OPEN ACCESS Freely available online

IDC Innovation on Design and Culture

ISSN XXXX-XXXX
Volume 1, Issue 1
https://www.iikii.com.sg/journal/IDC
Innovation on Design and Culture

Article

Application of DEMATEL and ANP in Fruit Bag in Service Design

Hsin-Hung Lin [1, 2, *] and Shu-Chun Chien [3]

[1] Department of Creative Product Design, Asia University, Taichung, 41354, Taiwan;
[2] Department of Medical Research, China Medical University Hospital, China Medical University,Taichung, 406040, Taiwan; kristi.chien@gmail.com
[3] Master Program of Hakka Cultural Industry, National Pingtung University, Pingtung, 900391, Taiwan
* Correspondence: hhlin@asia.edu.tw

Received: Feb 6, 2022; **Accepted:** Mar 6, 2022; **Published:** Mar 30, 2022

Abstract: Causal relationship and importance of evaluation factors for purchasing decisions were investigated by taking the kiwifruit bag design as the research object and by using the decision-making laboratory analysis method (DEMATEL). It was found that the three most important evaluation factors before purchasing kiwifruit bags are "beauty" as the influencing factor, "operability" and "durability" as the main factors. Purchasing decisions of Kiwifruit bags are influenced by the three factors. Therefore, it is recommended to use the DEMATEL method to investigate possible factors for marketing products. The modeling process quantitatively evaluates simple interacting factors compared to complex factors, and the result is used to determine future directions of product designs.

Keywords: Modular design, Product family, Interpretive structural model, Product design

1. Introduction

Tazki and Amagsa (1997) pointed out that people usually use their intuition and experience to judge when they have complex and disagreeable questions or need behavioral problem analysis and assessments. Therefore, ideal planning and efficient methods based on the relationship between the decision-making laboratory analysis method (DEMATEL) test criteria and the relative weights of the criteria are required in these cases with the analytic network process (ANP). The related analysis is based on internal and external customer satisfaction data as a comprehensive reference. In the past, many scholars believed that consumers' purchase intention determines the consumer's cognitive value of the product. Many scholars proposed models of cognitive price, quality, and value to explain the formation of consumers' purchase intention in empirical research. (Hsiao et al., 2013). According to relevant research, consumers are often influenced by aesthetics when purchasing products as for the purchaser, aesthetics is the easiest way to identify the product (Hsiao & Liu, 2005), and aesthetic awareness affects the consumer's purchasing habits in the transaction.

In a study of aesthetics, a general model of brand loyalty is established to propose factors affecting brand loyalty based on product characteristics, marketing strategy, and market structure. Snyder and Fromkin (1997) stated that the theory of uniqueness is that "when the uniqueness of the self-concept is threatened, the individual's different needs from others will be provoked by certain motives." Tseng proposed to employ the theory of mixed fuzzy sets and ANP. He checked two types of structures to investigate the problems and standards in the management of green supply chain (Tseng et al., 2014). Huang used DEMATEL and ANP to investigate the factors of investments in the development of wind power and the community's understanding of safety, quality, environment, and ecology. He gathered relative weights of the related standards, and these can serve as a reference for enterprises and governments (Yeh & Huang, 2014). Hsu (2012) adopted a mixed method of DEMATEL for the simplification and visualization of the relations between strategic decisions. Chang utilized the method of DEMATEL to analyze and predict suppliers in the electronics industry and assisted enterprises in precisely predicting supplier performance with the key indicator of cargo consignation. His approach is to understand the selection of suppliers. Although it may not comply with the expectation of the supplier of the highest value assessed, it can still effectively assist enterprises in selecting the optimal supply-chain management to manage suppliers (Chang & Chang, 2011). Based on the concept of modularization, diversified design ideas, and various suggestions, product development can be conducted for different demands to reduce the manufacturing costs by sharing components of products. Based on a concept proposed by Hsiao et al. (2003), the relations between product components can be investigated by the sequencing model of sharing parts and components between product assemblies.

