implementation.

Design Theory and Literature Review

*Logistics*

Logistics is increasingly identified as a key element in modern supply chain management. Growth of global trade requires advanced solutions for manufacturers, suppliers, wholesalers, retailers and importer while the movement of physical objects and vital information need large streams of goods around the world (Dekker, et al., 2012).

The management and optimization of logistics has prospered due to innovation of information technology that allows the supply chain to operate more efficiently. Successful logistics management requires the selection and coordination of activities that optimize the overall process (Porporato, 2016).

*The Balanced Scorecard*

Organizations commonly assess achievements through performance evaluations to improve overall operating performance. However, oversimplified assessment indicators are frequently used because of insufficient information and limited resources, which results in distorted evaluation results (Steele et al., 2013). It successfully interprets the causal relationship between stakeholders, financial management, and leadership styles in the planning process of urban development strategies (Rasoolimanesh et al., 2015).

The balanced scorecard suggests that information is collected and analyzed from four perspectives of a business:

1. Financial perspective: For most businesses, this includes financial topics such as increasing sales revenue, saving operation expenses, minimizing costs, and expanding market share (Bhattacharya et al., 2014).

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2. Customer perspective: Elbanna et al. (2015) noted that customer satisfaction is the major goal for enterprises, because satisfied customers lead to satisfactory performance. Enterprises should take the initiative to understand their customers' true expectations.

3. Internal business process perspective: Enterprise management should provide a clear timetable for whoever implements the balanced scorecard, because an overall strategy blueprint allows the implementer more space to account for more perspectives (Johnson et al., 2014). Empirical studies have indicated that constant innovation of procedures is a source of competitiveness for enterprises.

4. Learning & growth perspective: The learning and growth dimensions are the foundation of the balanced scorecard, which can create long-term business growth and improvements (Hoque, 2014).

This research has reviewed the literature to develop an evaluation system for an example case and then confirm these important dimensions and criteria with pre-test questionnaires of experts. Finally, important dimensions and criteria are adopted for the questionnaire. The evaluation model, with the four dimensions, has twelve criteria to be selected in Table 1.

Table 1. Dimensions and Criteria for Evaluating the Balanced Scorecard of Logistics Company.

| Perspective | Criteria | Definition |
|---|---|---|
| Financial perspective ($D_1$) | Revenue ($C_1$) | Total sales revenue |
| | Cost control ($C_2$) | Lower unit costs, saving on business and personnel expenses |
| | Productivity ($C_3$) | Ratio of input to output |
| Customer perspective ($D_2$) | Market share ($C_4$) | Ratio of sales of services to total market demand |
| | Customer satisfaction ($C_5$) | Customer satisfaction with services |
| | Customer retention ($C_6$) | Rate of maintaining or keep contacting existing customers |
| Internal business process perspective ($D_3$) | Distribution capability ($C_7$) | Delivery time must be punctual |
| | Innovation process ($C_8$) | Regularly review procedures to respond to market and customer demands |
| | After-sales service ($C_9$) | Track customer satisfaction, respond to customer suggestions, and improve procedures |
| Learning & growth perspective ($D_4$) | Staff motivation ($C_{10}$) | Authorization and reward system |
| | Staff quality ($C_{11}$) | Staff are given regular educational training and encouraged to participate in on-the-job training |
| | Staff retention ($C_{12}$) | Employees' desire to stay |

## Method

This study aimed to build a hybrid MCDM technique and combines a DANP with a VIKOR. The DEMATEL technique is used to build an influential network relations map (INRM), and DANP is expected to obtain the influential weights using the basic concept of Analytic Network Process (ANP). Then, it is possible to determine how to reduce the gaps to achieve the aspiration level. Finally, VIKOR is used to evaluate the total performance of Corporation L by performance values and gaps.

### DANP

The DANP is an appropriate tool to include interaction and interdependence among the dimensions and criteria that appear in the cases of real world problems (Saaty, 1996). The methodology can verify the interdependence of variables and attributes, building a relationship that reflects those characteristics with an essential system and evolutionary trend (Lu et al., 2013).

