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Full Length Research Paper

Multi-criteria decision making of brand innovation

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With the transition of globalization, competition among corporations has intensified due to the advancement of information technology (IT) and logistics. Taiwan has lost its competitive advantage of low cost owing to the rise of Brazil, Russia, India, and China (BRICs), the low production costs in these countries and the lack of natural resources in Taiwan itself. Therefore, Taiwan's industrial structure should reform towards the higher added-value intellectual industry. In this research, we intend to find the key success factors for corporations to carry out brand innovation and hence act as a reference for future management strategy. We combine decision making trial and evaluation laboratory (DEMATAL) with analytic network process (DANP) to identify the important factors for brand innovation, sorted according to their relative importance. The result shows that the frequency of new product introductions, management skill, and the rate of the introduction of new products are the most important factors. The production process, production skill and equipment function, meanwhile, have less effect on brand innovation.

Key words: Brand, innovation, key success factors (KSF), decision making trial and evaluation laboratory (DEMATAL), analytic network process (DANP).

INTRODUCTION

Taiwan lacks the competitive advantages that natural resources can bring. Furthermore, with the rapid development of information and logistics' technologies and the rise of BRICs, which are famous for their low production costs, Taiwan has lost its low cost advantages in such a liberalized, internationalized, and competitive environment. Thus, Taiwan's industrial structure has transformed from original equipment manufacturers (OEM) style, which is mostly labor-intensive, to high value added intellectual industries.

Foreign affairs columnist Thomas Friedman (1995) of the New York Times noted that Taiwan is a pioneer in IT. Under current global competition of green energy, Taiwan should speed up its pace in developing energy technology (ET). As the issues of climate change, energy depletion, and rapid population growth rise, human beings' desire in build up the green energy industry to help save energy and protect the environment has appeared. Therefore, Taiwan should speed up its development of the ET industry. In this regard, the Taiwanese government has positively planned the development of the ET industry. For example, from 2010 to 2016, Taiwan has practiced the plan of "the development strategy and action plan of intelligent electric vehicles," which is the first step of four major plans focusing on the emerging intelligent industries and lead by Executive Yuan of Taiwan.

Porter (1990) has initiated his competition research by studying successful industries within 10 different countries in the world and concluded that, the key success factors are in short "continuous innovation". Peter Drucker (1985) indicated that "to stop innovation means extinction". The economist Paul Krugman (1995) even mentioned that the critical elements that lead a country to go a step further in entering the next century are originality, creativity, imagination and real entrepreneurship. Under various types of pressures and challenges, Taiwan should positively adjust its direction towards innovation in order to achieve the goal of

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Sustainable management. Therefore, by confronting the current management issues aforementioned, the purpose of this study is to explore the key success factors of brand innovation and find the factors that enterprises should lay emphasis on while proceeding with their brand innovation.

The majority of the literature on innovation has adopted the analytic hierarchy process (AHP). However, less of the literature has looked into the significance and correlations between factors. Therefore, this study utilized decision making trial and evaluation laboratory (DEMATEL), combined with ANP (named DANP), to explore the weighted significance of each factor for the study of brand innovation.

In accordance with the research background and goal of this study, we have delineated our research purpose of this paper as follows:

1. To explore the key success factors for brand innovation.
2. To define the relatively weighted significance and priorities of key success factors.
3. To build up the relative significance of brand innovation so that enterprises have additional materials for reference.

LITERATURE REVIEW

Brand

Brand development is the current developing trend of the world which is the focus of much attention. As the brand is the critical bridge between customers and enterprises, enterprises can market their products and services via the brand and thus distinguish themselves from competitors. The brand enhances the corporate identity system and becomes one critical element that induces customers to make purchase decisions.

The American Marketing Association (AMA) (1960) defined brand as a name, term, sign, symbol, design, or a combination of these which distinguish sellers' products and services. The brand makes the products and services of the firm distinct from competitors (Aaker, 1991; Upshaw, 1995).

The controller of the International Brand Management Company, inter-brand, Kotler and Keller (2008) suggested that, a brand is a firm's consistent commitment to their consumers and provides a parcel of products' characters, benefits, and services to customers. Brand distributes six meanings to customers:

1. Attribute, which is the first impression that the brand brings to the customers.
2. Benefit: A brand contains different attributes. However, the customers aim to purchase "benefits." Thus, the attribute of the brand should be transformed into functional or emotional benefits for customers.
3. Value: A brand can deliver the value of the products to customers and reflects the values of the customers.
4. Culture: the brand represents the culture traits of the manufacturers or the countries of origin.
5. Personality: The brand frequently delivers the character of their products via persons of reputation.
6. User: Through customers' utilization of different brands, we can infer the types of customers.

Based on literature review regarding the definitions of brand, this study defines brand as a symbol of an enterprise, which can be a name and a sign, or factors which distinguish between the enterprise and its competitors, as well as the reference for customers when making purchase decisions. Also, brand is a commitment of the enterprise to its customers; customers can express their self-images and value systems and recognize their distinctions with others via purchasing products which are attached to certain symbols.

Innovation

Definition of innovation

The word innovation can be sourced from the economist of the classical school, Schumpeter. Schumpeter (1934) conceived that innovation is the new constitution of the production elements, and suggested that the ways and concepts of innovation include new products, new production methods, new markets, new resources, new development and the introduction of industrial organizations.

Drucker (1985) defined innovation as a new competence in creating wealth via resources and making resources become real "resources". Drucker (1985) proposed seven major sources of opportunities for innovation:

(i) Unexpected events
(ii) Inconsistent situations
(iii) Procedure needs;
(iv) Sudden changes of industrial or market structures;
(v) Changes of population structure;
(vi) Changes on the cognition, emotion, and meanings;
(vii) New knowledge – both scientific and non-scientific.