Therefore, in this study, we consider the key factors affecting consumers' choice of kiwifruit bags to provide relevant researchers with effectively evaluated development plans. Based on the general consumer purchase behavior, the plans are derived from the evaluation factors for making decisions on the purchase of exotic fruit bags. Therefore, the main purpose of this study is to define the decision-making factors for consumers to purchase kiwifruit bags in the evaluation model of causality. The research findings suggest relevant product marketing strategies and market development planning recommendations.

2. Theoretical Framework

In this study, the relationship between designs of products is determined with a matrix of the relationship. The relationship matrix is further used to determine the optimal product design. The flow chart of the research method is shown in Fig. 1. First, the component's methods are used to generate component weights. Then, the DEMATEL method is used to determine the product's relationship matrix. Finally, the cluster sample survey of the market segmentation is performed by using ANP to build the super matrix and obtain the weight of each element. The procedure of the method is as follows.

(1) Obtaining the impact matrix through the DEMATEL standard
(2) Constructing a relationship matrix
(3) Exporting the matrix
(4) Drawing an element distribution map
(5) Surveying cluster samples
(6) Establishing a supermatrix set
(7) Obtaining the weight of the element
(8) After establishing clusters and markets through ANP, determining the design with the best weight

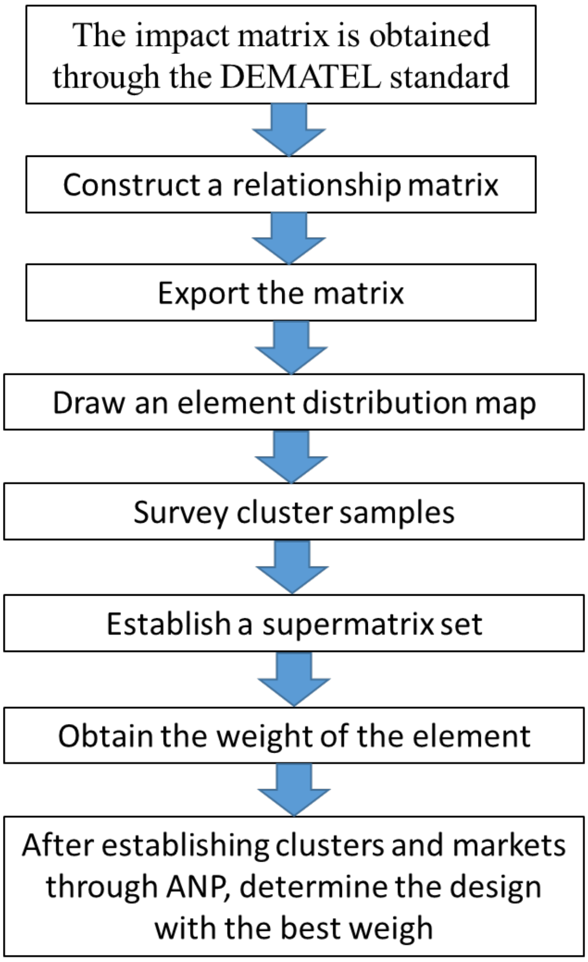

Fig. 1. Framework of the proposed method

3. Outline Of Development Process

We used DEMATEL for the data analysis as DEMATEL is used to analyze the relationship between problems and define the primary and secondary problems. Then, DEMATEL is used to construct the causal relationship between the decision-making evaluation factors of consumers purchasing kiwifruit bags. In addition, we also used in-depth interviews and a questionnaire survey on the relevant topics. The factors affecting consumer decision-making behavior were explored and summarized through literature review and are summarized in three main aspects: professional consumers, consumer purchase decision-making process, and eccentric fruit bag design evaluation. The "professional consumer" facet has three factors of "unique demand", "conspicuous consumption" and "materialism". The "consumer purchase decision-making processes" has two factors: "pre-purchase behavior" and "purchase". The " eccentric fruit bag design evaluation" has three factors: "popular", "product", and "brand".

