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Research Article

A Hybrid Network Model to Extract Key Criteria and Its Application for Brand Equity Evaluation

Chin-Yi Chen and Chung-Wei Li

Department of Business Administration, Chung Yuan Christian University, 200 Chung Pei Road, Zhongli 32023, Taiwan

Correspondence should be addressed to Chung-Wei Li, research.cwli@gmail.com

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Making a decision implies that there are alternative choices to be considered, and a major challenge of decision-making is to identify the adequate criteria for program planning or problem evaluation. The decision-makers' criteria consists of the characteristics or requirements each alternative must possess and the alternatives are rated on how well they possess each criterion. We often use criteria developed and used by different researchers and institutions, and these criteria have similar means and can be substituted for one another. Choosing from existing criteria offers a practical method to engineers hoping to derive a set of criteria for evaluating objects or programs. We have developed a hybrid model for extracting evaluation criteria which considers substitutions between the criteria. The model is developed based on Social Network Analysis and Maximum Mean De-Entropy algorithms. In this paper, the introduced methodology will also be applied to analyze the criteria for assessing brand equity as an application example. The proposed model demonstrates that it is useful in planning feasibility criteria and has applications in other evaluation-planning purposes.

1. Introduction

System engineering is an interdisciplinary field of engineering focusing on how complex engineering projects should be designed and managed over their life cycles, and it overlaps with both technical and human-centered disciplines such as control engineering, industrial engineering, organizational studies, and project management [1]. The principles of system engineering provided system thinking and have been applied to most projects and industry fields. In the system life-cycle process, as Figure 1 illustrates, system assessment-analysis and evaluation have to be undertaken in distinct phases.

When we want to execute an evaluation project, determining adequate criteria is critical to achieve the evaluation. Traditionally, criteria are derived through discussion with engineers, experts, researchers and, especially in the field of business administration, by

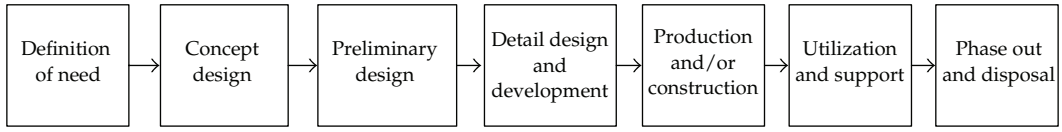

Figure 1: System assessment-analysis and evaluation in the system life-cycle process.

finding out about an object through consultation with customers. In this process, deciding upon consistent evaluation criteria is time-consuming work. In many situations when the assessing objects are similar, existing criteria could be referred to. If the criteria which can be referred to are numerous, it is necessary to choose the most appropriate basis of the benchmark assessment. After an in-depth literature review about evaluation criteria, a researcher established an adequacy criteria algorithm that reasonably satisfied the request of "face validity" or "content validity."

As an example application, brand equity was chosen as it is one of the important intangible assets that can bring competitive advantage for many enterprises. However, until now, measuring the value of a brand has been relatively abstractive and subjective and there are many different methods to explore the potential value of the brand in academia and industry. Many criteria have similar meanings and can be partially or totally substituted for one another. Based on the assumption that "a criterion can be substituted partially or totally by another criterion", in this paper, we develop a hybrid model for choosing the adequate evaluation criteria. By using the methods of the Social Network Analysis (SNA) and the Maximum Mean De-Entropy (MMDE) algorithm, the degree of substitutability of existing reference criteria will be judged to derive a criteria list for evaluation. In this paper, the issue of the assessment of brand equity will be addressed as an example to demonstrate the application of the proposed research model in the planning of other evaluation projects.

The rest of this paper is organized as follows: Section 2 describes the issues associated with choosing the criteria, the theories of SNA and MMDE methods, and explains how the model for this study was constructed. We also use an example, choosing the criteria to evaluate the value of brand equity, to illustrate the steps of our model and the applications of the model are discussed in Section 3. Finally, in Section 4, we will discuss the advantages of the proposed model and the feasibility of its application. We draw conclusions and offer some discussion related to future work in Section 5.

2. Criterion, Algorithm, and Hybrid Model

In this section, the importances of criteria for evaluation, especially for brand equity analysis, are described. Then we will explain the methods we applied to construct our hybrid model, and its feasibility in the work of extracting criteria.

2.1. Criteria for Brand Equity Evaluation

A criterion is the standard or test by which individual things or people may be compared and judged. A fair and just evaluation criteria set ensures the performance of an evaluation project. It is not easy to perform those processes in a completely objective way, especially in

the assessment of intangible assets such as technology, patents, or brand equity or concerning the characteristics of invisibility and abstractness, and as such, those characteristics also have a great influence on the assessment framework itself.