Innovation is for solving operation issues and creating or bringing in new things (new methods, technology, products, or service) with the expectation of hitting the performance target, in order to carry out substantial business values for for-profit business organizations or a social contribution for non-profit organizations.

Mol and Birkinshaw (2009) defined innovation as achieving the goal of the firm, increasing the firm's performance and adopting new management methods. Chalhoub (2010) considered that, the surplus of an

enterprise's performance is added on the part of innovation involving firm culture, system, and manufacturing procedure.

Based on the result of the literature review, we can see that most researchers have consistent expressions on the goal of innovation which is the increase in firm performance. Firms innovate and update their existing systems, products and services in order to maximize the profit and performance of the firm or the benefit of employees and thus ensure the sustainable growth and operation of the firm.

Types of innovation

The research scope of innovation has been wide. Innovation can be explored from a variety of perspectives. For investigating its determinants and innovation behaviors, many researchers have categorized innovations into different types. But the categorization results are different owing to the distinct perspectives and research of scholars. As follows are the types of innovation which are consistent with our research goal.

Knight (1967) indicated that there are four types of innovation:

Product or service innovation: The production of new products or sales of new services.

Production procedures' innovation: The innovation that takes place during the process of the job task and decision making, innovation of the information system, or new elements and new methods adopted for the production procedure or in technology management.

Innovation of organizational structure: The changes of job assignment, reward system, and communication systems between different business units and management level.

Staff innovation: The changes of the personnel structure, or transformation of employees' behaviors and beliefs within the organization.

Daft (1978) indicated that there are two types of innovation: One is the innovation of the management structure including innovative strategies and innovation of the components of organizational structure. The other is technological innovation, including the innovations of products, technologies, production procedure and so on.

Betz (1987) recognizes the distinction between technological innovations as follows:

Product innovation: Introduces new type of products into the market.

Procedure innovation: Induces a new technological production procedure into the firm or the market.

Service innovation: Introduces technology-based services into the market.

Chacke (1988) categorized innovation into three types.

Product innovation: Representing new products.

Procedure innovation: The new production methods.

Organizational innovation: New managerial skills or new organizational structure.

While investigating the high-technology manufacturers in Taiwan, Chuang (2005) divided technological innovation into product innovation and production procedure innovation respectively, categorized management innovation into staff innovation, marketing innovation and innovation of organizational structure and used these elements as constructs for exploration.

RESEARCH METHODS

Research framework

The research framework is formed in accordance with the literature review results mentioned above. As the reviewing results indicate that the types of innovation will affect the brand innovation of enterprises, we first processed the weighted and comparative analysis and assessment on relevant constructs. Figure 1 shows the research framework of this study in summary.

Questionnaire design and data collection

Table 1 is the organization of the determinants of brand innovation in accordance with the review results of the literature. There are five dimensions and 15 criteria in total as listed.

This research utilized Microsoft Office Excel 200 for data analysis and turned the analytical results, the assessment criteria for brand innovation, into a table. Afterwards, the authors used the questionnaires to proceed to a one on one interview with professionals and scholars. Those professionals have backgrounds in brand and innovation such as brand and innovation managers or researchers who have focused on the study of innovation management. Table 2 shows the demographic information of the professionals and scholars.

DEMATEL

DEMATEL helps us to effectively understand complicated causal relationships and effect levels between variables. It uses matrix and mathematical theories to work out the causal relationships between the overall factors and the strength of the relationships in between. The application of DEMATEL has been wide, including planning and decision making of enterprises, urban planning and design, assessment of geographical environment, group analysis on the global issues and so on.

There are three fundamental assumptions of DEMATEL:

1. The nature of the problem has to be clear: During the stage of formation of the problem and planning, researchers have to clearly understand the nature of the research question in order to accurately set up the target problem for solving.

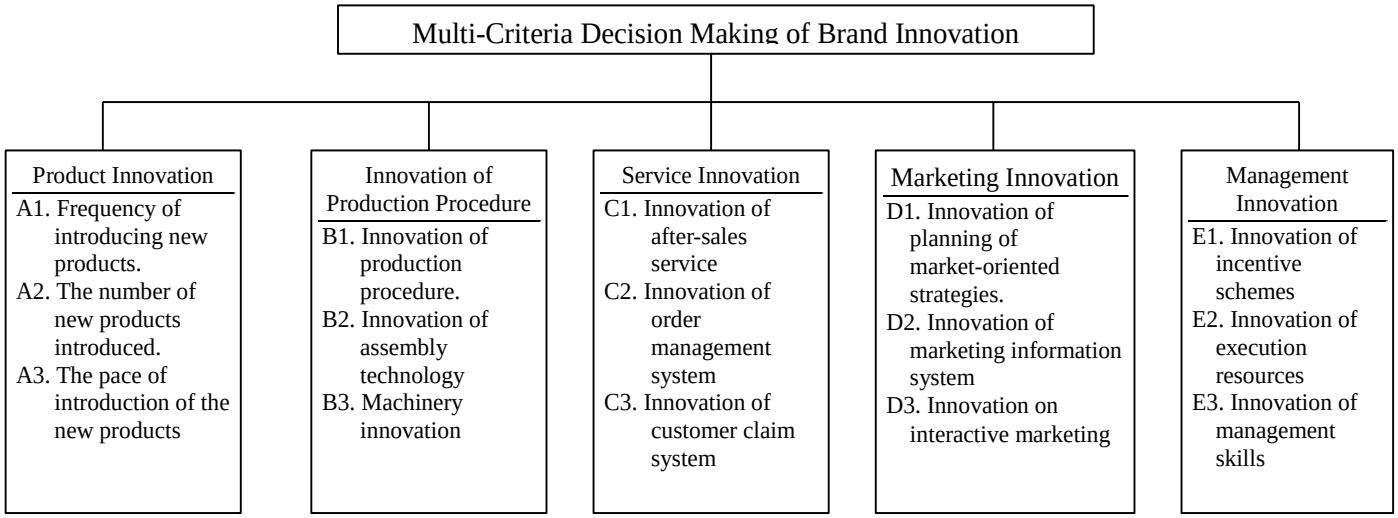

Figure 1. The research framework.