3.1. Dematel Decision Lab Analysis

DEMATEL is a method for checking whether there is an interactive relationship or self-reward between factors and constructing a network relationship diagram between the criteria. Tzeng et al. (2007) pointed out that DEMATEL provides a feasible solution for specific problems through a hierarchical structure. In recent years, relevant articles on the DEMATEL method have been widely used as this method effectively is used to understand complex causal relationships. By examining the degree of influence between factors, the relationship between the overall factors and the intensity of influence is quantified. Then, a network relationship structure model is constructed to graphically examine the complex influences between factors. The DEMATEL method has the following five steps (Wang et al., 2013).

Step 1: Average Impact Matrix

The criteria are used in a pairwise judgment to assess each respondent's perception of the extent of the impact between the indicators. Respondents are asked about the direct impact of the indicator and to score the impact scales as 0, 1, 2, 3, or 4 for "completely no impact (0)", "slight impact (1)", "general level" The impact (2), the "high impact (3)", and the "significant (4)", respectively. Respondent's answers are used to create a $n \times n$ direct impact matrix

$$\boldsymbol{A} = [a_{ij}]_{n \times n} \tag{1}$$

Step 2: Normalization

According to the direct influence matrix, normalization directly affects the matrix (Eqs. (2) and (3)). The normalized direct influence matrix is defined as $\boldsymbol{D} = [d_{ij}]_{n \times n}$ with the matrix diagonal of 0.

$$\boldsymbol{D} = k\boldsymbol{A} \tag{2}$$

$$k = \min \left\{ 1 / \max_i \sum_{j=1}^{n} a_{ij}, 1 / \max_j \sum_{i=1}^{n} a_{ij} \right\}, \quad i, j \in \{1, 2, \ldots, n\} \tag{3}$$

Step 3: Calculation of the total impact relationship matrix

After obtaining the normalized direct influence matrix, the total influence matrix T of the constructed network relationship graph is calculated by Eq. (4), where I is an identity matrix.

$$\boldsymbol{T} = \boldsymbol{D} + \boldsymbol{D}^2 + \boldsymbol{D}^3 + \ldots + \boldsymbol{D}^k = \boldsymbol{D}(\boldsymbol{I} + \boldsymbol{D} + \boldsymbol{D}^2 + \ldots + \boldsymbol{D}^{k-1}) \, [(\boldsymbol{I} - \boldsymbol{D})(\boldsymbol{I} - \boldsymbol{D})^{-1}]$$

$$= \boldsymbol{D}(\boldsymbol{I} - \boldsymbol{D}^k)(\boldsymbol{I} - \boldsymbol{D})^{-1}$$

$$\boldsymbol{T} = \boldsymbol{D}(\boldsymbol{I} - \boldsymbol{D})^{-1},$$

$$\text{when } k \to \infty, \quad \boldsymbol{D}^k = [0]_{n \times n} \tag{4}$$

$$\text{when } \boldsymbol{D} = [d_{ij}]_{n \times n}, \quad 0 \le d_{ij} < 1, \quad 0 < \sum_{j=1}^{n} d_{ij} \le 1, \; 0 < \sum_{i=1}^{n} d_{ij} \le 1$$

Step 4: Analysis of the results

The summation of columns ($\sum_{j=1}^{n} t_{ij} = t_i$) and rows ($\sum_{i=1}^{n} t_{ij} = t_j$) of the above-mentioned matrix are used to establish influence index vectors $\boldsymbol{r} = (r_1,...,r_i,...,r_n)'$ and $\boldsymbol{c} = (c_1,...,c_j,...,c_n)'$ as defined by Eqs. (5) and (6).

$$\boldsymbol{T} = [t_{ij}]_{n\times n}, \quad i, j = 1,2,...,n$$

$$\boldsymbol{r} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} = [t_{i\cdot}]_{n\times 1} = (r_1,...,r_i,...,r_n)' \tag{5}$$

$$\boldsymbol{c} = \left[\sum_{i=1}^{n} t_{ij}\right]'_{1\times n} = [t_{\cdot j}]_{n\times 1} = (c_1,...,c_j,...,c_n)' \tag{6}$$

where vector $\boldsymbol{r}$ and vector $\boldsymbol{c}$ represent the summation of rows or columns of the overall influence matrix $\boldsymbol{T} = [t_{ij}]_{n\times n}$ respectively

step 5: Establishment of DEMATEL network relation chart

Also known as the degree of influence, the difference in the strength of a measure expresses influence or is influenced by others. This value reveals how random questions belong to one question. A positive value indicates that the metric is close to the cause group, while a negative value indicates that the index is close to the resulting group.

