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Selection of the Most Proper Progress Payment and Approximate Cost Package Program by DEMATEL Method

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Abstract

In construction, a progress payment is a partial payment that covers the amount of work completed by a contractor who has undertaken to carry out construction work. Since construction projects are time-consuming and completed in high budgets, Step by step payment of the works undertaken by the Contractor keeps the owner on the safe side. In the construction sector, progress payments and approximate cost calculations can be prepared faster by package programs. The choice of package programs which perform similar calculations in the market is a multi-criteria decision-making problem. In this study, the most appropriate package selection problem is solved by using DEMATEL method, which determines the interaction between the variables that affect the decision in the multi criteria decision making environment.

Key Words: *DEMATEL, Multi-Criteria Decision Making, Construction Management.*

Introduction

For construction sector, payment is very significant in the construction process of the construction activities owing to the cost of the resources as materials, machines and manpowers. One of the construction contract administration function is progress payment valuations and certifications (Demachkieh et al.2019). Progress payments are made after satisfactory completion of contract requirements and specifications. Basically, progress payments are made when the owner is willing to allow design products to be released for construction, and when constructed products are inspected and found to comply with the approved design. The main objective of this study is to select the most appropriate progress payment and cost approximate package program that is a kind of multi-criteria decision making problem by using “Decision-Making Trial and Evaluation Laboratory (DEMATEL)” method. This method has been applied in various problems in different sectors such as construction, finance, logistic, health, textiles, social service. Ji et al.(2019), using DEMATEL method is to identify the main factors that affect the three stage construction cost of the fabricated building production, transportation, and installation. Biao et al.(2009) analyzed quantitatively of the relations between contributing factors by the DEMATEL model on the basis of analyzing the inter-relations between each pair of indices with the Delphi method. Song et.al(2015) established a structural model of risk cause system by using the integration of DEMATEL and the

interpretive structure model. Heravi and Charkhakan (2014) presented a framework for predicting and tracing change-formation components in construction projects using the DEMATEL technique.

DEMATEL Method

One of the decision making method is DEMATEL (Decision-Making Trial and Evaluation Laboratory) was developed by Fontela and Gabus in 1976 for the solution of problems in economic, political and scientific (Gabus and Fontela, 1972). DEMATEL method is useful to visualize the structure of complicated causal relationships with matrices or digraphs. It can convert the relationship between the causes and effects of criteria into an intelligible structural model of the system (Falatoonitoosi *et al*.,2013). The steps of the DEMATEL method are as follows (Fontela and Gabus, 1976):

Step 1: Establishing the direct-relation matrix:

Evaluation of the relationship between the criteria is done at this step. The decision maker scores the criteria in pairs based on a four level scale consisting of scores from 0 to 3. The definition of the scoring scale is shown in Table 1.

Table 1. Scoring scale.

Linguistic Expression	**Numeric Values**
no influence	0
low influence	1
high influence	2
very high influence	3

As a result of the decision of the decision maker, A direct relationship matrix in dimension nxn is obtained to represent the number of n criteria / factors. a_{ij}, which constitutes the elements of matrix A, shows the degree to which criterion i affects criterion j.

Step 2: Obtaining the normalized direct-relation matrix:

Based on the direct relationship matrix A, the normalized direct relationship matrix denoted by X is obtained with the help of the following equations, respectively.

$$X = k.A \qquad (1)$$

$$k = \frac{1}{maks \sum_{j=1}^{n} a_{ij}}, \qquad (2)$$

$$i, j = 1,2, \ldots., n \qquad (3)$$

With the equations (1), (2), (3) below, the sum of the direct relation matrix's rows and colums are calculated. The maxium value is selected from the row and column totals. The elements of matrix A are divided by this value. Thus, X normalized direct correlation matrix is obtained, each element of which is normalized between 0-1.

Step 3: Calculate the total-relation matrix:

By using the equation (4) shown below by the unit matrix I, the total relationship matrix T is obtained.

$$T = X(1 - X)^{-1} \qquad (4)$$

Step 4: Determination of affecting and affected criterion groups

Row total are taken from the T total relationship matrix, thus obtaining the D_i matrix in dimension $nx1$. Column totals of the total relationship matrix and then transposed of these total values are taken. Thus, $1xn$ column totals and then transposition of these total values will get R matrix in size $nx1$.

$$T = \left[t_{ij}\right]_{nxn},\ i,j = 1,2,\dots,n \qquad (5)$$

$$D_i = \left[\sum_{j=1}^{n} t_{ij}\right]_{nx1} = [t_i]_{nx1},\ i = 1,2,\dots,n \qquad (6)$$

$$R_i = \left[\sum_{i=1}^{n} t_{ij}\right]_{1xn}^{t} = \left[t_j\right]_{nx1},\ j = 1,2,\dots,n \qquad (7)$$

Step 5: Determination of threshold values

The sum of rows and sum of columns of the total relation matrix T in Equation (5) are computed as an D and R $nx1$ vectors.
As a result, while i = j the sum $(D_i + R_i)$ that is called "Prominence'' proves the degree of importance role of criterion i in system and also gives an index that shows the total effects both given and received by criterion i. Likewise , the (D_i, R_i) that in called "Relation" shows the net effect that criterion i donates to the system. When (D_i, R_i) is positive, criterion i will be to the cause group and when (D_i, R_i) is negative, criterion i is a net receiver (Falatoonitoosi *et al*.,2013).