2. The correlations between problems have to be accurately clarified. Starting from each element of the question, the correlations between these elements have to be present and to use 0, 1, 2, 3, and 4 to represent the strength of the correlations.
3. The features of these elements have to be well comprehended. For each element of the questions, the researchers, after analysis, need to supplement them with additional explanations.
The analytical steps of DEMATEL are described as follows:

Finding out the mean matrix

If there is R number of professionals and factors, each professional was requested to indicate factor i's impact level on factor j. The two factors come into a Pairwise Comparison Matrix a_{ij}, and the correlations in between were indicated by 0 as no effect, 1 as low effect, 2 as middle effect, 3 as high effect, and 4 as extremely high effect. The values recommended by those professionals then formed a $n \times n$ non-negative matrix $X^k = \left[X_{ij}^k\right]$, $1 \le k \le R$; that is, $X^1, X^2, ..., X^R$ represent every non-negative matrix of each professional. Each element x_{ij}^k within X^k is an integer; the answers of diagonal element in the answer matrix $\boldsymbol{X}^k$ is set up as 0. Therefore, we can work out the $n \times n$ mean matrix **A** for the number of R professionals. Equation 1 is the computation formula.

$$a_{ij} = \frac{1}{R}\sum_{k=1}^{R} x_{ij}^k \tag{1}$$

The mean matrix **A** = [a_{ij}] can also be named as a direct-relation matrix; **A** represents the factors and their primary effects and relationships on and with other factors. In addition, the figure of the dire-relation can be drawn via the causal relations between each pair of factors.

Computation of the standardized direct-relation matrix

The standardized direct-relation matrix **D** is achieved via the mean matrix **A**. Equation 2 is the computation formula.

To make
$$s = \max\left(\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}, \max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}\right) \tag{2}$$

To make
$$\boldsymbol{D} = \frac{\boldsymbol{A}}{s} \tag{3}$$

The grand total of each row in **A** matrix j stands for factor i's total direct effects on other factors. And $\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}$, stands for its maximum total effects on other factors. The grand total of each column i in matrix **A** stands for factor i's total effects on other factors. $\max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}$ also stands for its maximum total effects on other factors. s is the upper limit that was employed by the authors, and is the larger value. Matrix **D** is achieved via s's distinguishing each factor of matrix A. Each element in matrix **D**, d_{ij} is between 0 and 0.99.

Computation of the total-relation matrix

The indirect effect between each element will decrease as the power increases. For example, the guaranteed closed form solution is an inverse matrix such as the Markov chain matrix. $\lim_{R\to\infty} \boldsymbol{D}^{\boldsymbol{R}} = [0]_{n\times n}$ and $\lim_{R\to\infty}(\boldsymbol{I} + \boldsymbol{D} + \boldsymbol{D}^{\boldsymbol{2}} + \boldsymbol{D}^{\boldsymbol{3}} + ... + \boldsymbol{D}^{\boldsymbol{R}}) = (\boldsymbol{I} - \boldsymbol{D})^{-1}$, in which 0 is the zero.

Table 1. The organized dimensions and criteria.

Dimension	Criteria	Operational definitions
Product innovation (A)	Frequency of introducing new products (A1)	The firm frequently introduces e products that are favored by customers
	The number of new products introduced (A2)	The yield rate of resembling products of the firm is higher than its competitors
	The pace of introduction of new products (A3)	The introduction speed of the new products of the firm is better than its competitors
Innovation of production procedure (B)	Innovation of production procedure (B1)	The new technologies which focus on improving the production procedure are introduced
	Innovation of assembly technology (B2)	The new assembly technology is introduced to promote job efficiency
	Machinery innovation (B3)	New machinery products are purchased to improve production efficiency
Service innovation (C)	Innovation of after-sales service (C1)	The after-sales service efficiency is promoted to increase customer satisfaction
	Innovation of order management system (C2)	The order management system is applied to increase the efficiency and effectiveness of service quality
	Innovation of customer claim system (C3)	The new customer claim system is set to effectively solve complaints from customers
Marketing innovation (D)	Innovation on planning of the market-oriented strategies (D1)	New marketing methods which are thoroughly different from other competitors within the same industry are introduced
	Innovation on marketing information system (D2)	The sufficiency of the marketing information
	Innovation on interactive marketing (D3)	Trial products and services are provided for customers' undergoing their experiences
Management innovation (E)	Innovation of incentive schemes (E1)	Incentives are provided to encourage innovative behaviors
	Innovation of execution resources (E2)	Sufficient supply of resources for jobs
	Innovation of management skills (E3)	Innovative management skills of management level

Note: These dimensions and relevant data were sourced from literature and organized by this study.

matrix of $n \times n$, **I** is the unit matrix of $n \times n$, total-relation matrix **T** is the matrix of $n \times n$ that is defined as follows:

$$\mathbf{T} = \lim_{R \to \infty} \left(\boldsymbol{D} + \boldsymbol{D}^2 + \boldsymbol{D}^3 + \cdots + \boldsymbol{D}^R \right) = \boldsymbol{D}(\boldsymbol{I} - \boldsymbol{D})^{-1} \quad (4)$$