3.2. Analytic network process (ANP)

Saaty (1980) proposed the method of ANP on the foundation of the analytical hierarchy process (AHP). This method adds a feedback mechanism to the conventional linear AHP and presents the data in a network form. By simultaneously considering the interdependency development generated between various factors, a strategic decision can be made in a systematic manner (Saaty, 1996). This approach also provides a systematic method to identify the targets for an organization and its priorities. Karsak et al. (2002) proposed a type of combined analytic network process and quality functions to apply them to resource distributions. During the product design process, any limited resource has to be properly distributed to every workstation (Yu, 2002; Yu & Shing, 2013). The application of AHP to the solution of complicated problems has the following six steps.

Step 1: Defining a problem

All factors that might affect the problem are included in the system of the problem. In the meantime, a planning group should be set up to define the scope of the problem.

Step 2: Constructing a hierarchical structure

The members of the planning group brainstorm to find out the criteria and sub-criteria for assessing the problem, the nature of alternatives, and alternative solutions.

Step 3: Designing the questionnaire and conducting the survey

One of the higher-level elements is used as the evaluation criterion, and each element is compared pairwise with the other. Therefore, it is necessary to design a questionnaire for each pairwise comparison. The questionnaire is filled out on a scale of 1 to 9 by decision-makers or decision-making team members. The problem of each pairwise comparison must be clearly described.

Step 4: Checking the consistency of the levels

A pairwise comparison matrix is established based on the survey results, and then a calculator or computer is used to obtain the eigenvalues and eigenvectors of each pairwise comparison matrix to check the consistency of the matrix.

Step 5: Choosing a plan

If the overall

If the level is consistent, the priority vector of the alternative plan is firstly determined. If there is only one decision maker, only one comprehensive evaluation point (priority) of the alternative is determined. If there are multiple decision makers, the comprehensive evaluation point of each decision maker's alternative is calculated separately. Finally, the weighted average method (such as the geometric average method) is used to determine the weighted comprehensive evaluation points and the priority of the alternatives. Similar to the method of AHP, ANP also uses pairwise comparison to obtain network relationships on a scale of 1 to 9. ANP allows inner dependency within a cluster and outer dependence between clusters. It provides a complete framework that includes the connection between each cluster and element. The method of ANP is divided into two parts as follows.

The first part is "control hierarchy" which means the network relationship between criteria and sub-criteria. It affects the internal relationships between systems. The second part is the network relationship between elements and clusters.

From network relationships, the correlation between criteria can be demonstrated, and the limiting influence between each control criterion can be calculated to form a supermatrix.

$$W_i = \left(\prod_{j=1}^{m} a_{ij} \right)^{1/m} \Bigg/ \sum_{i=1}^{m} \left(\prod_{j=1}^{m} a_{ij} \right)^{1/m} \quad ; \quad i, j = 1, 2, 3, \ldots, m \tag{7}$$

where m is the number of decision factors。

The pairwise comparison matrix A is multiplied by the obtained eigenvector W_i to obtain a new vector, and then count is sought for the average fold therebetween $\lambda_{\max}$.

$$\begin{bmatrix} 1 & a_{12} & \cdots & a_{1m} \\ a_{21} & 1 & \cdots & a_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & 1 \end{bmatrix} \begin{bmatrix} W_1 \\ W_2 \\ \vdots \\ W_m \end{bmatrix} = \begin{bmatrix} W_1' \\ W_2' \\ \vdots \\ W_m' \end{bmatrix} \tag{8}$$

$$\lambda_{\max} = \frac{1}{m} \left(\frac{W_1'}{W_1} + \frac{W_2'}{W_2} + \cdots + \frac{W_m'}{W_m} \right) \tag{9}$$

4. Model Concept

In this study, we used the kiwifruit bag design as a case study. 10 different products are used to verify the feasibility of DEMATEL (Fig. 2).