### DEMATEL for building an INRM

DEMATEL uses matrix and related math theories to calculate the cause and effect on each element (Gabus and Fontela, 1972; Tzeng et al., 2007). The method employed can be summarized as follows:

Step 1: Calculate the direct relation matrix by scores. An assessment of the relationship between each mutual influence criterion is made according to the opinions of experts, using a scale ranging from 0 to 4. The experts are required to indicate the direct influence by a pairwise comparison, and if they believe that criterion $i$ has an effect and influence on criterion $j$, they should indicate this by $a_{ij}$. Thus, the initial average matrix $A$ ($A = \begin{bmatrix} a_{ij} \end{bmatrix}_{n \times n}$) of direct relations can be obtained.

Step 2: Normalize the initial average matrix $A$. The normalized influence matrix $X$ is acquired by using Eqs. (1) and (2). Its diagonal is zero, and the maximum sum of rows or columns is one.

$$X = A/s \qquad (1)$$

$$s = \max \left[ \max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}, \max_{1 \le j \le n} \sum_{i=1}^{n} a_{ij} \right] \quad (2)$$

Step 3: Attain a total influence matrix $T$. When the normalized influence matrix $X$ is obtained, the total influence matrix $T$ of the INRM can be obtained from Eq. (3), in which I denotes the identity matrix.

$$T = X + X^2 + X^3 + \cdots + X^h$$
$$= X(I - X)^{-1} \qquad (3)$$
$$as \ h \to \infty, \ X^h = \begin{bmatrix} 0 \end{bmatrix}_{n \times n}$$

Step 4: Analyze the results. By using Eqs. (4), (5) and (6), the row sum and the column sum of the matrix T are expressed as vector $r_i$ and $s_i$, respectively. Furthermore, $(r_i + s_i)$ provides an index of the strength of the influences that are given and received. When $(r_i - s_i)$ is positive, factor $i$ has more influence on other factors. However, if $(r_i - s_i)$ is negative, other factors have more impacts on factor $i$.

$$T = \begin{bmatrix} t_{ij} \end{bmatrix}_{n \times n}, i, j = 1, 2, .., n \qquad (4)$$

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$$r = \left[ \sum\nolimits_{j=1}^{n} t_{ij} \right]'_{n \times 1} = \left[ t_i \right]'_{n \times 1} \qquad (5)$$

$$s = \left[ \sum\nolimits_{i=1}^{n} t_{ij} \right]'_{1 \times n} = \left[ t_j \right]'_{1 \times n} \qquad (6)$$

*DANP for finding the influential weights in each criterion*

The DANP method consists of the followings:

Step 1: The total influence matrix $T_c$ for the criteria is shown as Eq. (7). The normalized total influence matrix $T_c^\alpha$ for the criteria is shown as Eq. (8).

$$T_c = D_i \begin{array}{c} c_{11} \\ \vdots \\ c_{1m_1} \\ c_{i1} \\ \vdots \\ c_{im_i} \\ c_{n1} \\ \vdots \\ c_{nm_n} \end{array} \begin{bmatrix} T_c^{11} & \cdots & T_c^{1j} & \cdots & T_c^{1n} \\ \vdots & & \vdots & & \vdots \\ T_c^{i1} & \cdots & T_c^{ij} & \cdots & T_c^{in} \\ \vdots & & \vdots & & \vdots \\ T_c^{n1} & \cdots & T_c^{nj} & \cdots & T_c^{nn} \end{bmatrix} \qquad (7)$$

$$T_c^\alpha = D_i \begin{array}{c} c_{11} \\ \vdots \\ c_{1m_1} \\ c_{i1} \\ \vdots \\ c_{im_i} \\ c_{n1} \\ \vdots \\ c_{nm_n} \end{array} \begin{bmatrix} T_c^{\alpha 11} & \cdots & T_c^{\alpha 1j} & \cdots & T_c^{\alpha 1n} \\ \vdots & & \vdots & & \vdots \\ T_c^{\alpha i1} & \cdots & T_c^{\alpha ij} & \cdots & T_c^{\alpha in} \\ \vdots & & \vdots & & \vdots \\ T_c^{\alpha n1} & \cdots & T_c^{\alpha nj} & \cdots & T_c^{\alpha nn} \end{bmatrix} \qquad (8)$$

Step 2: The unweighted supermatrix $W$ can be obtained by transposing $T_c^\alpha$ as in Eq. (9).