Portrayal of causal figure

$T = \lfloor t_{ij} \rfloor, \ t_{ij} = 1,2,...,n$ are the factors within the total-relation matrix **T**. The grand total of rows and columns are represented by r_i and c_j respectively, which are defined as follows:

$$r_i = \left(\sum_{j=1}^{n} t_{ij} \right)_{n \times 1} \quad (5)$$

$$c_j = \left(\sum_{i=1}^{n} t_{ij} \right)'_{1 \times n} \quad (6)$$

$\boldsymbol{r}_i$ represents factor i's total direct and indirect effects on other factors. $\mathbf{c}_j$ is the total effects of other factors on factor j. $\boldsymbol{r}_i + \boldsymbol{c}_j$, named as prominence, is the total effect influenced by this factor; it also demonstrates the prominence of the factor within this question. $\boldsymbol{r}_i - \boldsymbol{c}_j$ is named as a relation, in which if the outcome of the formula is negative, that means this factor tends to be an "inducer," otherwise, if the outcome is positive, the factor tends to be an "influencer." The causal figure uses ($\boldsymbol{r}_i + \boldsymbol{c}_j$, $\boldsymbol{r}_i - \boldsymbol{c}_j$)

Table 2. Demographic information of professionals and scholars.

Gender	Ages	Educational level	Job title	Job seniority
M	35 to 40	Doctor	Assistant profession	5 to 10
M	35 to 40	Doctor	Assistant profession	5 to 10
M	30 to 35	Doctor	Assistant profession	5 to 10
M	40 to 50	Doctor	Assistant profession	10 to 15
M	40 to 50	Master	Associate professor	15 to 20
M	50 above	Master	CEO	20 above
M	40 to 50	Junior College	Person in charge	15 to 20
M	40 to 50	University	Person in charge	15 to 20
M	35 to 40	University	Person in charge	5 to 10
M	50 above	Master	Person in charge	15 to 20
M	40 to 50	University	Manager	15 to 20
M	35 to 40	Junior College	Person in charge	10 to 15

as the sequence pair, in which the cross axle is ($\boldsymbol{r}_i + \boldsymbol{c}_j$), and the vertical axle is ($\boldsymbol{r}_i - \boldsymbol{c}_j$).

DANP

Yang et al. (2008) indicated that while dealing with the standardization, the supermatrix of ANP presumed that each dimension is weighted the same. Although this is an easy way to standardize the supermatrix, different degrees of effects on distinct clusters had been neglected. Therefore, the authors proposed to use the integrated DEMATEL and ANP methods in solving this issue. The empirical test result showed that the new method (combination of DEMATEL and ANP) is better applied in practice.

This study not only uses DEMATEL to ensure different levels of effects of DEMATEL on distinct clusters, but also applies the T total-relation matrix of DEMATEL in the supermatrix of ANP. Although the weighted impacts within the relationships between clusters are obtained via DEMATEL, we still need ANP to certify the "degree of significance" of these relations. Therefore, the total-relation matrix obtained by DEMATEL has implicit meanings within the dynamics of weighted relationships.

There are several stages for application of this new method:

1. The establishment of the unweighted supermatrix: That is to use the obtained total-relation matrix via DEMATEL and standardize the effects on each level of the total-relation matrix. Equation 7 is the computation formula.

$$\boldsymbol{T}_{\boldsymbol{E}} = \begin{array}{c} \\ \boldsymbol{B}_1 \\ \\ \\ \boldsymbol{B}_2 \\ \\ \\ \vdots \\ \boldsymbol{B}_n \\ \\ \end{array} \begin{array}{c} \begin{array}{cccc} \boldsymbol{B}_1 & \boldsymbol{B}_2 & \cdots & \boldsymbol{B}_n \end{array} \\ \begin{array}{cccc} \boldsymbol{E}_{11}\cdots\boldsymbol{E}_{1m_1} & \boldsymbol{E}_{21}\cdots\boldsymbol{E}_{2m_2} & \cdots & \boldsymbol{E}_{n1}\cdots\boldsymbol{E}_{nm_n} \end{array} \\ \begin{bmatrix} \boldsymbol{T}_{\boldsymbol{E}}^{11} & \boldsymbol{T}_{\boldsymbol{E}}^{12} & \cdots & \boldsymbol{T}_{\boldsymbol{E}}^{1n} \\ \\ \boldsymbol{T}_{\boldsymbol{E}}^{21} & \boldsymbol{T}_{\boldsymbol{E}}^{22} & \cdots & \boldsymbol{T}_{\boldsymbol{E}}^{2n} \\ \\ \vdots & \vdots & \ddots & \vdots \\ \boldsymbol{T}_{\boldsymbol{E}}^{n1} & \boldsymbol{T}_{\boldsymbol{E}}^{n2} & \cdots & \boldsymbol{T}_{\boldsymbol{E}}^{nn} \end{bmatrix} \end{array} \begin{array}{l} \\ \boldsymbol{E}_{11} \\ \boldsymbol{E}_{12} \\ \vdots \\ \boldsymbol{E}_{1m_1} \\ \boldsymbol{E}_{21} \\ \boldsymbol{E}_{22} \\ \vdots \\ \boldsymbol{E}_{2m_2} \\ \vdots \\ \boldsymbol{E}_{n1} \\ \boldsymbol{E}_{n2} \\ \vdots \\ \boldsymbol{E}_{nm_n} \end{array} \tag{7}$$