There are many diverse models for brand equity available in the academic world and in practice. These two sectors have already proposed many different assessment frameworks which constitute various dimensions and criteria, and various analytical perspectives accompanied by various dimensions and criteria in the assessment framework. However, aside from the complexity of the implementation of the assessment process in reality, the naming or definitions of dimensions and criteria are sometimes so similar making distinguishing them with certainty very difficult. Moreover, the existence of such ambiguity in the framework may bring about the issue of double counting resulting in bias of the assessment result. Therefore, it can be seen that developing a series of processes to arrange and select proper dimensions and criteria within the established framework to cover the full meaning of the evaluation structure and to prevent measurement bias will be crucial to building an appropriate evaluation model.

Hence, we determine the full dimensions to be applied to well-known brand equity assessment models and use the research methodology addressed in this paper to extract appropriate dimensions, to propose a reasonable and practical assessment framework of brand equity and hope to provide a reference for establishing relative models in the future.

2.2. Research Methods

2.2.1. Social Network Analysis

Social network analysis presumes social relationships in terms of network theory consisting of nodes and ties [2]. Graph theory is the main field of mathematics to provide social network as a model of a system consisting of a set of nodes with ties between them. Nodes are considered as the individual participants within the networks, and ties are the relationships between the nodes. The results of the analysis are graph-based structures for explaining the whole interrelated group [3]. The simplest social network is a map of specified ties, such as friendship, between the nodes being studied. Thus, the nodes to which an individual is connected are the social contacts of that individual. The network can also be used to measure social capital, that is, the value that an individual gets from the social network. These concepts are often displayed in a social network diagram, where nodes are the points and ties are the lines.

SNA has emerged as a key technique in modern sociology. It also has gained a significant following in anthropology, biology, communication studies, economics, geography, information science, organizational studies, social psychology, and sociolinguistics [4–8], and it has become a popular topic of speculation and study [2]. In this study, the SNA was used to view the referred criteria and substitutions between them (links of the social relations between nodes), which are useful in determining relevance, impact direction, and, more importantly, the degree of substitution on the criteria. Using this method in this study, we also can review the crucial role of the key criteria.

In the theory of social network, there are three properties that will be used in our study: "walk," "distance," and "centrality" of position [3, 9, 10]. For a network, the adjacencies of the network refer to the connections from one actor to another. Shown in Figure 2(a), two persons

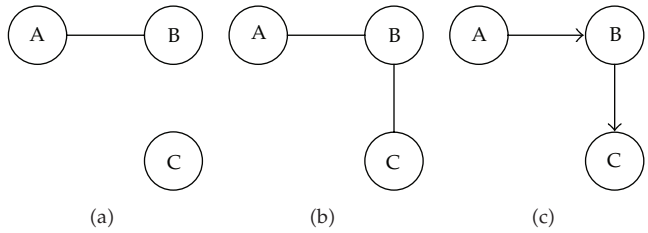

Figure 2

A and B have a relationship, between them but C is an isolated point with no relationship between C and the other two. If the relationship is not directed, then the relation is symmetric. In Figure 2(b), there is a relationship between A and B, and a relationship between B and C, but there is no relationship between A and C. If the relationship is not directed, the attribute of *transitive* is not suitable for analysis. A directed relation, such as Figure 2(c), will have the attribute of *transitive* and *asymmetric*.

A *walk* is an alternating sequence of incident nodes and lines. A walk begins and ends with nodes. The length of a walk is the number of occurrences of lines in it. Because some nodes and some lines may be included more than once, the definition of a *path* as a walk in which all nodes and all lines are distinct is necessary for our paper. If a node x can walk to another node y, we can say that node x and node y are connected. It is likely that there are several different connections between a given pair of nodes and that these connections differ in length. A connection with the shortest distance between two nodes is referred to as a geodesic, or the distance between two nodes.

"*Centrality*" is a concept which is used in social network analysis to identify the "importance" of nodes in a social network. There are some indices, such as "*degree*," "*closeness*," and "*betweenness*," which have been commonly used as the indices of centrality [11]. The definitions of these indices attempt to quantify the importance of an individual actor/node embedded in a network. Now, many indices have been established for identifying the important of a node. In this paper, we use the index "*Bonacich Power Centrality*" as the centrality scores of network nodes.

The original degree centrality approach argues that actors who have more connections are more likely to be powerful because they can directly affect a greater number of other actors. Bonacich proposed a modification of the degree centrality approach to include the concept that the same degree does not necessarily make actors equally important [12, 13]. A node is likely to be more influential if it is connected to another central node which can quickly reach a lot of other nodes with its message. But if the nodes that you are connected to are well connected, they are not dependent on you and that means you are not so important although there are a lot nodes that in fact connect with you. Connected to others makes a node central, but not powerful. One node being connected to others that are not well connected makes one powerful, because these other actors are dependent on you.