$$W = \left( T_c^\alpha \right)^* = D_i \begin{bmatrix} W^{11} & \cdots & W^{j1} & \cdots & W^{n1} \\ \vdots & & \vdots & & \vdots \\ W^{1j} & \cdots & W^{jj} & \cdots & W^{nj} \\ \vdots & & \vdots & & \vdots \\ W^{1n} & \cdots & W^{jn} & \cdots & W^{nn} \end{bmatrix} \qquad (9)$$

Step 3: The normalized total influence matrix $T_D^\alpha$ can be obtained by normalizing the total influence matrix $T_D$ of the dimensions, as shown from Eq. (10) to Eq. (12).

$$T_D = \begin{bmatrix} t_D^{11} & \cdots & t_D^{1j} & \cdots & t_D^{1n} \\ \vdots & & \vdots & & \vdots \\ t_D^{i1} & \cdots & t_D^{ij} & \cdots & t_D^{in} \\ \vdots & & \vdots & & \vdots \\ t_D^{n1} & \cdots & t_D^{nj} & \cdots & t_D^{nn} \end{bmatrix} \qquad (10)$$

$$d_i = \sum\nolimits_{j=1}^{n} t_D^{ij}, i = 1,2,..,n \qquad (11)$$

$$T_D^\alpha = \begin{bmatrix} t_D^{11}/d_1 & \cdots & t_D^{1j}/d_1 & \cdots & t_D^{1n}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_D^{i1}/d_i & \cdots & t_D^{ij}/d_i & \cdots & t_D^{in}/d_i \\ \vdots & & \vdots & & \vdots \\ t_D^{n1}/d_n & \cdots & t_D^{n1}/d_n & \cdots & t_D^{nn}/d_n \end{bmatrix} \qquad (12)$$

Step 4: $T_D^\alpha$ is multiplied by $W$ to obtain the weighted supermatrix $W^\alpha$, as shown in Eq. (13).

$$W^\alpha = T_D^\alpha W = \begin{bmatrix} t_D^{\alpha 11} \times W^{11} & \cdots & t_D^{\alpha i1} \times W^{i1} & \cdots & t_D^{\alpha n1} \times W^{n1} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1j} \times W^{1j} & \cdots & t_D^{\alpha ij} \times W^{ij} & \cdots & t_D^{\alpha nj} \times W^{nj} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1n} \times W^{1n} & \cdots & t_D^{\alpha in} \times W^{in} & \cdots & t_D^{\alpha nn} \times W^{nn} \end{bmatrix} \qquad (13)$$

Step 5: The weighted supermatrix $W^\alpha$ is multiplied by itself multiple times to obtain the limit supermatrix.

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That is, the DANP weights of each criterion can be obtained by $\lim_{k \to \infty} \left( W^\alpha \right)^k$, where $k$ represents any number for power.

## VIKOR

The VIKOR method was developed for the multi-criteria optimization of complex systems. It introduces a multi-criteria ranking index based on the particular measure of "closeness" to the "ideal" solution. This study focuses on modifying this method to the aspiration level and knowing how to improve and create management strategies. The VIKOR can be divided into the following steps (Opricovic, 1998; Shen, et al., 2014).

Step 1: The positive-ideal solution $x_i^*$ and negative-ideal solution $x_i^-$ are obtained through Eq. (14) and Eq. (15), respectively.

$$x_i^* = \max x_i \qquad (14)$$

$$x_i^- = \min x_i \qquad (15)$$

Step 2: The individual gaps of the criteria are obtained by using Eq. (16).

$$gap = w_i \left( x_i^* - x_i \right) / \left( x_i^* - x_i^- \right) \qquad (16)$$

This paper seeks to combine the influential weights of the DANP with the VIKOR method to determine how to minimize the average gap and prioritize improvement in the maximum gap overall and in each dimension based on the INRM by the DEMATEL technique. Thus, this study focuses on how to improve and reduce the performance gaps to achieve the aspiration level based on INRM.

## Application of the Model to Empirical Case

A. Background and Problem Description

As an example case, Corporation L has dedicated its efforts to provide freight logistics service in Taiwan. Corporation L faced critical problem regarding the delivery quality and the high rate of staff turnover. This study evaluates and improves the performance of this corporation by using the hybrid MCDM model combining DANP with VIKOR.