The standardized $\boldsymbol{T}_E^{\alpha}$ is then obtained based on $\boldsymbol{T}_E$. The results are demonstrated as follows (Equation 8):

$$\boldsymbol{T}_{\boldsymbol{E}}^{\alpha} = \begin{array}{c} \\ \boldsymbol{B}_1 \\ \\ \\ \boldsymbol{B}_2 \\ \\ \\ \vdots \\ \boldsymbol{B}_n \\ \\ \end{array} \begin{array}{c} \begin{array}{cccc} \boldsymbol{B}_1 & \boldsymbol{B}_2 & \cdots & \boldsymbol{B}_n \end{array} \\ \begin{array}{cccc} \boldsymbol{E}_{11}\cdots\boldsymbol{E}_{1m_1} & \boldsymbol{E}_{21}\cdots\boldsymbol{E}_{2m_2} & \cdots & \boldsymbol{E}_{n1}\cdots\boldsymbol{E}_{nm_n} \end{array} \\ \begin{bmatrix} \boldsymbol{T}_{\boldsymbol{E}}^{\alpha 11} & \boldsymbol{T}_{\boldsymbol{E}}^{\alpha 12} & \cdots & \boldsymbol{T}_{\boldsymbol{E}}^{\alpha 1n} \\ \\ \boldsymbol{T}_{\boldsymbol{E}}^{\alpha 21} & \boldsymbol{T}_{\boldsymbol{E}}^{\alpha 22} & \cdots & \boldsymbol{T}_{\boldsymbol{E}}^{\alpha 2n} \\ \\ \vdots & \vdots & \ddots & \vdots \\ \boldsymbol{T}_{\boldsymbol{E}}^{\alpha n1} & \boldsymbol{T}_{\boldsymbol{E}}^{\alpha n2} & \cdots & \boldsymbol{T}_{\boldsymbol{E}}^{\alpha nn} \end{bmatrix} \end{array} \begin{array}{l} \\ \boldsymbol{E}_{11} \\ \boldsymbol{E}_{12} \\ \vdots \\ \boldsymbol{E}_{1m_1} \\ \boldsymbol{E}_{21} \\ \boldsymbol{E}_{22} \\ \vdots \\ \boldsymbol{E}_{2m_2} \\ \vdots \\ \boldsymbol{E}_{n1} \\ \boldsymbol{E}_{n2} \\ \vdots \\ \boldsymbol{E}_{nm_n} \end{array} \tag{8}$$

The standardization procedures of $\boldsymbol{T}_{E}^{\alpha 11}$ are like Equations 9 and 10. Other working procedures such as $\boldsymbol{T}_{E}^{\alpha nn}$ are similar to what have been described earlier.

$$d_i^{11} = \sum_{j=1}^{m_1} t_{ij}^{11}, \quad i, j = 1, 2, ..., m_1 \tag{9}$$

$$\boldsymbol{T}_{\boldsymbol{E}}^{\alpha 11} = \begin{bmatrix} t_{11}^{11}/d_1^{11} & \cdots & t_{1j}^{11}/d_1^{11} & \cdots & t_{1m_1}^{11}/d_1^{11} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{11}/d_i^{11} & \cdots & t_{ij}^{11}/d_i^{11} & \cdots & t_{im_1}^{11}/d_i^{11} \\ \vdots & & \vdots & & \vdots \\ t_{m_11}^{11}/d_{m_1}^{11} & \cdots & t_{m_1j}^{11}/d_{m_1}^{11} & \cdots & t_{m_1m_1}^{11}/d_{m_1}^{11} \end{bmatrix} = \begin{bmatrix} t_{11}^{\alpha 11} & \cdots & t_{1j}^{\alpha 11} & \cdots & t_{1m_1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{\alpha 11} & \cdots & t_{ij}^{\alpha 11} & \cdots & t_{im_1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{n1}^{\alpha 11} & \cdots & t_{nj}^{\alpha 11} & \cdots & t_{nm_1}^{\alpha 11} \end{bmatrix} \tag{10}$$

Furthermore, the standardized total-relation matrix is transformed into a supermatrix in accordance with the dependence relationships between clusters (Equation 11) as follows:

$$W = \begin{array}{c} \\ E_{11} \\ B_1 \; E_{12} \\ \vdots \\ E_{1m_1} \\ E_{21} \\ B_2 \; E_{22} \\ \vdots \\ E_{2m_2} \\ \vdots \\ E_{n1} \\ B_n \; E_{n2} \\ \vdots \\ E_{nm_n} \end{array} \begin{array}{c} \begin{array}{cccc} B_1 & B_2 & \cdots & B_n \\ E_{11} \cdots E_{1m_1} & E_{21} \cdots E_{2m_2} & \cdots\cdots & E_{n1} \cdots E_{nm_n} \end{array} \\ \begin{bmatrix} W^{11} & W^{12} & \cdots & W^{1n} \\ W^{21} & W^{22} & \cdots & W^{2n} \\ \vdots & \vdots & \ddots & \vdots \\ W^{n1} & W^{n2} & \cdots & W^{nn} \end{bmatrix} \end{array} \quad (11)$$

W^{11} transposes based on $T_E^{\alpha 11}$ (Equation 12).

$$W^{11} = \left[T_E^{\alpha 11} \right]' = \begin{bmatrix} t_{11}^{\alpha 11} & \cdots & t_{1j}^{\alpha 11} & \cdots & t_{1m_1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{\alpha 11} & \cdots & t_{ij}^{\alpha 11} & \cdots & t_{im_1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{n1}^{\alpha 11} & \cdots & t_{nj}^{\alpha 11} & \cdots & t_{nm_1}^{\alpha 11} \end{bmatrix}' \quad (12)$$