Fig. 2. Kiwi Bags Design

We used DEMATEL for data analysis as DEMATEL is used to analyze the relationship between the problems to find the primary and secondary problems and construct the causal relationship between the evaluation factors of consumers' decision-making for purchasing kiwifruit bags. We also used in-depth interviews and a questionnaire survey to find out the respondents' views. The questionnaire was distributed to 32 respondents. 26 passed the conformance test, and 6 were considered invalid. All respondents were fruit farmers.

With DEMATEL, we calculated the input value, obtained the total influence degree matrix of the criterion, and evaluated the total influence relationship condition and the important indicators. Table 1 shows that the five aspects have a mutual influence relationship. The degree of influence of display is the most influential factor on comfort, and delivery is the least influential among all aspects. Values in the total impact relationship matrix (*T*) are removed to represent a more significant causal relationship by setting a threshold which is the arithmetic mean of the values in *T*. Finally, the value greater than or equal to the threshold is plotted on the coordinate graph according to the comparison of the seven criteria (Table 2). It is assumed that only *T* is greater than the threshold value to make the causal relationship easier to see between the criteria and simplify the total impact of DEMATEL. Figure 3 shows ranks, (*D*+ *R*), and the row difference (*D*-*R*). (*D*+*R*) is put on the horizontal axis, while (*D*-*R*) on the vertical axis. The seven selection criteria are plotted on the coordinate according to their coordinate values to show a significant causal relationship. All criteria have an influential relationship. Compared with other criteria, conformity to production and aesthetics is the most influential criterion. Productivity and delivery have the least impact. Therefore, operability, practicality, aesthetics, safety, and functionality represent the interrelationship most likely to be affected by other criteria.

Table 1. Overall influence relation matrix of criteria

T=	Operability	Practicability	Aesthetics	Safety	Productivity	Functionality	Deliverability		
Operability	1.030456135	1.086996308	1.046119724	1.221081608	0.974676084	0.754620643	0.469219732	6.583170235	5
Deliverability	1.183668108	0.970672091	1.097656134	1.184830887	1.018078655	0.743123121	0.475021699	6.673050697	4
Aesthetics	1.379781804	1.303539515	1.089730603	1.403633598	1.09050279	0.901127329	0.563686504	7.732002144	1
Safety	1.266536185	1.150374133	1.108980836	1.089440607	0.983520273	0.785217396	0.498597741	6.88266717	3
Productivity	1.092696971	1.025807138	0.967561723	1.093354904	0.773246713	0.695080665	0.449080532	6.096828646	7
Practicability	1.312593784	1.198969668	1.216882343	1.356769144	1.046505017	0.742038392	0.545426699	7.419185048	2
Functionality	1.131859435	1.0826283	1.076430893	1.16600499	0.915033992	0.765231465	0.415248219	6.552437294	6
	8.397592422	7.818987153	7.603362257	8.515115738	6.801563525	5.386439011	3.416281126	0.978353903	
	2	3	4	1	5	6	7		

Table 2. DEMATEL Averages.

Deliverability	Operability	Practicability	Aesthetics	Safety	Productivity	Functionality	Deliverability
Operability	1.030456135	1.086996308	1.046119724	1.221081608	0	0	0
Deliverability	1.183668108	0	1.097656134	1.184830887	1.018078655	0	0
Aesthetics	1.379781804	1.303539515	1.089730603	1.403633598	1.09050279	0	0
Safety	1.266536185	1.150374133	1.108980836	1.089440607	0.983520273	0	0
Productivity	1.092696971	1.025807138	0	1.093354904	0	0	0
Practicability	1.312593784	1.198969668	1.216882343	1.356769144	1.046505017	0	0
Functionality	1.131859435	1.0826283	1.076430893	1.16600499	0	0	0

	Operability	Practicability	Aesthetics	Safety	Productivity	Functionality	Deliverability
D+R	14.98076266	14.49203785	15.3353644	15.39778291	12.89839217	12.80562406	9.96871842
D-R	-1.814422188	-1.145936456	0.128639887	-1.632448568	-0.704734879	2.032746036	3.136156168