B. Data Collection

The data in this study were collected from 17 experts with professional management and decision-making experiences in the logistics industry. All the experts, including general manager, senior supervisors, professors, had worked or conducted research in the logistics industry more than ten years, and their responses were collected via personal interviews.

C. Data Analysis

(a)The relationship among dimensions and criteria to build the INRM

The normalized influence matrix $X$ is calculated by using Eqs. (1) and (2). Then, the total influence matrix $T$ can be derived by using Eq. (3), as shown in Tables 2. By using Eqs. (4), (5) and (6), the results of the criteria analysis according to each dimension and criterion can be summarized, as shown in Table 3. Then, the INRM of the DEMATEL technique can be obtained as shown in Fig. 1.

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(b)Influential weights of criteria

The DANP method was applied to obtain the influential weights of the criteria. The unweighted supermatrix $W$ (Table 4) is the transpose matrix of $T_c^{\alpha}$. The weighted supermatraix $W^{\alpha}$ (Table 5) can be obtained by using Eqs. (7)-(13). The influential weights of DANP can be obtained by limiting the power of $W^{\alpha}$ until it reaches a steady-state (Table 6).

(c)Using the method to evaluate logistics management performance and gaps

The global influential weights and local influential weights of the dimensions/criteria are obtained based on the influential weights of DANP, which is followed by combining the DANP with the VIKOR method to obtain the average performance scores of logistics Corporation L.

Table 2. Total Influence Matrix $T$

| A | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ | $C_{10}$ | $C_{11}$ | $C_{12}$ |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|----------|----------|
| $C_1$ | 0.504 | 0.496 | 0.505 | 0.552 | 0.551 | 0.554 | 0.511 | 0.484 | 0.473 | 0.464 | 0.472 | 0.438 |
| $C_2$ | 0.528 | 0.362 | 0.462 | 0.471 | 0.493 | 0.487 | 0.463 | 0.418 | 0.422 | 0.415 | 0.409 | 0.386 |
| $C_3$ | 0.579 | 0.489 | 0.412 | 0.526 | 0.544 | 0.535 | 0.535 | 0.464 | 0.456 | 0.454 | 0.439 | 0.421 |
| $C_4$ | 0.576 | 0.442 | 0.445 | 0.436 | 0.527 | 0.522 | 0.484 | 0.443 | 0.450 | 0.429 | 0.427 | 0.399 |
| $C_5$ | 0.580 | 0.455 | 0.468 | 0.555 | 0.473 | 0.571 | 0.502 | 0.467 | 0.480 | 0.434 | 0.454 | 0.415 |
| $C_6$ | 0.616 | 0.487 | 0.505 | 0.582 | 0.597 | 0.494 | 0.543 | 0.500 | 0.503 | 0.466 | 0.467 | 0.441 |
| $C_7$ | 0.568 | 0.460 | 0.475 | 0.544 | 0.561 | 0.555 | 0.427 | 0.464 | 0.452 | 0.431 | 0.434 | 0.403 |
| $C_8$ | 0.566 | 0.469 | 0.484 | 0.532 | 0.559 | 0.546 | 0.510 | 0.394 | 0.460 | 0.426 | 0.437 | 0.400 |
| $C_9$ | 0.519 | 0.410 | 0.428 | 0.494 | 0.514 | 0.509 | 0.446 | 0.416 | 0.354 | 0.382 | 0.390 | 0.355 |
| $C_{10}$ | 0.519 | 0.422 | 0.442 | 0.474 | 0.504 | 0.488 | 0.453 | 0.436 | 0.422 | 0.348 | 0.430 | 0.422 |
| $C_{11}$ | 0.529 | 0.433 | 0.458 | 0.496 | 0.533 | 0.517 | 0.483 | 0.459 | 0.438 | 0.429 | 0.362 | 0.417 |
| $C_{12}$ | 0.549 | 0.452 | 0.474 | 0.492 | 0.515 | 0.504 | 0.481 | 0.444 | 0.436 | 0.441 | 0.433 | 0.341 |