2. To obtain the weighted supermatrix: To formulate the total-relation matrix as follows (Equation 13), each dimension's effect of each level is standardized.

$$T_B = \begin{bmatrix} t_B^{11} & \cdots & t_B^{1j} & \cdots & t_B^{1n} \\ \vdots & & \vdots & & \vdots \\ t_B^{i1} & \cdots & t_B^{ij} & \cdots & t_B^{in} \\ \vdots & & \vdots & & \vdots \\ t_B^{n1} & \cdots & t_B^{nj} & \cdots & t_B^{nn} \end{bmatrix} \quad (13)$$

The standardized T_B is then transformed into T_B^{α} as follows:

$$d_i = \sum_{j=1}^{n} t_{ij}, \quad i, j = 1, 2, ..., n \quad (14)$$

$$T_B^{\alpha} = \begin{bmatrix} t_B^{11}/d_1 & \cdots & t_B^{1j}/d_1 & \cdots & t_B^{1n}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_B^{i1}/d_i & \cdots & t_B^{ij}/d_i & \cdots & t_B^{in}/d_i \\ \vdots & & \vdots & & \vdots \\ t_B^{n1}/d_n & \cdots & t_B^{nj}/d_n & \cdots & t_B^{nn}/d_n \end{bmatrix} = \begin{bmatrix} t_B^{\alpha 11} & \cdots & t_B^{\alpha 1j} & \cdots & t_B^{\alpha 1n} \\ \vdots & & \vdots & & \vdots \\ t_B^{\alpha i1} & \cdots & t_B^{\alpha ij} & \cdots & t_B^{\alpha in} \\ \vdots & & \vdots & & \vdots \\ t_B^{\alpha n1} & \cdots & t_B^{\alpha nj} & \cdots & t_B^{\alpha nn} \end{bmatrix} \quad (15)$$

The standardized dimension T_B^{α} is led into the unweighted supermatrix, and thus the weighted supermatrix as follows (Equation 16) is obtained.

$$W^* = \begin{bmatrix} t_B^{\alpha 11} \times W^{11} & t_B^{\alpha 21} \times W^{12} & \cdots & \cdots & t_B^{\alpha n1} \times W^{1n} \\ t_B^{\alpha 12} \times W^{21} & t_B^{\alpha 22} \times W^{22} & \vdots & & \vdots \\ \vdots & \cdots & t_B^{\alpha ji} \times W^{ij} & \cdots & t_B^{\alpha ni} \times W^{ni} \\ \vdots & & \vdots & & \vdots \\ t_B^{\alpha 1n} \times W^{n1} & t_B^{\alpha 2n} \times W^{n2} & \cdots & \cdots & t_B^{\alpha nn} \times W^{nn} \end{bmatrix} \quad (16)$$

To gain the limit supermatrix, the weighted supermatrix is multiplied numerous times. Thus, the limit supermatrix is gained, as well as $\lim_{h \to \infty} = W^h$ the weighted number of different assessment criteria , in which **W** is the limit supermatrix, and **h** is random numbers.

RESEARCH ANALYSIS

Background analysis and question description

Thomas Friedman (1995) delineated that Taiwan is the pioneer of IT. With the changes in the environment, Taiwan should positively be involved in the ET industries and the coming men of Taiwan should create their own brands as the development space for OEM and ODM has been eventually limited.

Literature on brand and innovation has been limited to factor analysis and AHP only. This study appeals to DANP to investigate the determinants of brand innovation and the key success elements of brand innovation. The authors suggest that enterprises should use innovation strategy as their significant operational methods; and certain factors should be paid much attention to while processing brand innovation, which serve as the challenges of the firms. This study aimed to explore the factors enterprises should lay emphasis on while processing their innovations in order to offer firms advanced reference information.

The test and verification of DEMATEL's network effect on relationships

This study applied DEMATEL to confirm the question structure of the decision, and analyzed five dimensions, 15 criteria, and their interactive relationships. The obtained total effect of relation-matrix **T** and the degree of influences are listed in Tables 3 and 4.

Table 4 shows that, compared to other criteria, the direct or indirect effects of sub-dimension (D1), the innovation on planning of the market-oriented strategies, is the most significant assessment criterion. On the contrary, dimension B2, the innovation of assembly technology,

Table 3. The degree of influence via different criteria.

Criteria	r_i (effects)	c_j (effects of being influenced)	r_i+c_j (the degree of prominence)	r_i-c_j (the degree of cause)
Frequency of introducing new products (A1)	5.707	6.658	12.365	-0.951
The number of new products introduced (A2)	5.882	5.261	11.143	0.620
The pace of introduction of new products (A3)	5.630	5.511	11.140	0.119
Innovation of production procedure(B1)	5.061	5.113	10.174	-0.053
Innovation of assembly technology (B2)	5.045	5.157	10.202	-0.112
Machinery innovation (B3)	5.402	4.681	10.083	0.720
Innovation of after-sales service (C1)	5.792	6.507	12.299	-0.716
Innovation of order management system (C2)	5.486	5.592	11.077	-0.106
Innovation of customer claim system (C3)	5.850	6.541	12.392	-0.691
Innovation of planning of market-oriented strategies (D1)	6.411	5.945	12.356	0.466
Innovation of marketing information system (D2)	5.742	5.853	11.594	-0.111
Innovation of interactive marketing (D3)	5.867	5.627	11.494	0.240
Innovation of incentive schemes (E1)	5.989	5.373	11.361	0.616
Innovation of execution resources (E2)	5.955	5.378	11.332	0.577
Innovation of management skills (E3)	5.864	6.484	12.348	-0.620

Table 4. The degree of influences via different dimensions.