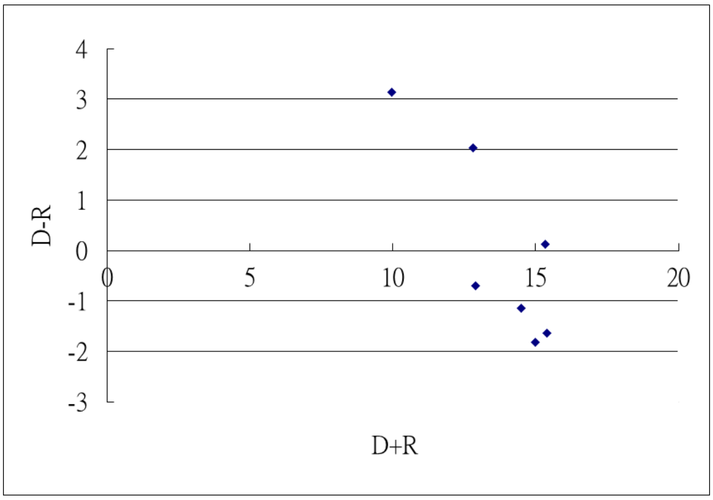

Fig. 3. DEMATEL element distribution

4.1 Evaluation criteria

The standard criteria were evaluated by using the survey criteria from the DEMATEL questionnaire survey. Data on the operability, practicality, aesthetics, safety, manufacturability, functionality, and transportability of the kiwifruit bags have been processed and investigated. The input values are calculated by the DEMATEL method, and the average opinion matrix of the professionals is obtained as shown in Table 3.

Table 3. ANP Weights

image	Considerations	Weights		Weights
	Operability	0.154		0.185
	Practicability	0.060		0.249
	Aesthetics	0.494		0.313
	Safety	0.043		0.028
	Productivity	0.250		0.225
	Functionality	0.167		0.174
	Practicability	0.077		0.149
	Operability	0.477		0.504
	Aesthetics	0.058		0.042
	Safety	0.222		0.131
	Functionality	0.192		0.135
	Practicability	0.104		0.219
	Operability	0.154		0.324
	Aesthetics	0.303		0.037

	Safety	0.247		0.286
	Functionality	0.191		0.204
	Practicability	0.230		0.238
	Operability	0.208		0.235
	Aesthetics	0.105		0.183
	Safety	0.266		0.139

The average of all values is 0.79, and the relationship matrix below this value is excluded. There are interactions between the five components. The practicality and aesthetic standards are the most influential evaluation criteria. On the other hand, manufacturability and deliverability have the least impact. Therefore, operability, usability, aesthetics, security, and functionality are more susceptible than other standards and are classified as result clusters. The interaction between the indices is shown in Fig. 4.

image				
Weights:	0.781	0.871	0.978	0.952
image				
Weights:	0.867	0.921	0.872	0.812

Fig. 4. Kiwi Bags DEMATEL Weights

The main five parameters considered for the kiwifruit bag are described as follows.

(1) Function: The function provided by the product during the application process. The main considerations are energy savings or other special features.
(2) Practicality: Whether the use of the product is suitable for the individual, the main considerations are ease of use, ease of storage, weight, and size.
(3) Operability: In addition to the necessary structural functions, the additional functions of the fast. In order to consider functionality, the main factor consumers consider is an accessory, such as a manual adjustment function.
(4) Aesthetics: The overall aesthetics of the product's appearance, including the shape, material, and color. Design taste and beauty, style change, color in pairs or groups, and product texture are usually considered.
(5) Safety: The safety features of the product during its use. The main considerations are better ruggedness and durability.

Through the calculation of ANP, it is possible to develop and redistribute to meet each requirement. A component with a different weight is considered for design. The weight that is not much different from the weight distribution is combined to analyze the distribution of the design values, and the optimized public ANP weight values are calculated as shown in Table 3.

5. Acquisition of Element Weights

DEMATEL evaluates the standard conditions, obtains the criteria for the total impact matrix condition, applies the evaluation conditions of the DEMATEL total impact relationship matrix, and establishes the results of the case study for different product designs. In addition to establishing the appropriate distinction between customers, it is also applied to the design of established product services. In the design process, in addition to the product design service development results, the following recommendations are proposed.