Bonacich proposed that both centrality and power were a function of the connections of the nodes in one's neighborhood. The more connections the nodes in your neighborhood have, the more central you are. The fewer the connections the actors in your neighborhood have, the more powerful you are. Bonacich's power centrality measure, or BP score, is defined as (2.1) where $\mathbf{A}$ is the graph adjacency matrix, $\mathbf{1}$ is column vector of 1. The β is the

"attenuation parameter," and the α is a scaling parameter which is set as the sum of squared scores equal to the number of nodes [14]:

$$C_{BP}(v) = \alpha(\mathbf{I} - \beta\mathbf{A})^{-1}\mathbf{A}\ \mathbf{1}. \tag{2.1}$$

For any criterion with influence from node x to node y through node z, the influence from x to node z includes direct and indirect influence recursively. The BP score is the notion that the power of a node is recursively defined by the sum of the power of its alter. The nature of the recursion involved is then controlled by the power exponent: positive values imply that vertices become more powerful as their alters become more powerful (as occurs in cooperative relations), while negative values imply that nodes become more powerful only as their alters become weaker (as occurs in competitive or antagonistic relations). The magnitude of the exponent indicates the tendency of the effect to decay across long walks; higher magnitudes imply slower decay. The BP score is suitable for this paper because of the purpose of finding out the degree of substitution between criteria.

2.2.2. Maximum Mean De-Entropy (MMDE) Algorithm

We used the MMDE algorithm to determine the threshold value for delineating the network diagram that was derived from the SNA. The MMDE algorithm was developed from the basis of entropy theory. Entropy is a physical measurement of thermal-dynamics and has become an important concept in the social sciences. In information theory, entropy is used to measure the expected information content of certain messages and is a criterion for measuring the amount of "uncertainty" represented by a discrete probability distribution.

Definition 2.1. Let a random variable with n elements denoted as $X = \{x_1, x_2, \ldots, x_n\}$, with a corresponding probability $P = \{p_1, p_2, \ldots, p_n\}$, then one defines the entropy, H, of X as follows:

$$H(p_1, p_2, \ldots, p_n) = -\sum p_i \lg p_i, \tag{2.2}$$

subject to constraints

$$\begin{gathered} \sum_{i=1}^{n} p_i = 1, \\ p_i \lg p_i = 0 \quad \text{if } p_i = 0. \end{gathered} \tag{2.3}$$

The function "lg" means the logarithms which are taken to an arbitrary but fixed base. The value of $H(p_1, p_2, \ldots, p_n)$ is the largest when $p_1 = p_2 = \cdots = p_n$, and we denote this largest entropy value as $H(1/n, 1/n, \ldots, 1/n)$. Now we will define another measure for the decreased level of entropy: *de-entropy*.

Definition 2.2. For a given finite discrete scheme of X, the *de-entropy* of X is denoted as H_n^D and defined as

$$H_n^D = H\left(\frac{1}{n}, \frac{1}{n}, \ldots, \frac{1}{n}\right) - H(p_1, p_2, \ldots, p_n). \tag{2.4}$$

By Definition 2.2, the value of H^D is equal to or larger than 0. Unlike entropy, which is used for the measure of uncertainty, the H_n^D can explain the amount of useful information derived from a specific dataset, which reduces the "uncertainty" of the information. We define the de-entropy for the purpose of searching the threshold value in order to assess the effect of information content when adding a new node to an existing impact-relations map. By Definition 2.1, Formula (2.5) can be proven (the proof can be found in [15]):

$$H_n = H\left(\frac{1}{n}, \frac{1}{n}, \ldots, \frac{1}{n}\right) \leq H\left(\frac{1}{n+1}, \frac{1}{n+1}, \ldots, \frac{1}{n+1}\right) = H_{n+1}. \tag{2.5}$$

Based on Definitions 2.1 and 2.2, the MMDE algorithm is developed to obtain a threshold value for delineating a network diagram. This algorithm can be used to derive a set of dispatch-nodes, the factors that strongly dispatch influences to others, and a set of receive-nodes, which are easily influenced by another factor. According to these two sets and a unique threshold value, we can obtain an influence network of criteria.

We propose the maximum mean de-entropy (MMDE) algorithm to find a threshold value for delineating the impact relations between criteria. The MMDE algorithm has some properties that differ from the traditional method of determining a network. First, the MMDE algorithm serves mainly to decide the "node" rather than the "network," and this is helpful for understanding a problem in that it decreases the uncertainty of information. Second, the MMDE algorithm considers the properties of the dispatch influence and the received influence of a node, and this is useful to the analyst in determining the "nodes" or criteria, which are easily influenced by other factors. The MMDE algorithm can also obtain a unique threshold value, which is helpful in solving the problems that a researcher may confront regarding the selection of a consistent threshold value and is decided by searching a suitable criteria set. The theory and steps of this algorithm are described In Li and Tzeng (2009) [16, 17], and we summarize the steps of the MMDE as follows.

Step 1. Transforming the relation matrix into an ordered triplets set.

Step 2. Taking the second element from the ordered triplets set to establish a dispatch-node set.

Step 3. Calculating the mean de-entropy of dispatch-node set.

Step 4. Finding the maximum mean de-entropy.

Step 5. Similar to Steps 2 to 4, an ordered receive-node set and a maximum mean de-entropy receive-node set can be derived.

Step 6. Finding the threshold value.