Dimensions	r_i (effects)	c_j (effects of being influenced)	r_i+c_j (the degree of prominence)	r_i-c_j (the degree of cause)
Product innovation(A)	1.913	1.937	3.850	-0.024
Innovation of production procedure(B)	1.723	1.661	3.384	0.062
Service innovation(C)	1.903	2.071	3.974	-0.168
Marketing innovation(D)	2.002	1.936	3.938	0.066
Management innovation(E)	1.979	1.915	3.894	0.064

is the least significant assessment criterion. In addition, by observing the effects being influenced, the criterion being influenced most easily is dimension A1, frequency of introducing the new products. Dimension C3, innovation of customer claim system, has the highest prominence degree, which is then the most significant criterion viewed by all the professionals. The maximum value in degree of cause ($r_i - c_j$) is B3, the machinery innovation; which is then the criterion with the highest effect on other criteria. Comparatively, the least degree of cause is dimension A1, frequency of introducing the new products, which can be most easily influenced.

According to the test results shown on Tables 3 and 4, the authors depicted the causal criteria amidst dimensions of this study. That is the causal figure does concisely indicate that dimension D, the marketing innovation, has maximum effects on others and dimension C, the service innovation, has least impact on others. That is because dimension C is most easily being influenced by other dimensions. Figure 2 clearly depicts these facts.

Calculation on weights of DANP

Based on the dynamic and influential relationships gained by DEMATEL, this study first established unweighted supermatrix, and then obtain the weighted supermatrix via degree of influences of different dimensions. Moreover, the authors obtain the limit supermatrix as described in Table 5.

The opinions of professionals, the frequency of introducing the new products (0.098) and innovation of management skills (0.082) have been the most emphasized dimensions. Therefore, we can see that: frequency of introducing the new products does affect the market position of a firm; continuous innovation can bring in a sustainable development indicator for the enterprises; and leaders' management skills enhance the enterprise to develop more business opportunities and bring the teamwork into full play. Knight (1967) conceived that an innovation in organizational structure is to change the system of job assignment, authority structure, communication, and rewards, and that personnel

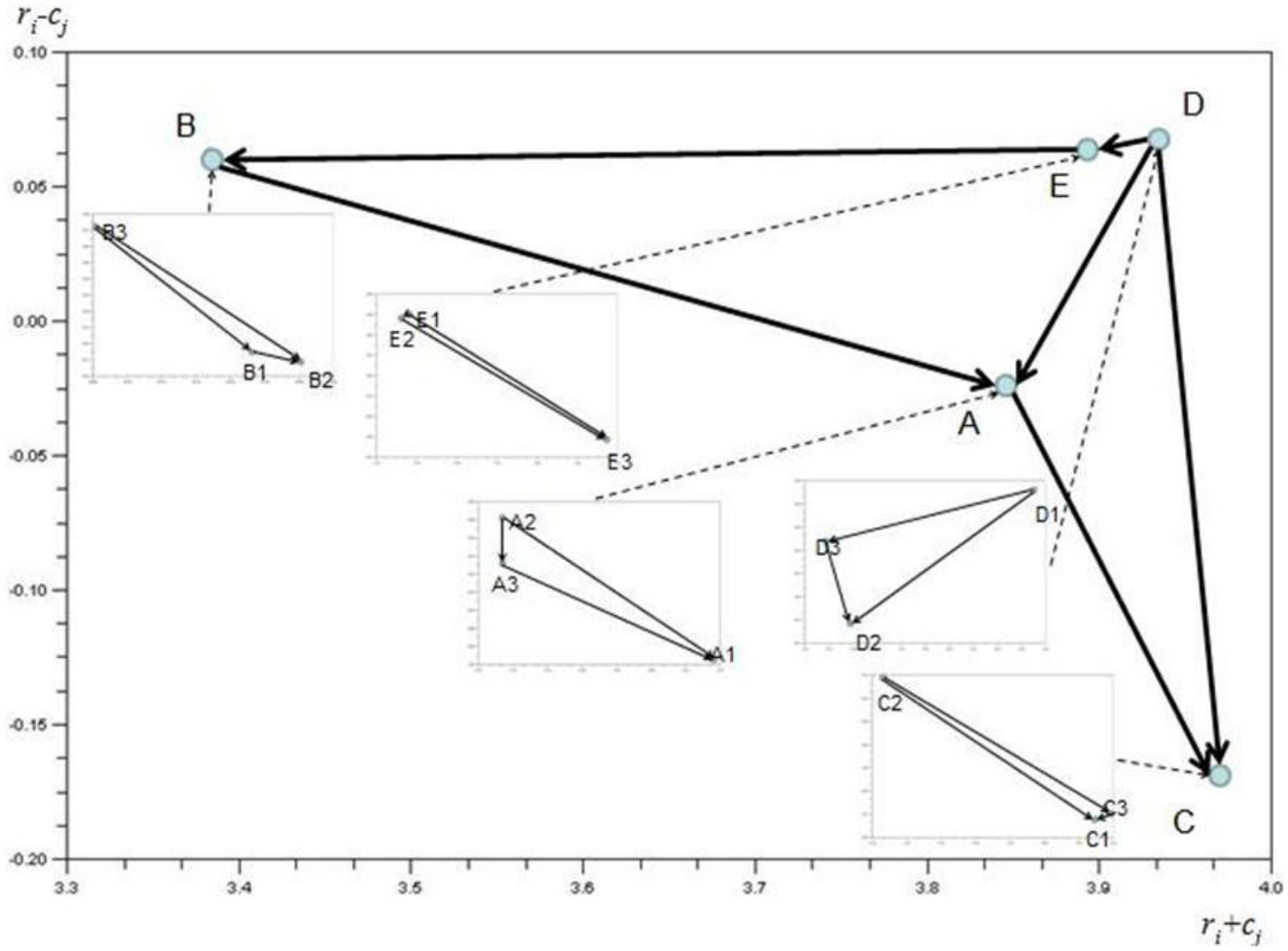

Figure 2. Causal figure of dimensions and criteria.