(1) The method is suitable for products because DEMATEL relies on eliminating certain relationships between components.
(2) The standard criteria for DEMATEL assessment are used to determine connectivity and process ANP between components through questionnaires.
(3) Concerning the design of ANP, complex designs are found to stimulate subjects and reduce the likelihood of passing a conformance test, although pairwise comparisons objectively demonstrate the importance of the questionnaire.
(4) The product development model established in this study has been verified by respondents. This approach involves complex calculations and time constraints. The method will be more effective when the amount of interview data is sufficient.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used “conceptualization, Lin,H.H and Chien,S.C ; methodology, Lin,H.H;validation,Lin,H.H,Chien,S.C and Lin,H.H.; formal analysis, Lin,H.H; investigation, Lin,H.H; resources, Lin,H.H; data curation, Lin,H.H; writing—original draft preparation, Lin,H.H; writing—review and editing, Chien,S.C; visualization, Chien,S.C; supervision, Lin,H.H” Authorship must be limited to those who have contributed substantially to the work reported.

Funding: This research did not receive external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Chang, B.; Chang, C.W. & Wu, C.H. (2011) Fuzzy DEMATEL method for developing supplier selection criteria. *Expert. Syst. Appl*, *38*: 1850–1858.
2. Hsiao, S.W.; Ko, Y.C.; Lo, C.H. & Chen, S.H. (2013) An ISM DEI and ANP based approach for product family development. *Advanced Engineering Informatics*, *27*:131–148.
3. Hsiao, S.W. & Liu, E. (2005) A structural component-based approach for designing product family. *Computers in Industry*, *56*: 13–28
4. Hsu, C.C. (2012) Evaluation criteria for blog design and analysis of causal relationships using factor analysis and DEMATEL. *Expert. Syst. Appl*, *39*:187–193.
5. Yeh, T.-M. & Huang, Y-L. (2014) Factors in determining wind farm location: Integrating GQM,fuzzy DEMATEL, and ANP. *Renew Energ*, *66*:159–169.
6. Karsak, E.E.; Sozer, S. & Alptekin, S.E. (2002) Product planning in quality function deployment using a combined analytic network process and goal programming approach. *Comput. Ind. Eng.*, *44*: 171–190.
7. Saaty, T.L. (1996) Decision making with dependence and feedback – The analytic network process, RWS publications, USA.
8. Saaty,T.L. (1980) The analytic hierarchy process, McGraw-Hill, New York.
9. Snyder, C.R.; Fromkin, H. (1997) Abnormality as a Positive Characteristic: The Development and Validation of a Scale Measuring Need for Uniqueness. *Journal of Abnormal Psychology*, *86* (5) 518–527.

10. Tazki, E. & Amagsa, M. (1997) Structural Modeling in a Class of Systems Using Fuzzy Sets Theory. *Fuzzy Sets and Systems*. *2* (1), 87–103.
11. Tseng, M.L.; Lin, R.J.; Lin, Y.H., Chen, R.H. & Tan, K.H. (2014), Close-loop or open hierarchical structures in green supply chain management under uncertainty. *Expert. Syst. Appl*, *41*, 3250–3260.
12. Tzeng,G.H., Chiang, C.H. & Li, C.W. (2007) Evaluating intertwined effects in e-learning programs: A Novel Hybrid MCDM Model Based on Factor Analysis and DEMATEL. *Expert. Syst. Appl.*, *32* (4), 1028–1044.
13. Wang, W.M.; Lee, H.I.; Peng, L.P. & Wu, Z.L. (2013) An integrated decision making model for district revitalization and regeneration project selection, *Decision Support Systems*, *54*: 1092–1103.
14. Yu, C.S. (2002) A GP-AHP method for solving group decision-making fuzzy AHP problems, *Comput. Oper. Res.*, *29* (14), 1969–2001.
15. Yu, J.R. & Shing, W.Y. (2013) Fuzzy analytic hierarchy process and analytic network process: An integrated fuzzy logarithmic preference programming, *Appl. Soft. Comput.*, *13*:1792–1799.