2.3. The Hybrid Model

The purpose of our proposed model is to resolve the problem when researchers are faced with excessive available criteria with a considerable degree of substitution, by using a mathematical algorithm to obtain key criteria following a preliminary judgment of degree of substitution. Hence, first, the experts' judgments about the degree of substitution between each other should be obtained. The measure of degree of substitution should be recognized as distinct. For example, the value 1 means a criterion can almost be totally substituted/replaced by another and 2 means that a criterion can be partially substituted/replaced. The value of scale, or the degree of substitution, can be considered as "distance" between two criteria. This allows us to determine the number and lengths of geodesics between all nodes. With edge values being interpreted as distances, where edge values reflect proximity or tie strength, we can construct the substitution degree matrix. Based on this substitution degree matrix, there are steps to achieve the purpose of the purposed hybrid model.

First, we use the BP score to find the "powerful" criteria. Because the BP scores imply both centrality and power of the nodes in one's neighborhood, we can separate the original criteria into the powerful criteria set, whose element's alter will influence the weaker criterion, and the weaker set. The elements in the weaker set are considered as replaceable criteria. But the BP score was calculated based on the connections, whose value is binary; however, the degree of substitution between the elements in the powerful set also should be considered.

Secondly, we use the MMDE method to obtain a substitution network and find the criteria which can be substituted by another. When we apply the MMDE algorithm to the substitution degree matrix, there were some steps to obtain the maximum mean de-entropy values. After the substitution degree matrix is normalized, a continuous decrease of the indirect effects of substitution along the powers of matrix $\mathbf{D}$, for example, $\mathbf{D^2}, \mathbf{D^3}, \ldots, \mathbf{D^\infty}$, guarantees convergent solutions to the matrix inversion, a process similar to an absorbing Markov chain matrix. We can also use the MMDE algorithm to determine the threshold value and draw the network which can explain the replaceable criteria [18].

In this paper, the SNA was used to view the referred criteria and substitutions between them (links of the social relations between nodes), which are useful in determining relevance, impact direction, and, more importantly, the degree of substitution on the criteria. Using this method in this paper, we also can review the crucial role of the key brand equity evaluation criteria. The usage of the Bonacich power score was to group the similar criteria by the metric of each criterion (node) with the others. This metric is a nondirectional relations' measure, which is why we applied the MMDE tool to find the evaluation structure with consideration of the direction of relationships between criteria.

After we obtain the results from the SNA and MMDE algorithms, we can exclude the weaker criteria and replaceable criteria. The remainders in the powerful criteria set, which are important and cannot be substituted, are the criteria that meet the objectives of the proposed hybrid model. We summarize the steps of the proposed model in Figure 3.

3. The Case for Model Application

Brand equity is an important intangible asset since it can bring competitive advantage for many enterprises. However, until now, measuring the value of a brand is relatively abstractive and subjective and many different methods have been developed to explore

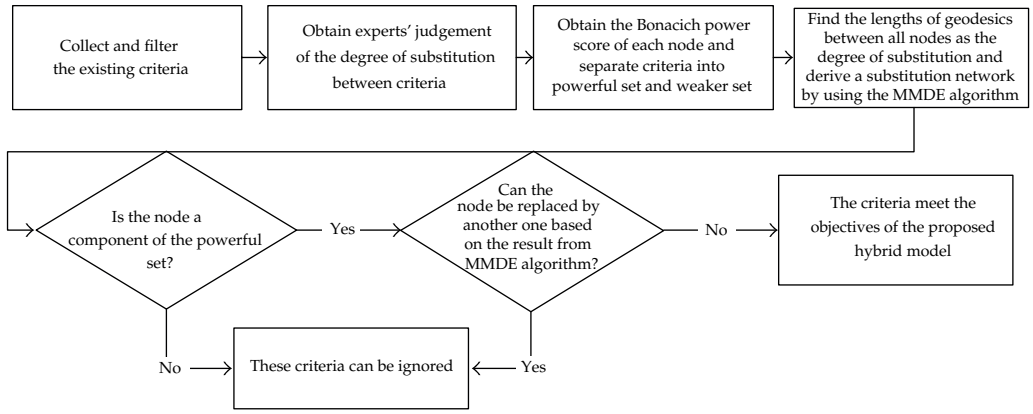

Figure 3: The flow of the proposed hybrid model.

the potential value of brand, both from academic or practical viewpoints. Generally, from an analytical point of view, those methods can be divided into financial, marketing, and a combination of perspectives.

Briefly, the financial perspective applies the real data from the financial statements of the company to evaluate the brand equity; the marketing perspective tends to extend the meaningfulness of a brand to customers, that is, consumers' feelings toward a brand and its potential influences on a company's profit, is usually divided into several dimensions to explore a brand's potential value to a company; the combination perspective integrates the two formers' concepts and is viewed both from financial and marketing perspectives which are important but to a different extent. The two methods should be considered simultaneously in the measurement process.