Table 3. The Results of the Criteria Analysis

| Dimension/Criteria | $r_i$ | $s_i$ | $r_i + s_i$ | $r_i - s_i$ |
|--------------------|-------|-------|-------------|-------------|
| **Financial perspective ($D_1$)** | **1.909** | **1.952** | **3.861** | **-0.044** |
| Revenue ($C_1$) | 6.005 | 6.634 | 12.639 | -0.629 |
| Cost control ($C_2$) | 5.317 | 5.377 | 10.694 | -0.061 |
| Productivity ($C_3$) | 5.855 | 5.560 | 11.414 | 0.295 |
| **Customer perspective ($D_2$)** | **1.960** | **2.090** | **4.049** | **-0.130** |
| Market share ($C_4$) | 5.579 | 6.155 | 11.735 | -0.576 |
| Customer satisfaction ($C_5$) | 5.855 | 6.371 | 12.226 | -0.517 |
| Customer retention ($C_6$) | 6.202 | 6.283 | 12.485 | -0.081 |
| **Internal business process perspective ($D_3$)** | **1.864** | **1.842** | **3.706** | **0.022** |
| Distribution capability ($C_7$) | 5.774 | 5.839 | 11.614 | -0.065 |
| Innovation process ($C_8$) | 5.785 | 5.391 | 11.176 | 0.393 |
| After-sales service ($C_9$) | 5.218 | 5.345 | 10.563 | -0.128 |
| **Learning & growth perspective ($D_4$)** | **1.831** | **1.679** | **3.510** | **0.152** |
| Staff motivation ($C_{10}$) | 5.362 | 5.119 | 10.481 | 0.243 |
| Staff quality ($C_{11}$) | 5.555 | 5.155 | 10.709 | 0.400 |
| Staff retention ($C_{12}$) | 5.562 | 4.838 | 10.400 | 0.724 |
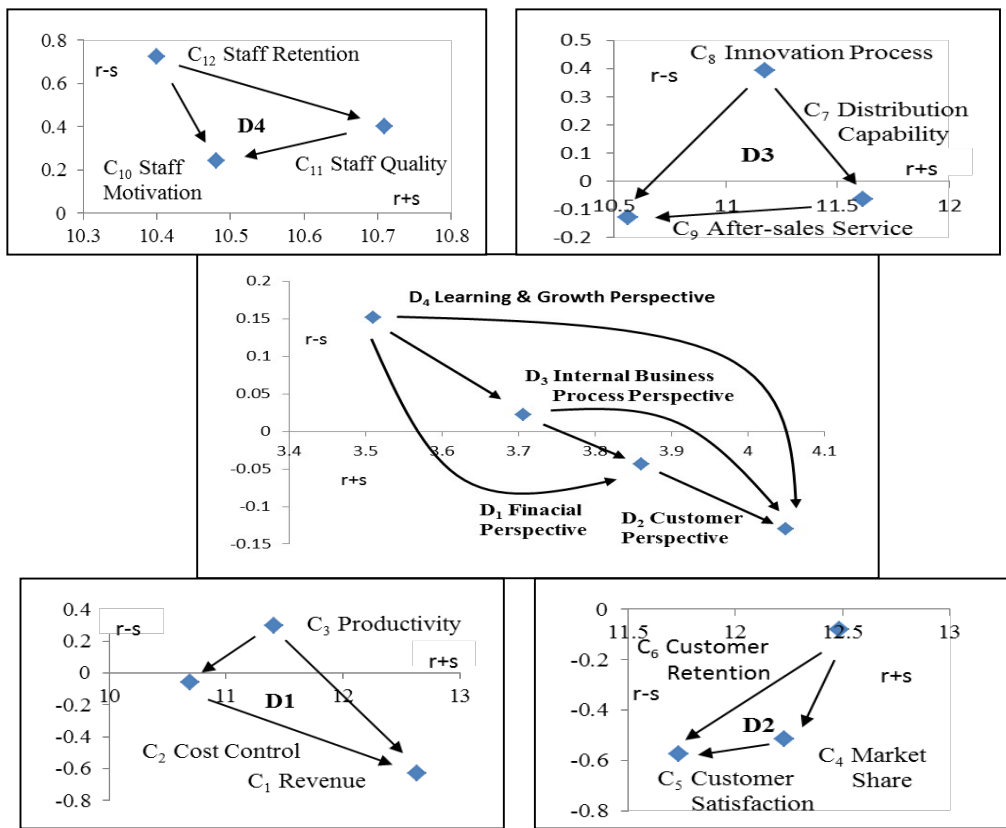
Figure 1. The Influential Network Relation Map of 12 Criteria within 4 Dimensions

