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DEMATEL : A Methodology for Research in Library and Information Science

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Abstract:

For different composite issues and factors on a complicated problem, there is a need to structure the problem with analyzed casual inter-dependency and influences with graphical illustration. In this paper the authors are explained the Decision-Making Trail and Evaluation Laboratory (DEMATEL) methodology, kind of different problems for which DEMATEL can be used and the method of the approach with steps. To solve complex and intertwined problem group this approach is proposed. It is capable to verify inter-relationship between the factors and offer a specific chart to inter-relationship. It is based on the technical experts' opinion and they plays complementary role. Direct influenced matrix clarified the key factors and specifies the priorities of the factors.

Keywords: DEMATEL, MCDM, Research Methodology

Introduction

DEMATEL is basically founded on graph theory and very effective to evaluate and formulate all intertwined cause and effect relationship in any structured model. This technique is used all over the world but it is very popular Japan. The casual relationships among related factors can be realized by the cause and effect group though using DEMATEL. It is possible to visualize the cause relationship of sub factors or a little control relationships between individuals. Interdependency among the factors/attributes can be verified and the interrelationship between factors/attributes by the direct graph can be reflected through this methodology. DEMATEL helps to better understand for identifying of practical solutions, particular problem and above all, the cluster of

complicated problems. The final result of the DEMATEL procedure is Impact Relation Map (IMR).

In DEMATEL structure, each factors/ sub factor may obtain from other higher or lower level factors. One of excellence of this technique is applying feedback application rather than others decision making method. Through the DEMTAL study a MCDM method can be adopt for solving complicated issued, evaluating, comparing and improving the effectiveness of every factor by dividing all factors in cause and effect group. Interdependencies among the unpredictable aspects through interrelationship map (IRM) can be visualized through this technique. The effect group can be improved easily by improving the cause group because effect group influenced by the other features in cause group. This methodology helps the managers to reach a high performance regarding to the effect group criteria. Library professionals can use this technique to improve the services of library in all fields.

Literature Review

This approach is used in various situations in manufacturing planning and controlling based on multi criteria decision making such as Customer behavior (Yi 2007), E learning Program (Wei & Hshiung 2009), Quality of Digital Library (Cabrerizo et al 2010), Material Selection (Shih-Chi et el 2011) Quality improvement (Yang el al 2013), Youth Violence (Felix and Devadoss 2013), International Business (Souri, 2014), Competency model (Kashi and Franek 2014), Knowledge Management (Mahmoodi and Jahromi 2014), HR Management (Kashi, 2015), Investment Management (Liu, Weng-Kun 2015) and Customer relationship (Pechová, Hana 2015) etc.

Year	**Title**	**Author**	**Aim**
2007	FMCDM with Fuzzy DEMATEL Approach for Customers' Choice Behavior Model	Chen-Yi at el	Customer's choice behavior
2009	Identification of a Threshold Value for the DEMATEL Method: Using the Maximum Mean De-Entropy Algorithm	Wei and Hshiung	E-learning programs
2010	A Model Based On Fuzzy Linguistic Information To Evaluate The Quality Of Digital Libraries	Cabrerizo et al	Quality of Digital Library
2011	The DEMATEL approach applied to solar cell industry material selection process in Taiwan	Shih-Chi at el	Material Selection
2013	A Fuzzy DEMATEL- Trapezoidal Structure for Modeling Cause and Effect Relationships of Youth Violence	Felix and Devadoss	Youth Violence
2013	Evaluating Influential Factors in Event Quality Using DEMATEL Method	Yang at el	quality improvement
2014	Utilizing DEMATEL Method in Competency Modeling	Kashi and Franek	competency model

2014	A New Fuzzy DEMATEL-TODIM Hybrid Method for evaluation criteria of Knowledge management in supply chain	Mahmoodi and Jahromi	Knowledge Management
2014	Evaluation of research methodologies in international business	Souri at el	International Business
2015	DEMATEL Method in practice: finding the causal relations among key competencies	Kashi, Katerina	HR Management
2015	Using FDM and DEMATEL Approaches to Evaluate the Location Selection of Investment	Liu, Weng-Kun	Investment Environment
2015	Application of DEMATEL Method in CRM Performance Measurement	Pechová, Hana	Customer Relationship

Besides the results from final step of DEMATEL (IRM) could be used in fuzzy approach to evaluate the super additive efficiency rate. After determining the interrelations between criteria and also it could be combined with another multi criteria decision making methods like Analytic Hierarchy Process (AHP), Analytic Network Process method (ANP) to quantify dependence and feedback relationships between certain criteria. In these cases the final decision will be effected by DEMATEL result while it is applied as a part of hybrid MCDM model.