In practice, there are many different models to evaluate brand equity, the most famous and most reliable models named Interbrand, BBDO, and HIORSE. The model developed by Interbrand, a British global branding consultancy company, covers market segmentation, financial analysis, demand, and competition analysis and takes both marketing and financial perspectives into consideration. It can be viewed as a conscientious measurement structure of brand equity, but the calculating process of the model has not been completely disclosed, preventing its widespread adoption [19].

The BBDO model, developed by a worldwide advertising agency belonging to the Omnicom group, puts market quality, dominance of relevant market, international orientation, brand status, and monetary basis into the measurement process. The data for the model are relatively easy to collect, but the calculation is comparatively complex, especially the repetition of meanings between dimensions, which could result in the possibility of double counting [20, 21], since these three models all reflect the marketing and financial aspects that previous researchers consider important when it comes to evaluating the brand equity. Moreover, these three models are widely applied in practice and accepted by many stock exchanges in the U.S. and Europe. Therefore, considering the theoretical integrity and representativeness, we chose these three models as the empirical cases to analyze.

HIROSE is constructed by the Japanese Government to reflect the development background and put more emphasis on industrial competiveness [22]. Therefore, this model includes the three drivers of prestige, loyalty, and expansion and is inclined to include

Table 1: Fifteen criteria used for assessing the value of brand equity.

Notation	Criteria description
x_1	Brand leadership
x_2	Brand stability
x_3	Market
x_4	International reach of brand
x_5	Brand trend
x_6	Marketing support
x_7	Legal protection of brand
x_8	Market quality
x_9	Dominance of relevant market
x_{10}	International orientation
x_{11}	Brand status
x_{12}	Monetary basis
x_{13}	Prestige driver
x_{14}	Loyalty driver
x_{15}	Expansion driver

financial statements and can be regarded as a reliable value measurement index. Even so, focus on the financial statements also limits its application scope in practice.

To conduct our research, a list of 15 criteria was created after comparison of these three models, shown as Table 1. After we interviewed senior technical personnel and marketing managers to determine the degree of substitution between each other, we can obtain the matrix as shown in Table 2. In Table 2, a_{ij} is the element located at row i and column j. If a_{ij} is 0, it means that the criterion i has no interrelationship with criterion j. If a_{ij} is 1, it means that the criterion i can almost totally substitute/replace criterion j. If a_{ij} is 2, it means that the criterion i can partially substitute/replace criterion j. The values 0, 1, and 2 are ordinal scale by the means of distance.

Our hypothesis was analyzed using the SNA method. With the directed line that implies the degree of substitution from one node to another, we divided the support measures into a group that dispatches influence and a second group that receives influence so that we could understand the influence relationships better. The purposes of the SNA enquiry in this research, with the expert's knowledge for contributing to a deeper comprehension of the criteria, are the analysis of the structure and interrelationships of the criteria and the identification of the key feasible and efficient criteria for evaluating the value of brand equity.

3.1. Social Network Analysis Results

In this step, we applied the software "sna," an R language package for social network analysis. This tool's functions include node and graph-level indices, structural distance and covariance methods, structural equivalence detection, p^* modeling, random graph generation, and 2D/3D network visualization [23, 24]. After we applied the tools to Table 2, we obtained some key indices for each criteria (Table 3).

According to the normalized BP score of each node, we can find that twelve criteria have positive scores and three criteria have negative scores, as shown as Figure 4. There are twelve powerful criteria with positive BP scores but three criteria in the weaker criteria set.

Table 2: 15 × 15 degree of substitution matrices between criteria.

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
x_1	1	2	2	2	2	0	0	2	1	0	2	2	2	2	0
x_2	2	1	0	0	2	2	0	0	2	0	2	2	2	2	0
x_3	2	0	1	2	2	0	0	2	2	0	0	2	2	2	0
x_4	2	0	2	1	2	0	0	2	2	1	0	0	2	0	2
x_5	2	2	2	0	1	0	0	2	2	0	0	2	2	2	0
x_6	2	2	0	0	2	1	0	2	2	0	2	2	2	2	0
x_7	0	2	0	0	0	0	1	0	0	0	2	0	0	0	2
x_8	2	0	2	0	2	0	0	1	2	0	2	2	2	2	0
x_9	2	0	0	0	0	0	0	2	1	0	2	2	2	2	0
x_{10}	0	0	0	2	0	0	0	0	0	1	0	0	0	0	2
x_{11}	1	1	0	0	0	0	0	2	2	0	1	2	2	1	2
x_{12}	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2
x_{13}	2	2	0	0	0	0	0	2	1	0	2	2	1	2	0
x_{14}	2	1	0	0	2	0	0	2	2	0	2	2	0	1	0
x_{15}	0	0	0	2	0	0	0	0	0	1	0	2	0	0	1

Table 3: Key indices of the network of support measures.