Table 4. Unweighted Supermatrix $W$

| A | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ | $C_{10}$ | $C_{11}$ | $C_{12}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_1$ | 0.335 | 0.391 | 0.391 | 0.394 | 0.386 | 0.383 | 0.378 | 0.373 | 0.383 | 0.375 | 0.373 | 0.372 |
| $C_2$ | 0.330 | 0.268 | 0.330 | 0.302 | 0.303 | 0.303 | 0.306 | 0.309 | 0.302 | 0.305 | 0.305 | 0.306 |
| $C_3$ | 0.335 | 0.341 | 0.279 | 0.304 | 0.312 | 0.314 | 0.316 | 0.319 | 0.316 | 0.320 | 0.323 | 0.322 |
| $C_4$ | 0.333 | 0.325 | 0.328 | 0.294 | 0.347 | 0.348 | 0.328 | 0.325 | 0.326 | 0.323 | 0.321 | 0.326 |
| $C_5$ | 0.333 | 0.340 | 0.339 | 0.355 | 0.296 | 0.357 | 0.338 | 0.341 | 0.339 | 0.344 | 0.345 | 0.341 |
| $C_6$ | 0.334 | 0.336 | 0.333 | 0.351 | 0.357 | 0.295 | 0.334 | 0.333 | 0.336 | 0.333 | 0.334 | 0.333 |
| $C_7$ | 0.348 | 0.356 | 0.368 | 0.351 | 0.347 | 0.351 | 0.318 | 0.374 | 0.367 | 0.346 | 0.350 | 0.353 |
| $C_8$ | 0.330 | 0.321 | 0.319 | 0.322 | 0.322 | 0.324 | 0.346 | 0.289 | 0.342 | 0.332 | 0.333 | 0.327 |
| $C_9$ | 0.322 | 0.324 | 0.313 | 0.327 | 0.331 | 0.325 | 0.336 | 0.337 | 0.291 | 0.322 | 0.318 | 0.320 |
| $C_{10}$ | 0.338 | 0.343 | 0.346 | 0.342 | 0.333 | 0.339 | 0.340 | 0.337 | 0.339 | 0.290 | 0.355 | 0.363 |
| $C_{11}$ | 0.343 | 0.338 | 0.334 | 0.340 | 0.349 | 0.340 | 0.342 | 0.346 | 0.346 | 0.359 | 0.300 | 0.356 |
| $C_{12}$ | 0.319 | 0.319 | 0.320 | 0.318 | 0.319 | 0.321 | 0.318 | 0.317 | 0.315 | 0.351 | 0.345 | 0.281 |

Table 5. Weighted supermatrix $W^\alpha$

| A | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ | $C_{10}$ | $C_{11}$ | $C_{12}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_1$ | 0.085 | 0.099 | 0.099 | 0.102 | 0.100 | 0.099 | 0.099 | 0.097 | 0.100 | 0.097 | 0.097 | 0.097 |
| $C_2$ | 0.083 | 0.068 | 0.083 | 0.078 | 0.079 | 0.079 | 0.080 | 0.081 | 0.079 | 0.079 | 0.079 | 0.079 |
| $C_3$ | 0.085 | 0.086 | 0.070 | 0.079 | 0.081 | 0.081 | 0.083 | 0.083 | 0.082 | 0.083 | 0.084 | 0.083 |
| $C_4$ | 0.091 | 0.089 | 0.090 | 0.079 | 0.094 | 0.094 | 0.094 | 0.093 | 0.093 | 0.089 | 0.088 | 0.089 |
| $C_5$ | 0.091 | 0.093 | 0.093 | 0.096 | 0.080 | 0.096 | 0.097 | 0.098 | 0.097 | 0.094 | 0.095 | 0.094 |
| $C_6$ | 0.092 | 0.092 | 0.092 | 0.095 | 0.096 | 0.080 | 0.096 | 0.096 | 0.096 | 0.091 | 0.092 | 0.092 |
| $C_7$ | 0.086 | 0.088 | 0.090 | 0.087 | 0.086 | 0.087 | 0.074 | 0.087 | 0.086 | 0.085 | 0.086 | 0.087 |
| $C_8$ | 0.081 | 0.079 | 0.079 | 0.080 | 0.080 | 0.080 | 0.081 | 0.068 | 0.080 | 0.082 | 0.082 | 0.080 |
| $C_9$ | 0.079 | 0.080 | 0.077 | 0.081 | 0.082 | 0.081 | 0.079 | 0.079 | 0.068 | 0.079 | 0.078 | 0.079 |
| $C_{10}$ | 0.077 | 0.078 | 0.078 | 0.076 | 0.074 | 0.076 | 0.074 | 0.074 | 0.074 | 0.064 | 0.078 | 0.080 |
| $C_{11}$ | 0.078 | 0.077 | 0.076 | 0.076 | 0.078 | 0.076 | 0.075 | 0.075 | 0.075 | 0.079 | 0.066 | 0.078 |
| $C_{12}$ | 0.072 | 0.072 | 0.073 | 0.071 | 0.071 | 0.072 | 0.069 | 0.069 | 0.069 | 0.077 | 0.076 | 0.062 |