Table 5. Limit weighted significance of each sub-dimension.

Criteria	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3
	0.098	0.078	0.081	0.038	0.038	0.035	0.063	0.058	0.063	0.064	0.063	0.061	0.068	0.068	0.082

innovation is the change of organizational personnel and their behaviors or beliefs. But the test results of this study show that the innovation of production procedure (0.038), assembly technology (0.038), and machinery (0.035) have less correlations in between. This means that the frequency in introducing new products and managerial skills of the management level have higher impacts on brand innovation. Nevertheless, the innovations on production procedure, assembly technology and machinery have less impact. Finally, the overall weights of all factors are prioritized in Table 6.

CONCLUSIONS AND SUGGESTIONS

In recent years, due to the rapid development of IT, the competition between enterprises has been intensive. Within this fast-changing environment, enterprises have to continuously be adaptive for sustainable operation and management via obtaining sustainable competitive advantages. Updating a firm's capacity is one critical factor preventing the enterprise from being eliminated by the society.

Morris Chang, known as the godfather of Taiwan's

Table 6. Weights and Priorities of criteria and dimensions.

Dimensions	Criteria (sub-dimensions)	Overall	
		Weights	Priorities
Product innovation (A)		0.257	1
	Frequency of introducing new products (A1)	0.098	1
	The number of new products introduced (A2)	0.078	4
	The pace of introduction of new products (A3)	0.081	3
Innovation of production procedure (B)		0.111	5
	Innovation of production procedure (B1)	0.038	13
	Innovation of assembly technology (B2)	0.038	13
	Machinery innovation (B3)	0.035	15
Service innovation (C)		0.184	4
	Innovation of after-sales service (C1)	0.063	8
	Innovation of order management system (C2)	0.058	12
	Innovation of customer claim system (C3)	0.063	8
Marketing innovation (D)		0.188	3
	Innovation of planning of market-oriented strategies (D1)	0.064	7
	Innovation of marketing information system (D2)	0.063	8
	Innovation of interactive marketing (D3)	0.061	11
Management innovation (E)		0.217	2
	Innovation of incentive schemes (E1)	0.068	5
	Innovation of execution resources (E2)	0.068	5
	Innovation of management skills (E3)	0.082	2

semiconductor business, suggested that Taiwan enterprises' innovation should not be limited to the innovations of products, marketing, management, and administrations only, but should thoroughly be innovative.

This study found that the dimension of product innovation (0.257) is the most critical dimension for brand innovation, and the next ones are, in turn, management innovation (0.217), marketing innovation (0.188), service innovation (0.184), and innovation of the production procedure (0.111).

In regards to the criteria (sub-dimensions), the most critical criterion is the frequency of introducing new products (A1) (0.098); and the next are, in turn: Innovation of management skills (E3) (0.082), and the pace of introduction of the new products (A3) (0.081).

Therefore, the research results of this study suggest that the key success elements for enterprises executing their brand innovations are the frequency of introducing the new products (A1), the pace of introduction of the new products (A3), and innovation of management skills (E3). Hence, the research results which are mainly based on professionals' opinions have the notions that: Based on the idea of customer-driven, enterprises' frequently introducing products that are consistent with customers' expectations, helps firms to earn the customers' affirmative attitudes toward the enterprises, which become the best final beneficiaries. As to the dimension of innovation of management skills, top managers need to have innovative managerial skills in order to effectively lead their personnel to execute innovations. Furthermore, for pursuing the goal of profit maximization, if enterprises can introduce new products at a faster pace than their competitors, they should be able to carry out their goals. The research results also indicate that the innovations of production procedure (0.038), assembly technology (0.038) and machinery have lower impacts on brand innovation.

Suggestions to firms

Owing to the rapid development of IT, the competition between firms has intensified. To gain advantage in sustainable management, enterprises should know how to prioritize their innovation competence for operation and management. In accordance with the comprehensive analytical results of this study, we found that the key success elements for enterprises' brand innovations are the frequency of introducing the new products (A1), the pace of introduction of new products (A3), and innovation of

management skills (E3). While setting up their operational strategies, enterprises should lay emphasis on these three key success elements and strengthen the firms' competences in the aspects of product development and training of innovative managerial skills for managers in order to achieve the goal of profit maximization.

Suggestions for future studies

This study has categorized the idea of innovation into five dimensions. Relevant researchers and professionals, without being limited to specific industries, should be able to use their distinct perspectives to re-specify dimensions of innovation or add in more dimensions or industrial types for exploration on the idea of innovations.

Based on the current environmental factors, innovation is one critical strategy for enterprises to survive sustainably and compete within industries. However, the issue of environmental protection has been a trend that many professionals, organizations, and competent authorities have paid much attention to. Therefore, many of the enterprises have made efforts to strengthen their "green" brand images, which serve as a new and innovative brand image for the enterprises, as well as being a bridge between the enterprises and customers for promoting the level of customers' trust. Therefore, this study suggests that for future studies, researchers can add in more "green" issues and turn it into an additional dimension to those proposed by this study, so that managers are able to make operational decisions which are more adaptive to the current operational environment.

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