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
Degree	21	14	10	10	16	4	2	20	20	4	18	22	20	19	10
Betweenness	0.08	0.08	0.01	0.12	0.03	0.00	0.00	0.04	0.02	0.00	0.07	0.45	0.03	0.02	0.07
Closeness	0.78	0.70	0.70	0.64	0.70	0.74	0.54	0.70	0.64	0.45	0.70	1.00	0.67	0.67	0.56
BP score (normalized)	0.02	−0.05	0.60	0.11	−0.04	−0.02	0.05	0.11	0.19	0.13	0.18	0.04	0.07	0.07	0.09

3.2. *Usage of the MMDE Algorithm*

Based on Table 2 and the degree of substitution between criteria judged by experts, we applied the MMDE algorithm to these data. When applied to the matrix, there were some steps to obtain the de-entropy values matrix, shown as Table 4.

Following the steps of MMDE algorithm, we can obtain the threshold value, 0.379. Based on this threshold value, we derived the substitution networks, as shown in Figure 5. According to Figure 5, we found that criteria x_1, x_2, x_9, and x_{14} are all influenced by criterion x_{11} directly or indirectly. In other words, although x_1, x_9, and x_{14} are elements of the powerful set with positive BP scores, all these three criteria can be substituted by criterion x_{11}.

3.3. *Key Criteria*

After we obtain the results from the SNA and MMDE algorithms, we analyzed the results according to the flow chart shown in Figure 3. At first, we exclude the weaker criteria, x_2, x_6, and x_5, then we can exclude the replaceable criteria, x_1, x_9, and x_{14}. The nine remainders in the powerful criteria set, which are important and cannot be substituted, are the criteria that meet the objectives of the proposed hybrid model, as shown as Figure 6. The original fifteen criteria can be replaced by nine criteria, as the result of the proposed model in this paper.

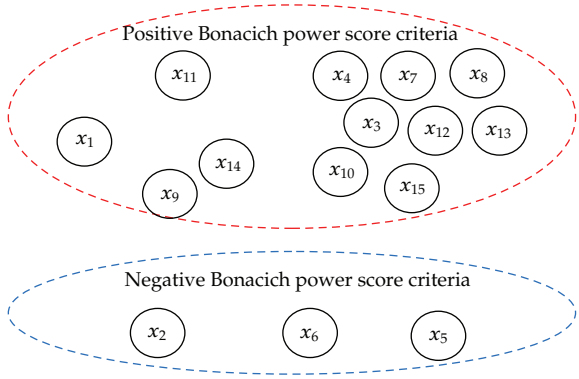

Figure 4: Criteria separated into positive and negative BP score sets.

Table 4: The de-entropy values matrix.

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
x_1	0.238	0.295	0.232	0.229	0.257	0.176	0.160	0.274	**0.379**	0.227	0.263	0.282	0.277	0.292	0.194
x_2	0.267	0.202	0.176	0.175	0.229	0.187	0.142	0.213	0.283	0.189	0.235	0.251	0.246	0.260	0.170
x_3	0.268	0.243	0.147	0.208	0.232	0.156	0.143	0.245	0.286	0.204	0.205	0.252	0.248	0.259	0.172
x_4	0.261	0.223	0.207	0.145	0.226	0.141	0.129	0.240	0.279	0.285	0.198	0.217	0.242	0.221	0.202
x_5	0.263	0.260	0.206	0.174	0.165	0.154	0.141	0.241	0.281	0.187	0.203	0.249	0.244	0.256	0.168
x_6	0.276	0.273	0.183	0.180	0.237	0.128	0.147	0.250	0.293	0.195	0.243	0.259	0.253	0.268	0.176
x_7	0.205	0.223	0.140	0.147	0.164	0.131	0.086	0.173	0.205	0.172	0.199	0.181	0.176	0.198	0.175
x_8	0.270	0.247	0.210	0.178	0.232	0.157	0.143	0.183	0.286	0.191	0.237	0.253	0.248	0.262	0.172
x_9	0.253	0.231	0.167	0.165	0.188	0.147	0.134	0.230	0.205	0.179	0.224	0.238	0.233	0.246	0.161
x_{10}	0.160	0.145	0.125	0.156	0.138	0.099	0.091	0.146	0.170	0.108	0.128	0.150	0.148	0.143	0.153
x_{11}	0.391	0.390	0.233	0.232	0.265	0.207	0.177	0.299	0.355	0.250	0.228	0.312	0.303	0.381	0.243
x_{12}	0.310	0.305	0.239	0.238	0.266	0.212	0.196	0.281	0.329	0.259	0.271	0.228	0.285	0.300	0.233
x_{13}	0.275	0.271	0.181	0.180	0.204	0.160	0.146	0.249	0.351	0.194	0.243	0.258	0.189	0.267	0.175
x_{14}	0.281	0.337	0.187	0.184	0.242	0.176	0.149	0.253	0.297	0.198	0.247	0.264	0.239	0.210	0.179
x_{15}	0.194	0.189	0.150	0.184	0.167	0.131	0.121	0.177	0.206	0.260	0.168	0.212	0.179	0.186	0.117

4. Discussion

In this section, we will discuss the advantages of the proposed model and its application in the brand equity evaluation.