Table 6. The Influential weights of DANP

| Criteria | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ | $C_{10}$ | $C_{11}$ | $C_{12}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| weights | 0.097 | 0.079 | 0.082 | 0.090 | 0.093 | 0.092 | 0.086 | 0.079 | 0.079 | 0.075 | 0.076 | 0.071 |

Table 7. Gap values combined with the influential weights of the criteria according to the DANP

| Dimension/Criteria | Local weight (based on DANP) | Global weight (DANP) | Gaps (by VIKOR) |
|---|---|---|---|
| **Financial perspective (D₁)** | **0.258** | | **0.026** |
| Revenue ($C_1$) | 0.377 | 0.097 | 0.037 |
| Cost control ($C_2$) | 0.306 | 0.079 | 0.020 |
| Productivity ($C_3$) | 0.317 | 0.082 | 0.020 |
| **Customer perspective (D₂)** | **0.276** | | **0.046** |
| Market share ($C_4$) | 0.327 | 0.090 | 0.045 |
| Customer satisfaction ($C_5$) | 0.338 | 0.093 | 0.031 |
| Customer retention ($C_6$) | 0.334 | 0.092 | 0.023 |
| **Internal business process perspective (D₃)** | **0.244** | | **0.027** |
| Distribution capability ($C_7$) | 0.352 | 0.086 | 0.029 |
| Innovation process ($C_8$) | 0.325 | 0.079 | 0.026 |
| After-sales service ($C_9$) | 0.323 | 0.079 | 0.026 |
| **Learning & growth perspective (D₄)** | **0.222** | | **0.038** |
| Staff motivation ($C_{10}$) | 0.339 | 0.075 | 0.038 |
| Staff quality ($C_{11}$) | 0.341 | 0.076 | 0.038 |
| Staff retention ($C_{12}$) | 0.320 | 0.071 | 0.039 |

## Results and Discussions

According to the empirical case, the proposed hybrid MCDM model could provide the interdependence and feedback relationship of dimensions and criteria used for performance improvement. Some findings are obtained as follows:

(a) From INRM in Fig. 1, learning & growth perspective ($D_4$), the most influential dimension, is the highest priority for improvement. Also, with respect to learning & growth perspective ($D_4$), staff retention ($C_{12}$) is the most influential criterion and should be improved upon first, followed by staff motivation ($C_{10}$) and staff quality ($C_{11}$).

(b) According to the results of the VIKOR, the hybrid MCDM model can be used to analyze the gaps of aspired level for the company L's performance. The dimension of customer perspective ($D_2$), with the largest gap value (0.046), should be the first priority for improvement. Furthermore, INRM indi-cates that customer perspective ($D_2$) is highly influenced by Learning & growth perspective ($D_4$), also with the second largest gap value (0.038). Therefore, the criteria of staff retention ($C_{12}$) will be considered the first priority improvement for decision makers attempting to achieve the desired level

## Conclusions

This study used the hybrid MCDM model (DEMATEL, DANP, and VIKOR) to develop improvement solutions. These findings can assist Corporation L management in using strategic planning to reduce the rate of staff turnover in order to gain competitive advantages. This study demonstrates how the necessary behaviors can be improved or how to reach the desired performance by identifying the key criteria for decision-making and finding the best way to improve the existing problem of staff turnover.

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