The Dematel Method:

For applying DEMATEL, there are following main step:

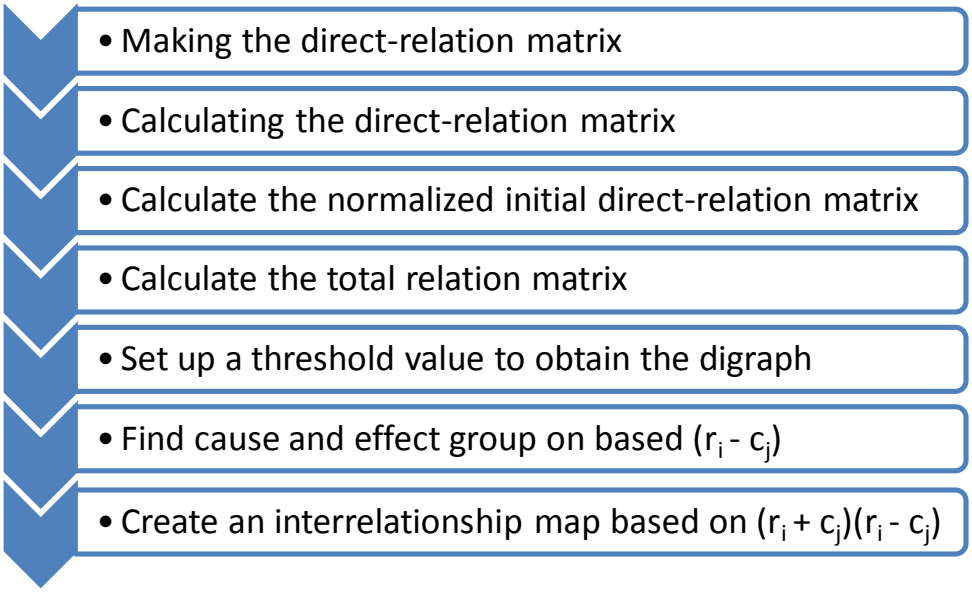

Figure 1

The procedures of the DEMATEL method can be expressed as follow:
Step 1: Finding the direct-relation (Average) matrix: First of all each respondent asked to evaluate the direct influence between any two factors by an integer score from 0-4 representing as

0 = no influence
1 = low influence
2 = medium influence
3 = high influence
4 = very high influence

The notation of x_{ij} indicates the degree to which the respondent believes factor i affects factor j. For $i = j$, the diagonal elements are set to zero. For each respondent, a $n \times n$ non-negative matrix can be established as $x^k = [x_{ij}^k]$, where k is the number of respondents with $1 \leq k \leq H$, and n is the number of factors. Thus, $X^1, X^2, X^3, \ldots\ldots, X^H$ are the matrices from H respondents. To incorporate all opinions from H respondents, the average matrix $\boldsymbol{A} = [a_{ij}]$ can be constructed as follows:

$$\boldsymbol{A} = [a_{ij}] = \frac{1}{H}\sum_{k=1}^{H} x_{ij}^k \tag{1}$$

Step 2: Calculate the normalized initial direct-relation matrix. Normalize initial direct-relation matrix $\boldsymbol{D}$ by

$$\boldsymbol{D} = m \times \boldsymbol{A}, \tag{2}$$

$$\text{Where, } m = min\left[\frac{1}{max_i \sum_{j=1}^{n} a_{ij}}, \frac{1}{max_j \sum_{i=1}^{n} a_{ij}}\right], i, j \in \{1,2, \ldots, n\} \tag{3}$$

Each element in matrix D falls between zero and one.

Step 3: Calculate the total relation matrix. The total-influence matrix T is obtained by utilizing Eq. (5), in which, I is an n x n identity matrix. The element of t_{ij} represents the indirect effects that factor $i$had on factor j, and then the matrix T reflects the total relationship between each pair of system factors.

$$T = \lim_{m \to \infty} (D + D^2 + \cdots + D^m)$$

$$= \sum_{m=1}^{\infty} D^i \tag{4}$$

Where,

$$\sum_{m=1}^{\infty} D^i = D^1 + D^2 + \cdots + D^m$$
$$= D(I + D^1 + D^2 \ldots + D^{m-1})$$
$$= D(I - D)^{-1}(I - D)(I + D^1 + D^2 \ldots + D^{m-1})$$
$$= D(I - D)^{-1}(1 - D)^m$$
$$\boldsymbol{T} = D(I - D)^{-1} \tag{5}$$