4.1. Hybrid Model for Extracting Key Criteria

In this study, the proposed hybrid model combined both SNA and the MMDE algorithm to extract the key criteria from the existing criteria, especially when researchers were faced with excessive available criteria and with a considerable degree of possible substitution. The main purpose of using SNA to calculate the BP scores was to separate existing criteria into powerful and weaker criteria sets. Because the BP scores imply both centrality and power of the nodes in one's neighborhood, we can exclude the criteria which are not "powerful" or "central." If there are too many criteria without obvious substitution, it is especially useful and reasonable for the analyst to simplify the criteria by groups.

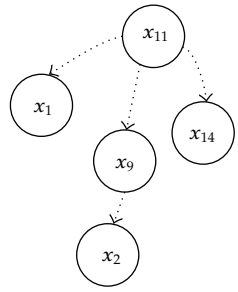

Figure 5: Steps to obtain the substitution network.

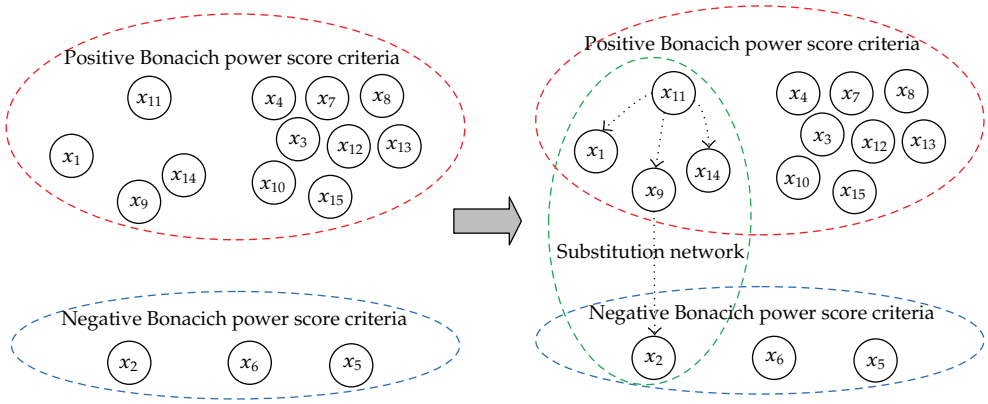

Figure 6: Steps to extract nine criteria from the original fifteen criteria.

The MMDE algorithm was used to set an appropriate threshold value and obtain adequate information to delineate the substitution network for further analysis. The results of the MMDE algorithm can be tracked and evaluated easily because of the obvious casual relationship. It is useful for a researcher if some specific criteria are considered as necessary criteria for evaluation. The researcher can easily find out which criteria should also be included in evaluating if the specific criterion has to be included.

After we obtained the results from the SNA and MMDE algorithms, we can exclude the weaker criteria and replaceable criteria and obtain the criteria which meet the objectives of the proposed hybrid model. In this paper, we demonstrated the effect and feasibility of the hybrid model, the first model to reduce criteria and consider the power, centrality, and substitution of criteria, for extracting key criteria.

4.2. The Application of Proposed Model in Brand Equity Evaluation

Compared to other assessment frameworks, the strength of three dimensions of Interbrand, namely, brand stability, brand trend, and marketing support is relatively week. This can be explained by the fact that they are easily substituted by other dimensions, which means that they share similar meaning with each other. Take brand stability as an example, aside from the fact that the contents of its measurement criteria are closely related to brand leadership, market, and brand trend of Interbrand, they are related to the dominance of the relevant

market, psychographic and identity status of BBDO, and also overlap with the loyalty driver of HIROSE. Brand trend measures the long-term performance of market share, expected brand performance, the sensitivity of the brand planning, and competitive action. Those four criteria are relative to brand leadership; market and marketing support those dimensions of Interbrand; therefore, both brand trend and marketing support are regarded as comparative weak and suggest to be ruled out of the assessment framework.

In the second analytical phase, we found that brand leadership, dominance of relevance market, and loyalty drivers were the three dimensions that can be substituted by brand status of BBDO. If we look carefully at the breakdown of BBDO in brand status, it contains two indicators of brand strength and brand appeal; five different levels of the dimension were constructed to measure the functional, market, psychographic, identify, and legendary status of the brand. However, brand leadership of Interbrand mainly measures market share, visibility, market position, and competitors outline which are very similar to the market status of BBDO. Then the dimension dominance of relevance market from BBDO mainly investigates the size of the brand revenue relative to the market leader which can also be included in brand strength and brand appeal of the market status of the brand status. Finally, the loyalty driver of HIROSE is also highly related to brand trust and brand loyalty of the identity status of the brand status.

According to data analysis, the original 15 dimensions are extracted into the final 9 dimensions using appropriate research methods to establish an assessment framework which can integrate the complete concept from various models of brand equity. From the analysis above we can conclude that the brand status of BBDO has relatively strong substitution capability since this dimension is more completely compared to other dimensions among different models since it can both cover the brand leadership of Interbrand and dominance of relevance market of BBDO. Therefore, it can be seen that, with the exception of dimensions between the different models, there are possibilities for mutual substitution and that the proposed model can efficiently extract the key criteria required.