Case Study

A construction company decided to purchase a computer program to make progress payments and approximate cost calculations. As a result of market research, it was determined that 3 criteria were important: *price*, *user-friendly* and *compatibility with CAD software*. In addition, the company owners thought that there was an interaction between the selection criteria.

Firstly, by taking the opinions of a group of experts consisting of technical office manager, technical office chief and technical office engineers totally 6 people who are experts in their fields, by means of the scale in Table 1. As a result of the pairwise comparisons, A direct relation matrix shown in Table 2 was obtained.

Table 2. Relationship matrix between criteria

	Criteria			
	Price (C1)	User-Friendly (C2)	Compatibility With Cad Software (C3)	**Total**
C1	0	2	3	5
C2	2	0	2	4

C3	3	1	0	4
Total	5	3	5	

In Table 2, as an example of binary comparisons, a_{12}= 2.00 means that the price criterion highly affects the user-friendly criterion.
With the help of equations in the 2nd step, the X normalized direct relationship matrix presented in Table 3 was obtained.

Table 3. Normalized direct relationship matrix

	Criteria		
	Price (C1)	User-Friendly (C2)	Compatibility With Cad Software (C3)
C1	0	0,4	0,6
C2	0,4	0	0,4
C3	0,6	0,2	0

As seen in Table 3, all values in the normalized direct relationship matrix are in the range of 0-1. After the normalized direct relationship matrix, the T total relationship matrix shown in Table 4 was obtained using the equation in the 3th step. Depending on the number of evaluation criteria, 3x3 dimension unit matrix was used in this equation. The values shown in Table 4 were obtained by applying equations in the 4th step to the T total relationship matrix.

Table 4. Effect / Relationship values of the criteria

	Criteria			**Effects / Relationships**			
	Price (C1)	User-Friendly (C2)	Compatibility With CAD Software (C3)	D	R	D+R	D-R
C1	0,52	0,28	0,44	1,24	1,2	2,44	0,04
C2	0,16	0,24	0,16	0,56	0,56	1,12	0
C3	0,52	0,04	0,44	1	1,04	2,04	-0,04

When the degree of affecting the criteria is examined, it can be said that the price criterion has the highest degree of affecting other criteria with $D_2 = 1{,}24$, on the other hand, the price criterion with the value of $R_2 = 1{,}2$ has the highest degree of effect from other criteria. When we look at $D_i - R_i$ the impact values of the criteria, the degree of impact with positive values is "net effecting" the price and user-friendly criteria respectively. The compatibility with CAD software criterion, which has a negative impact rating, is "net affected".

Finally, an effect-relationship diagram was drawn by determining the threshold value. The threshold value for this problem was accepted as 0,2. The effects above this threshold are presented in Figure 1 in the effect-relationship diagram, drawn by using $D_i + R_i$ and $D_i - R_i$ values.

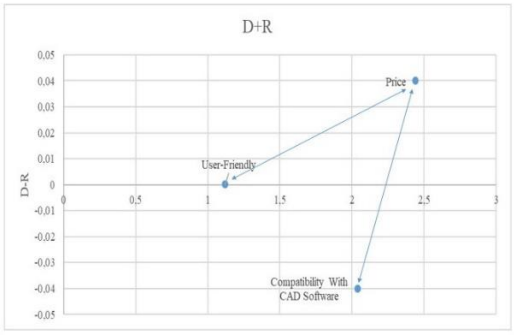

Figure 1. Effect / Relationship diagram.

Results

Progress payment and cost approximation is significant for construction companies. Every activity that takes place in executing a construction contract revolves around the contractor satisfactorily completing some requirement so that it can get paid, or the owner determining that a given requirement or specification has satisfactorily been completed so that the contractor get paid. In this study, by using DEMATEL (decision making trial and evaluation laboratory) method to analyze the structure of the influencing factors of purchasing a package program for progress payment and approximate cost to a construction company, it is getting the structure of the effect relation among these factors. The result indicate that criterion of price has a highest effect degree. Results of DEMATEL applied the case study showed the potential of this method in MCDM, so it can help decision makers for acquiring more strong decisions.

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