Define r and c be $n \times 1$ and $1 \times n$ vectors representing the sum of rows and sum of columns of the total relation matrix T, respectively, which are obtained by:

$$\boldsymbol{r}=[r_i]_{n\times 1} = [\sum_{j=1}^{n} t_{ij}]_{n\times 1} \quad (6)$$

$$\boldsymbol{c}=[c_i]_{n\times 1} = [\sum_{i=1}^{n} t_{ij}]_{1\times n} \quad (7)$$

Suppose r_i be the sum of ith row in matrix T, then r_i summarizes both direct and indirect effects given by factor i to the other factors. If c_j denotes the sum of jth column in matrix T, then c_j shows both direct and indirect effects by factor j from the other factors. When $j = i$, the sum $(r_i + c_j)$ shows the total effects given and received by factor i. That is, $(r_i + c_j)$ indicates the degree of importance that factor i plays in the entire system. On the contrary, the difference (r_i - c_j) depicts the net effect that factor i contributes to the system. Specifically, if (r_i - c_j) is positive, factor i is a net cause, if (r_i - c_j) is negative factor is effect.

Step 4:. The threshold value (α) computes by the average of the elements in matrix T, as computed by Eq. (8). This calculation aims to eliminate some minor effects elements in matrix T.

$$\boldsymbol{\alpha} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}[t_{ij}]}{N} \quad (8)$$

Where, N is the total number of elements in the matrix T. Since matrix T provides information on how one factor affects another, it is necessary for a decision maker to set up a threshold value to filter out some negligible effects. In doing so, only the effects greater than the threshold value, would be chosen and shown in digraph. In study, the threshold value is set up by computing the average of the elements in matrix T. The digraph can be acquired by mapping the data set of $(r + c, r - c)$.

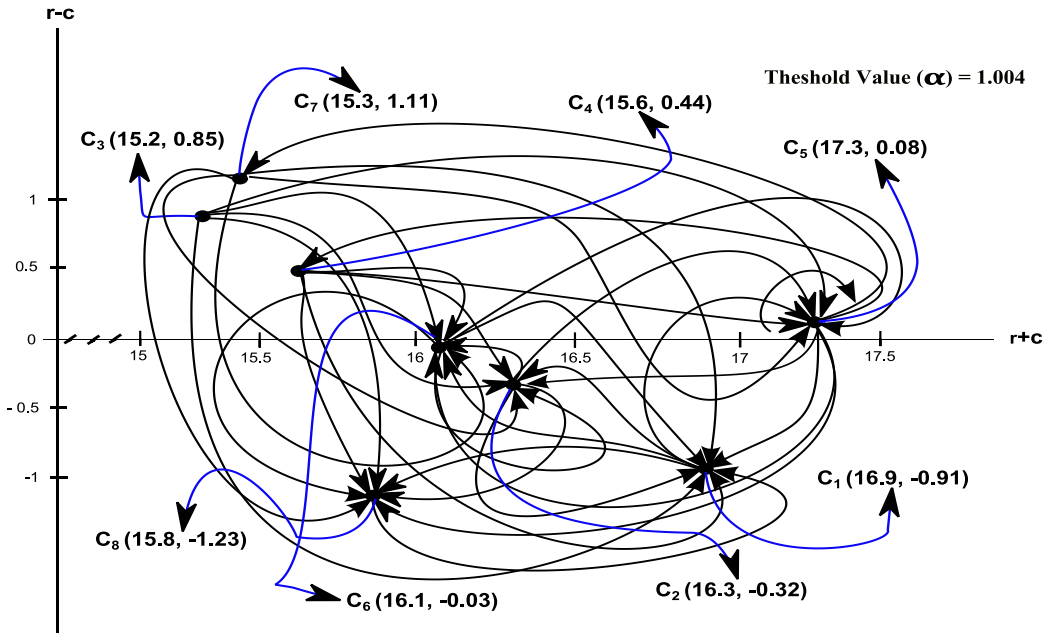

Figure 2: Sample of Interrelationship Map (IRM)

Figure 2 is the sample of interrelationship between the factors and graphical display of influence.

Conclusion

According to a novel hybrid Multi Criteria Decision Making (MCDM), DEMATEL is a flexible and effective decision making method. DEMATEL approach is based on the values of a review algorithm with emphasize on compromise solution in hybrid decision making methods as well as criteria interrelationship studies. For designers and decision makers for making strong decision in every field of management including academic services such as library services, this approach is very helpful.

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