5. Conclusions

In this paper, we used social network analysis and the maximum mean de-entropy algorithm to extract key criteria from numerous existing criteria. We also applied the proposed model to evaluating brand equity. The effect and feasibility of the hybrid model were demonstrated. However, we were able to have discussions with only a few experts and applied the model only to evaluating brand equity. In a follow-up study, we recommend that a further criteria extraction project(s) be executed using the proposed hybrid model to demonstrate increased feasibility of our model and allow the provision of more reliable conclusions.

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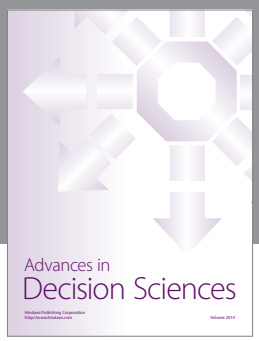

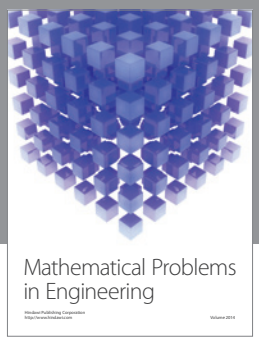

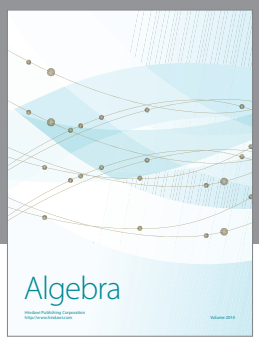

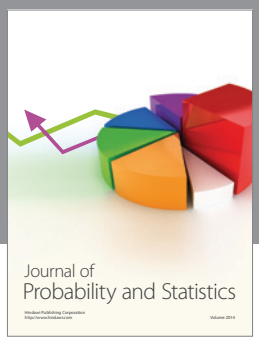

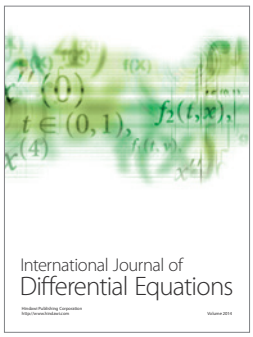

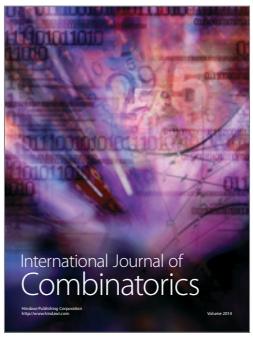

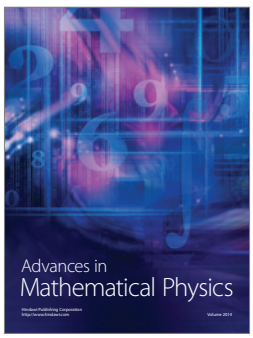

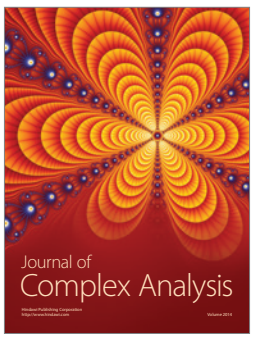

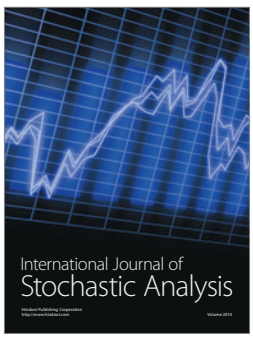

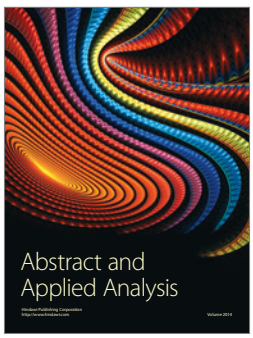

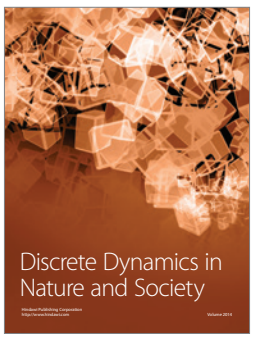

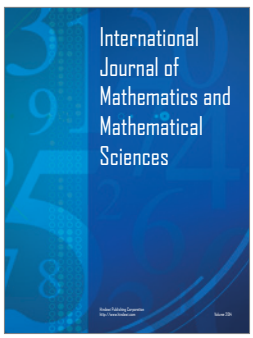

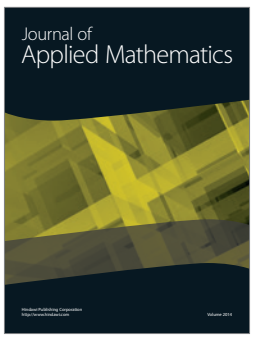

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